
Transit ENCENS-SHEBA

R. V. Marion Dufresne

Colombo (Sri Lanka) – Salalah (Oman)

June 3th 2000 - June 12th 2000

Catherine KISSEL

Hartmut SCHULZ

Transit ENCENS-SHEBA

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1 - Participants (scientists)

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2 - Introduction

The first aim of the cruise was to retrieve sediment cores from the Pakistani margin (6 stations) and from the Owen Ridge (1 station) in order to study in the variations in the past of the East Asian monsoon. These sites were all characterized by high sedimentation rates allowing high temporal resolution analyses.

The first three sites, proposed by the German group from the Institut für Ostseeforschung Warnemünde (IOW) (P.I.: Hartmut Schulz) were located along the Pakistani coast between 500 and 900 m water depth. One site proposed by the Laboratoire des Sciences du Climat et de l'Environnement, France (P.I. Catherine KISSEL) and two others proposed by the Free University of Amsterdam, The Netherlands (P. I. Gerald Ganssen) were located on the Murray Ridge. The seventh core on the Owen Ridge had been asked by the Museum National d'Histoire Naturelle (P. I. Pierre Clément)

The Marion Dufresne left Sri Lanka on June 3rd at the beginning of the afternoon and the arrival at the first station was planned on June 7th, early in the morning. However, on June 6th, a few hours before getting to the site, *via* the French Embassy at Karachi, we met with a refusal from the Pakistani authorities to work in the Pakistani waters.

The R.V. Marion Dufresne was thus re-routed and it has been decided to work, in addition to the Owen Ridge initially planned, at other stations located in the international waters.

No analyses were made on the sediment cores on board. The physical properties, spectrophotometry and sediment description will be investigated at Gif-sur-Yvette when the cores will be available (sent back from La Réunion island). This report will be then completed.

3 - Sediment Coring

General aspects

As a consequence of the changed route of the RV MARION DUFRESNE, it was decided to retrieve sediment cores from a number of stations in the central and western part of the northern Arabian Sea. We used the giant coring system CALYPSO with tube lengths of 37.4m to 49m. The length of the corer was modified for each station, depending on the information available from previous coring and the ship's survey data. On four stations, high sedimentation rates and continuous sedimentation could be expected, based on previous investigations, mainly provided by the Netherlands Indian Ocean Programme NIOP (van der Linden et al., 1993) and by the results of ODP Leg 117 (Prell et. al., 1986). Optionally, near the end of the cruise, we were able to retrieve a fifth core from a shallow site near the Oman shelf area off Ras Sharbithat. Along with the ship track and between the stations, a detailed bathymetric survey was focused on the topography of the Murray Ridge and Owen Ridge by the ship's multibeam system.

