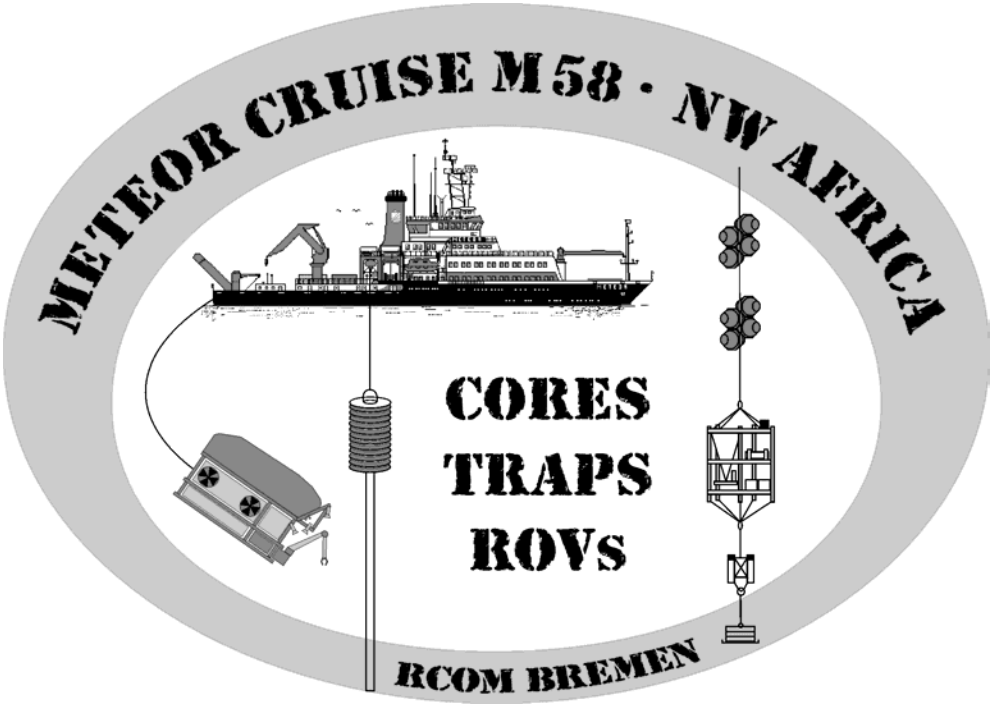


# METEOR Cruise M58/2

## Upwelling and Sedimentation off NW Africa

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Las Palmas – Las Palmas, Canary Islands, Spain

# Short Cruise Report

## Research Objectives

Off NW Africa one of the world's most important upwelling systems is located, influenced by large amounts of Saharan dust deposits delivering nutrients into the ocean. Both processes are of fundamental importance for the particle formation in the water column, substantially affect the biological and carbonate pumps and thus the global atmospheric $CO_2$ budget. Notwithstanding the fact that the main driving forces of climatic variability are identified in the centers of deep water formation in the northern North Atlantic, the upwelling area off NW Africa is most suitable for detailed reconstructions of past climatic changes due to the regionally very high rates of sediment accumulation. The phenomenon of abrupt climate variability will be in the focus of the projected research. Various ice core studies and paleoceanographic investigations have clearly documented that climatic variations of the past repeatedly occurred at very high rates, at times within but a few decades. In high resolution sediments of the North Atlantic numerous short-term climatic changes such as 'Bond-Cycles' and 'Heinrich-Events' have been described. These rapid shifts of the climatic system in the past as well as today's knowledge and rising concern about antropogenic influences recently attracted increasing public interest to such paleoceanographic investigations.

Analyses of high accumulation rate Holocene marine sediments have a particularly great potential to understand historical climatic changes of the last 2000 years like the 'Little Ice Age' or the 'Medieval Warm Period' in context of the long-term climatic variability of the last 11,500 years. According to results achieved on several previous METEOR cruises, high accumulation rate sedimentary deposits are found east of the Canary Islands and west of Dakhla and Cape Blanc which should comprise appropriate climatic archives and are therefore prime choices for high-resolution paleoceanographic studies. Additional information about the individual depositional settings is provided by seismic and echographic pre-site surveys performed during METEOR Cruise M 58/1 in April 2003.