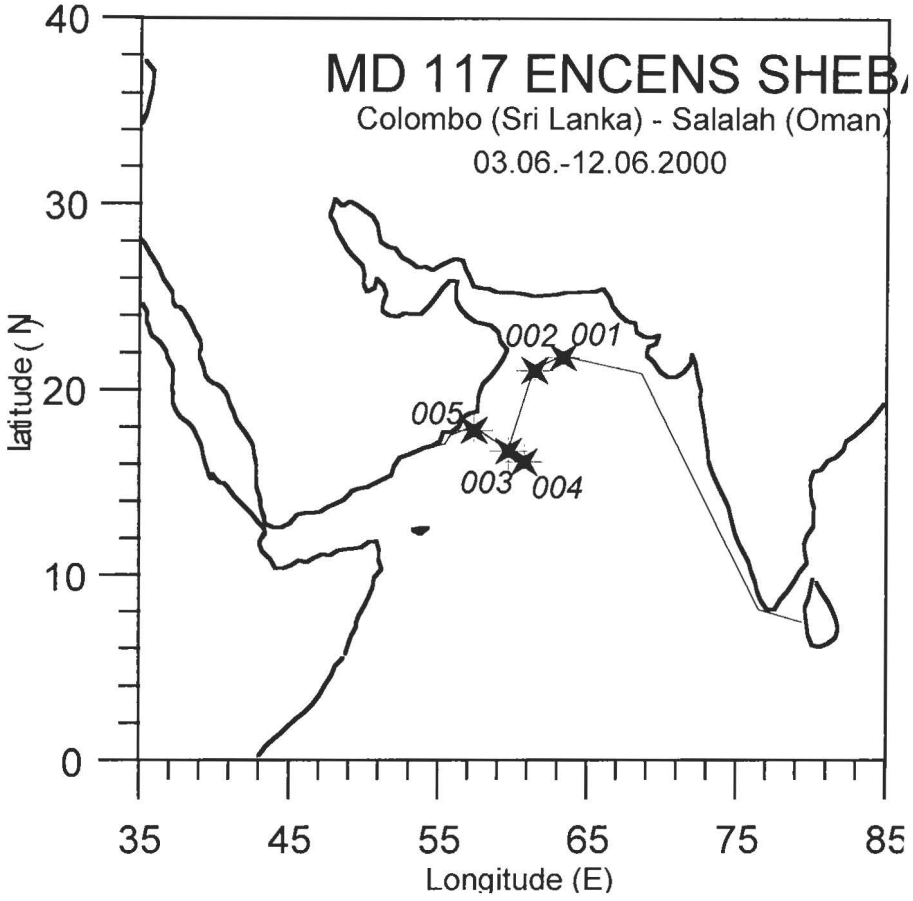


Figure 1: Ship track (thin line) from Colombo, Sri Lanka to Salalah, South Oman, and coring sites numbered from 001-005 (stars) during the IMAGES VI cruise MD117 of MARION DUFRESNE. For exact position and details see following text and tables in the appendix.

Cores	Water Depth (m)	Latitude (N)	Longitude (E)	Latitude (N)	Longitude (E)	Length (m)
MD 00-2353	3180	21°45.12	63°23.21	21.7520	63.3868	30.53
MD 00-2354	2740	21°02.55	61°28.51	21.0425	61.4752	31.43
MD 00-2355	2420	16°42.31	59°42.67	16.7060	59.7103	32.49
MD 00-2356	4020	16°07.38	60°45.54	16.1226	60.7588	33.98
MD 00-2357	345	17°50.05	57°23.60	17.8433	57.401	20.00

Description of the coring sites and first results

CALYPSO CORE MD00-2353, Station 001 (bis)

A core of 30,53m was recovered from 3180m water depth South of the Murray Ridge, on the northernmost Indus Fan. Favorable sediment for coring was evidenced be the flat topography and well-layered sediments of at least 70m thickness, using the multibeam and 3.5khz systems. Based on the inspection of the sediments at the ends of the segments when cutting the tube into 1.5m-long sections, a continuous sequence of light- to medium dark-colored, hemipelagic calcareous muds can be expected. Assuming a sedimentation rate of about 7-8cm/1000yr from nearby cores (Kögler, 1967; Prins and Weltje, 1999), core MD00-2253 may span the last ~400,000yr.

CALYPSO CORE MD00-2354, Station 002 (bis)

Core MD00-2354 of 31,43m length was taken from 2740m water depth on the Northern Owen Ridge, at the same site as NIOP station No. 483 (van der Linden et al., 1993). Sedimentation rates tend to be somewhat lower at this top position than on the upper Indus Fan close to the Murray Ridge. In comparison with core MD00-2353, this high-quality core from a shallower site, above the foraminiferal lysocline at about 3300m (Cullen and Prell, 1984), is expected to cover the last 500,000 to 550,000yr, assuming a mean sedimentation rate of 5.5cm/1000yr.

CALYPSO CORE MD00-2355, Station 003 (bis)

Core MD00-2355 (32.49m) was taken near the crest of the Owen Ridge at 2420m water depth. Its particular position at the upper slope was selected based on the results of the ODP Leg 117. Mean sedimentation rates are lower at the proper top (~1930m), possibly because of winnowing or condensed sedimentation. We assume that core 2355, from far above the foraminiferal lysocline, permits the reconstruction of pelagic conditions for the past ~700,000yr. Previous studies have demonstrated (e.g. de Menocal et al., 1991) that this site, due to its "hillock" position isolated from the continents, may provide a high-quality record of Arabian dust deposition, carried to the site during the summer monsoon season (Sirocko and Sarnthein, 1989).

CALYPSO CORE MD00-2356, Station 004 (bis)

In contrast to the previous site, core MD00-2356 was recovered from the deep Arabian Basin at approximately 4000m depth, close to carbonate lysocline at 3900-4000m (Kolla et al., 1976) in the Arabian Basin. The ends of the sections revealed light-colored fine-grained hemipelagic sediments, intercalated with dark gray silts and

sands that can be interpreted as turbiditic fan sediments. We assume that these inhomogenities resulted in the coring disturbances and some water-filled sections in between the sediments. The core got stuck in a more than 5m-thick sequence of stiff silty to clayey sediments and the tube was bent. However, this site may be in a key position to monitor the deep ventilation history of the northwestern Indian Ocean as it is placed downstream the path of deep waters entering into the Arabian Basin from the South through the Owen Fracture zone.

CALYPSO CORE MD00-2357, Station 005 (bis)

Station MD00-2357 at only 315m water depth from the upper continental slope off the South Oman was selected as a shallow end member, forming a depth transect together with core MD00-2355, 2420m depth and core MD00-2356, 4020m depth off the Arabian Peninsula (Fig. 1). Previous site surveys and drilling by ODP show that there may exist only a few favorable sites for coring in this area, as intense resuspension of the fine-grained sediments may occur due the physical process of upwelling subsurface waters (Rixen et al., 2000), or due to contour currents, resulting in condensed sedimentation or even erosion. Following a detailed site survey, we obtained a core of 20m length. The sediment consists of dark-colored, pteropod- and foraminifer-bearing muds, eventually with a strong H_2S-smell, indicating suboxic to anoxic bottom water conditions. Concretes of ?phosphorite also indicates extremely high productivity and high vertical fluxes due to intense coastal upwelling (see water column measurements).

The absence of the planktonic foraminifer *Globigerinoides ruber* (pink) indicates an age younger than 115,000 to 120,000 years for the base of that core. However, detailed stratigraphical investigations are necessary for validation and to obtain precise sedimentation rates.

4 - Observations from the water column measurements

At every coring station the ship's CTD system (SBE, Sea-Bird Electronics INC, SBE 04-04/0) and a flourometer, together with a rosette of 22-Niskin bottles was used to measure the content of dissolved oxygen, chlorophyll, salinity and water temperature between the surface and about 300m water depth (see Figure) and to obtain samples from selected water depths, depending on the position of the chlorophyll maximum. At each level, 1-2 bottles were sampled for stable oxygen isotope analysis and dust/trace metals of particle-bound material and for the collection of coccolithophorids.

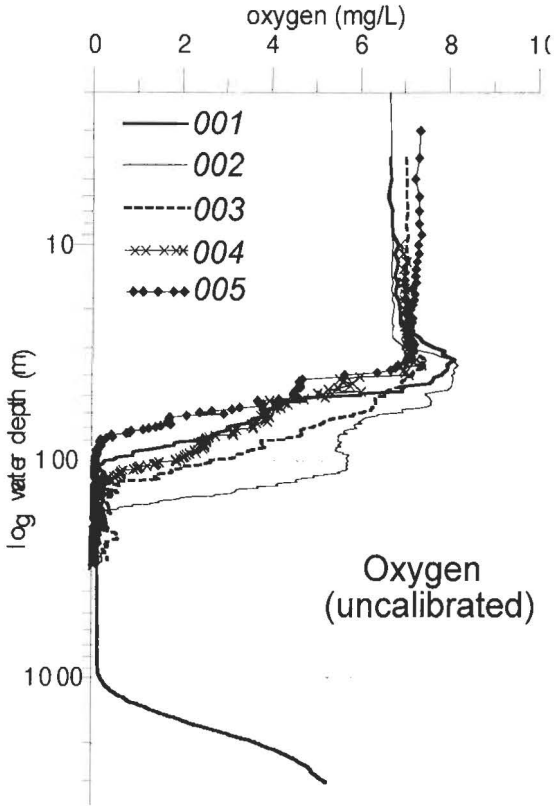
At station 001, a profile down to 3000m was measured for a general picture of the typical water properties of the Northern Arabian Sea, including the deeper water column. In the oxygen profile, the upper and the lower boundary of the OMZ (oxygen minimum zone) is clearly seen between approximately 100m and 1000m water depth, where oxygen values (uncalibrated) drop to nearly zero.