For logistic reasons the Cruise M 58/2 had to be divided into two legs. During the first part, prime objective was to recover high-resolution sediment sequences at the NW African continental margin from about 31 to 25°N. For this purpose, the shelf and upper continental slope were sampled with the multicorer, gravitiy corer and large box corer in the upwelling centers between Cape Ghir and Cape Yubi and south of Cape Bojador. Moreover, the water column was regularly sampled with the multinet and rosette for biologic and isotopic investigations.

Additional to the geologic working program west of Dakhla and Cape Blanc particle flux studies were a principal goal during the second part of Cruise M 58/2. A long-term sediment trap mooring of the University of Bremen was exchanged at around 21°W off Cape Blanc and another mooring newly deployed at about 19°W to compare the particle fluxes in the complex filament patterns of the extended regional upwelling complex. In the immediate and wider vicinity of the two mooring stations the depth distribution of marine aggregates were documented at high resolution using a particle camera system and selectively sampled by means of a remotely operated vehicle (ROV). Sampling of the water column was performed with *in situ* pumps and rosette casts in the same region for chemical analyses of dissolved and suspended matter.

**Summarized Cruise Report**

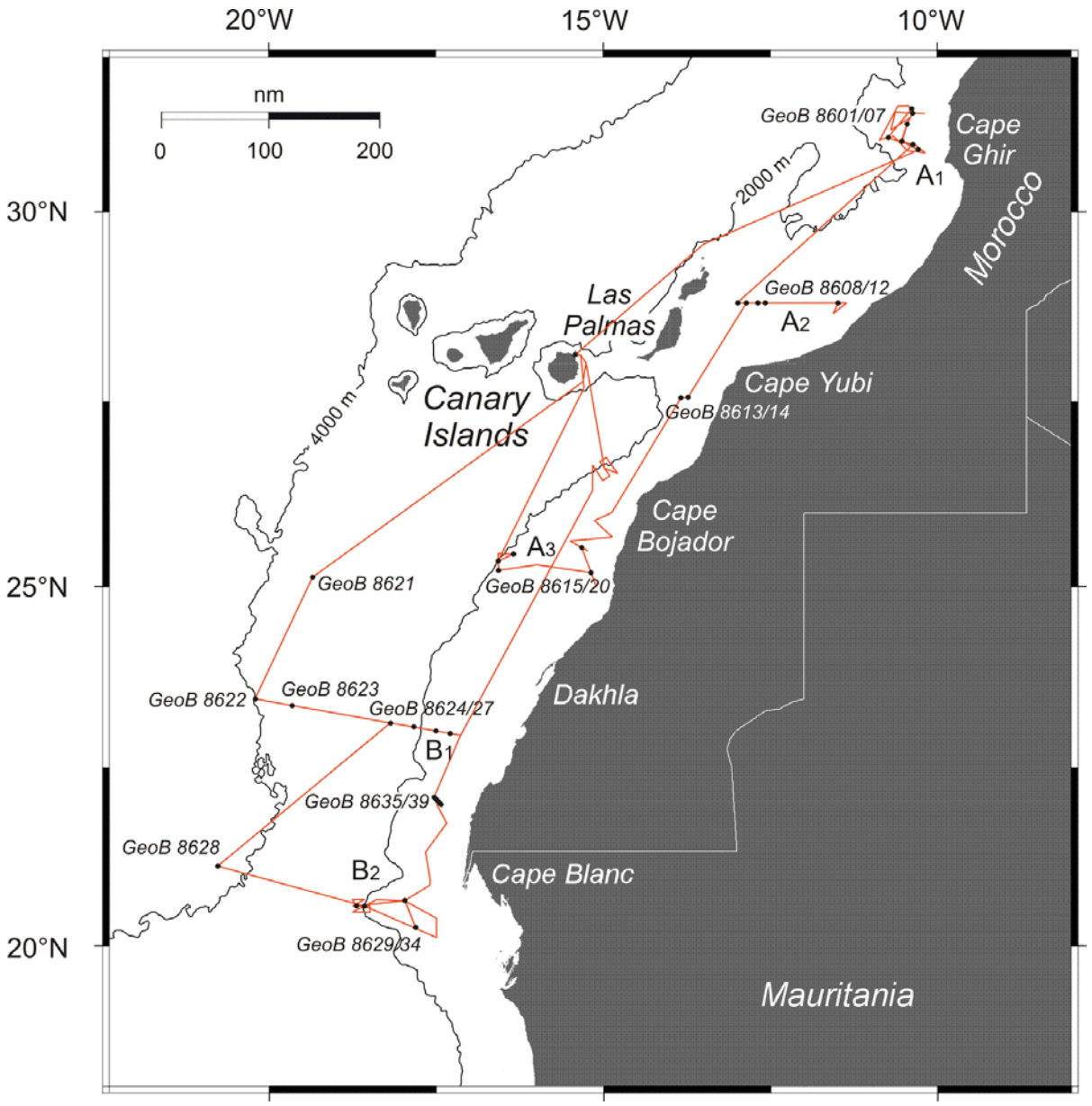
R/V METEOR sailed as scheduled in the morning of May 15, 2003 from Las Palmas, Canary Islands, Spain to Leg 2 of Cruise M 58. Before, 3 days in port had been very efficiently used to exchange scientific equipment, replenish the stocks of utensils for the research program and to refit various laboratories. Twenty-five scientists from the Department of Geosciences and the DFG Research Center 'Ocean Margins' at the University of Bremen took part in the cruise. The Moroccan observer appointed did finally not arrive.

Almost immediately after leaving port, we faced quite adverse weather conditions that further deteriorated during transit to the first working area (A1) on the Moroccan continental margin at 31°N. An extended high pressure system near the Azores paired with low pressure over northwestern Africa resulted in very intense trade winds. The May 16 forecast of our shipboard weather station '7 to occasionally 8 Bft winds and up to 5 m seas' summarized the actual situation only inadequately. It was of little help that, according to the same source, such conditions are merely impossible at this time of the year (less than 1% probability).

While a number of people suffered, the station work was but marginally affected thanks to a most proficient support from the bridge and all hands on deck. From May 16 to 18 the multicorer and the gravity corer could thus be employed without problems at 7 locations (GeoB 8601 to 8607) in the area north of Cape Ghir and the Agadir Canyon. All laboratories were promptly active measuring and analyzing the series of sediments recovered from between about 500 and 1200 m water depth. For some of them clear evidence could be found that they may indeed represent the detailed Holocene archives expected to reconstruct at high temporal resolution both the development of upwelling and marine productivity off NW Africa and the climate history in the continental hinterland. Totally unexpected on the other hand was the recovery of only some pieces of volcanic debris and corals at 2 sites in the northern part of this working area. Multiple successful multinet and rosette casts completed the scientific activities in the Cape Ghir region.

After transit to the Moroccan continental margin at around 28°N stations work was continued, now under mostly pleasant atmospheric conditions, on Monday May, 19 north of Cape Yubi (working area A2). Here, as well as south of Cape Bojador (working area A3), main objective was the sampling of sediments on the broad shelves. Despite extended surveys with the ship's *Parasound* echosounding system no appropriate locations could be identified for this purpose, though. Attempts to penetrate the thin layers of recent deposits overlaying steeply inclined Mesozoic formations with the large box corer and gravity corer all failed and several times deformed devices were retrieved on deck containing minimal quantities of coarse sand. Strong bottom current apparently prevent the accumulation of finer grained material on these shelves and also on the upper continental slope to about 500 m water depth.

In clear contrast, multicorer and gravity corer deployments in deeper waters were always successful and a number of high quality sediment series could be recovered for the various research interests. In total the working program comprised 20 station between about 25 and 31°N at the African continental margin, when R/V METEOR set course to Las Palmas ending the first part of Leg M 58/2.