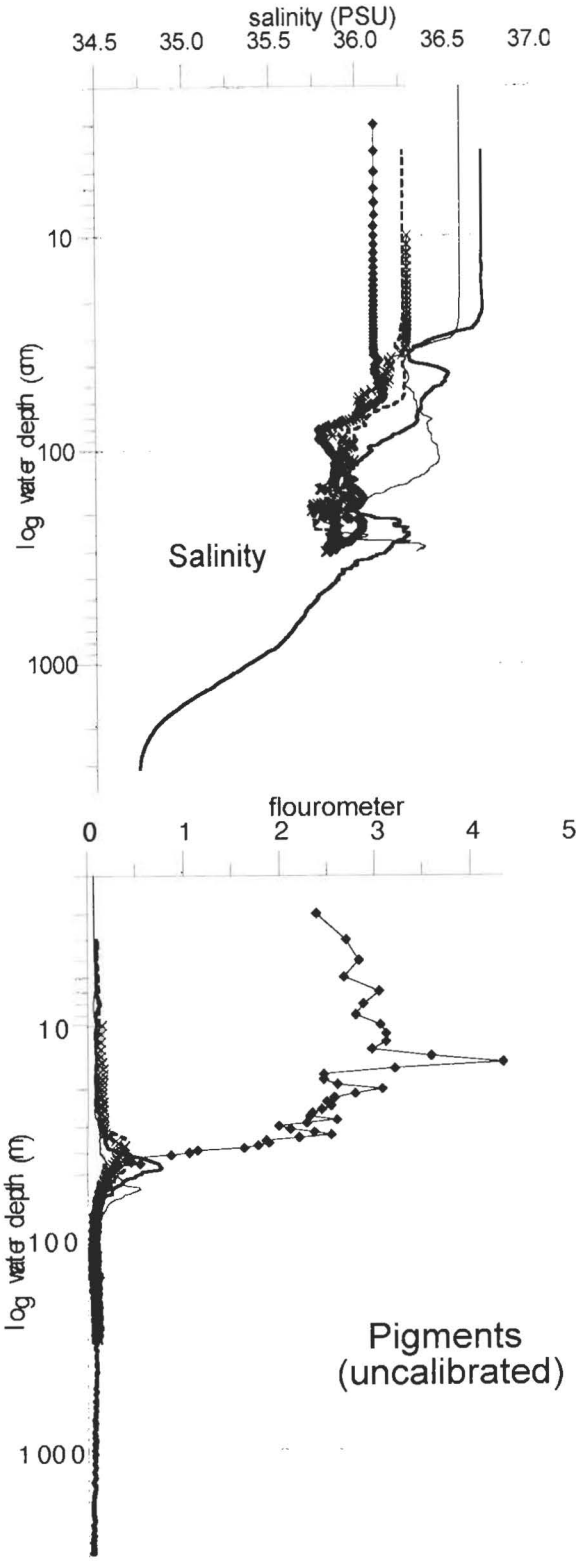
The upper boundary of the OMZ was slightly variable between the five stations and seems to be shallowest in the Omani coastal waters. At station 005, a sharp decrease is observed between 40m and 80m water depth, whereas the upper edge of the OMZ is significantly deeper at the stations 001 and 002 from the central Northern Arabian Sea with a major decline of oxygen is between water depths of 70m to 120m and from 80m to about 180m, respectively. These differences between the Northern and Southern sites may be due to the presence of well-oxygenated subsurface waters originating from the Persian Gulf.

The influence of the warm and highly saline Persian Gulf waters is also feasible in the slightly higher water temperatures and salinity values at equivalent depths in the profiles of station 001 and 002. However, the salinity profile 001 suggest that the core of this water mass is placed at about 200m to 400m, and thus may only partly represented in the shallow profiles. Additionally, in profile 001, another sharp decrease in salinity can be identified at about 900m which marks the lower boundary of the saline waters originating from the Red Sea.

The most prominent feature is the distinctly different profile of pigments found at the station 005 situated on the shelf off the Oman. This profile shows a broad interval of two-fold higher concentrations throughout the upper water column of 0m-40m, suggesting a well-mixed and highly productive surface water mass off the Omani coast due to pristine coastal upwelling. In contrast, there the sharp concentration spikes with values of only < 1 (uncalibrated) in the profiles 001-004 show the presence of a narrow deep chlorophyll maximum between 20m and 80m water depth, bound to the depth of the thermocline. In agreement, oxygen content at station 005 is somewhat higher possibly due to photosynthesis, and water temperature drops to about 26°C.

Evidence for open ocean and coastal upwelling generally was found offshore the south Oman coast along the cruise track by slightly cooler sea-surface temperatures than further North. A minimum was found on June, 11th at about 17N 15`, 055E 22`, when water temperatures of only 21.1° where measured en route.




salinity (PSU)
34.5
35.0
35.5
36.0
36.5
37.0
10
100
1000
log water depth (m)
Salinity
flourometer
0
1
2
3
4
5
10
100
1000
log water depth (m)
Pigments
(uncalibrated)

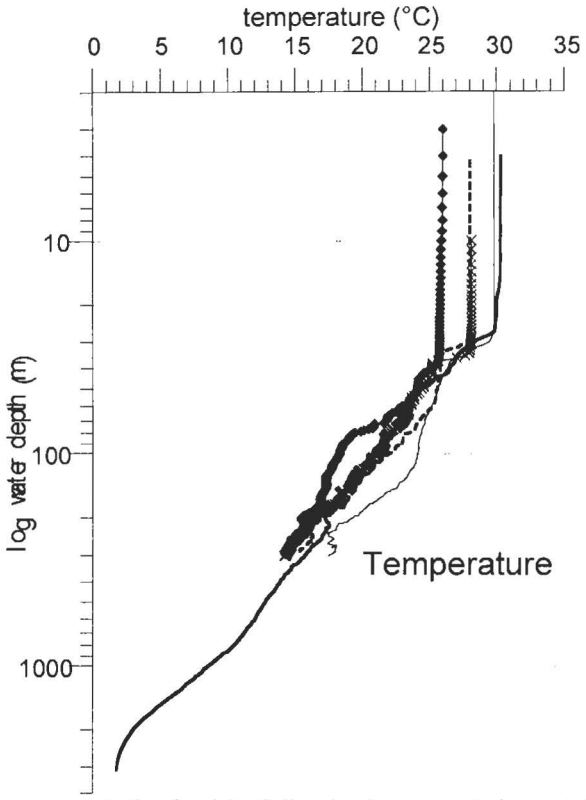


Figure 2: Collected CTD-measurements (up hauls) of dissolved oxygen, "pigments", salinity and temperature of the near surface layer down to 300m water depth (except for station 001, ca. 2-3000m) at the five water stations. Note logarithmic scale of y-axis.

5 - References

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6 - Summary of shipboard operations

Date (GMT)	Site	GMT time	Latitude (N)	Longitude (W)	Water depth (m)	Operations
3/06/00		08h30	07°0	079°48		departure from the pier at Colombo
6/06/00		06h00	20°16	068°31		re-routing of the boat(direction: 289)
7/06/00	1	04h20	21°45.69	063°23.30		arrival at station *South Murray Ridge*
						electric failure of the front propeller
		05h54	21°47.01	063°22.99		plancton tow in the water (50 m)
		05h59				plancton tow out of the water
		09h25	21°46.05	063°24.61	3180	Rosette and CTD deployed down to the bottom (3100 m)
		11h44				Rosette and CTD out of the water
		12h56	21°45.12	063°23.21	3180	corer in the water
		16h44				corer on the deck
						(Calypso : **MD00-2353,** 30.53m)
		17h00				departure from site 1
8/06/00	2	03h15	21°02.48	061°28.73		arrival at station *Northern Owen Ridge*
		03h20				Rosette and CTD deployed down to 300 m
		04h03				Rosette and TD out of the water
		04h55	21°02.55	061°28.51	2740	corer in the water
		07h34				corer on the deck
						(Calypso : **MD00-2354,** 31.43m)
		07h43	21°02.38	061°29.59		plancton tow in the water (50 m)
		07h50				plancton tow out of the water
		07h50				departure from site 2
						bathymetry recorded
9/09/00	3	11h32	16°49.68	059°51.8		site survey for station *Owen Ridge*
		15h42	16°42.36	059°42.64		arrival at site 3
		16h06	16°42.31	059°42.67	2420	corer in the water
		18h35				corer on the deck
						(Calypso : **MD00-2355** ; 32.49 m)
		19h00	16°42.13	059°42.92		Rosette and CTD deployed down to 300 m
		19h41	16°41.79	059°43.02		CTD out of the water
		19h55				plancton tow in the water (50 m)
		20h10				plancton tow out of the water
		20h16				departure from site 3
10/06/00	4	03h30	16°07.71	060°45.17		arrival at station *Arabian basin*
		03h56				Rosette and CTD deployed down to 300 m
		04h43				Rosette and CTD out of the water
		05h30	16°07.38	060°45.54	4020	corer in the water
		09h07				corer on the deck
						(Calypso **MD00-2356** ; 33.98 m)
		09h15	16°06.40	060°46.68		plancton tow in the water (50 m)
		09h30				plancton tow out of the water
		09h30				departure from site 4
						check of the seismic line for ENCENS SHEBA seismic cruise
11/06/00	5	05h04				arrival at station *Arabian shelf*
		06h06	17°50.05	057°23.60	345	corer in the water
		07h10				corer on the deck

				(Calypso **MD00-2357** ; 20 m)
	07h20	17°50.39	057°24.10	Rosette and CTD deployed down to 300 m
	08h10			Rosette and CTD out of the water
	08h15			plancton tow in the water (50 m)
	08h30			plancton tow out of the water
	08h30			departure from site 5
				Bathymetry survey
12/06/00	08h00			arrival at Salalah.