R/V METEOR Cruise M 58/2 track and station chart. Black dots denote locations of sediment and/or water column sampling, red lines transit routes with *Parasound* and *Hydrosweep*.

During the short port call in Las Palmas on May 24 and 25 several scientists have been replaced and additional instrumentation, among others a 'Remotely Operated Vehicle' (ROV) and numerous equipment for sediment trap moorings, was taken on board. In the first working area (B1) of the second part of Leg M 58/2 a transect from the deep sea to the shelf off Dahkla comprised 6 stations (GeoB 8622 to 8627). After *Parasound* and *Hydrosweep* surveys, the multicorer and gravity corer and also the multinet and rosette were most always successfully operated in water depths from about 4000 to 900 m. The sediment sequences recovered specifically appealed to the geochemists and geophysicists as they showed more and more distinct effects of diagenetic processes on approaching the continent and the centers of elevated marine productivity. Soon a wealth of diagnostic data was available for a preliminary yet detailed characterization of the regional sedimentation and alteration regime.

Highlight during the second half of this week was the recovery and redeployment of the sediment trap moorings CB13 / CB14 some 200 nm west of Cape Blanc (Mauritania). This mesotrophic station at around 21°N / 21°W is operational since 1988. Its long-term observations particularly aim at documenting a possible influence of the large-scale climate variability in the North Atlantic on the NW African upwelling systems. CB13 had been installed more than a year ago by R/V METEOR. It was now retrieved with both the upper and lower traps, positioned in 1200 and 3600 m water depth, respectively, carrying complete series of the last 12 months' particle sedimentation which, compared to recent years, has been rather low and less seasonally controlled. CB14 subsequently deployed at the same position will be retrieved next spring. The standard sampling scheme of the water column with the multinet and rosette was supplemented at the CB station (GeoB 8628) by a first deployment of the *in situ* pumps for chemical analyses of trace elements and a detailed vertical profile of the particle camera to 3000 m water depth.

The scientific activities of the cruise were completed with a tight schedule at 10 stations in the Cape Blanc region (GeoB 8629 to 8639, working area B2). Of central importance was locality GeoB 8633 in direct vicinity of the former Ocean Drilling Program Site 658 (Leg 108, 1986). Including an echographic pre-site survey, it took more than one and a half days there to successively put all the different devices to use. The multicorer recovered a complete tube series of surface sediments, the gravity corer a more than 15 m long sediment sequence and the multinet, rosette and *in situ* pumps plenty of material from the water column. Finally, also the particle camera and ROV *Cherokee* were successfully deployed. With all these data and material the eutrophic environment shall be perfectly defined for the new sediment trap mooring CBi1 in around 2700 m water depth that will monitor the marine productivity in the upwelling system off Mauritania as well as the influx of terrigenous material transported by the NE trade winds from Africa during the next 12 mouths.

Vertical profiling in the water column with the particle camera and the ROV was the main work at several other stations, mostly in shallower water on the upper continental slope. Prime objectives of the optical measurements, selective sampling and subsequent analysis of the sinking and suspended material were to improve the at present still inadequate understood formation of aggregates and their vertical and lateral transport in the ocean. Information about the settling velocities of individual particle clouds was obtained with repeated deployments of both devices at different stations. For a quantitative balancing of the particle fluxes and an advanced insight of their steering processes the data sets collected will be interpreted together with sediment trap records and satellite images of the pigment concentration in the surface waters. During the final days at sea, the trade winds considerably intensified again to the extent that a secure operation of the ROV was no more possible and further planned operations had to be canceled.

R/V METEOR safely returned to Las Palmas in the morning of Sunday June 8, 2003 completing Leg 2 of Cruise M 58. The scientific party gratefully acknowledges the friendly and most effective cooperation with Captain Papenhagen, his officers and crew. Their as always perfect technical assistance substantially contributed to make this cruise a scientific success. We also appreciate the valuable support by the Leitstelle METEOR at the University of Hamburg. The work was funded by the Deutsche Forschungsgemeinschaft.