

**SHORT CRUISE REPORT**  
RV METEOR Cruise M 74/4

**Dates:** 30.11.2007 – 22.12.2007  
**Port calls:** Malé – Port Louis  
**Chief scientist:** Prof. Christian Betzler

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## **Objectives:**

The Maldives archipelago is among the world's largest carbonate platforms. It formed during the Cenozoic in a regime of high-amplitude sea-level fluctuations and global climate cooling, as well as palaeo-oceanographic change. The aim of METEOR cruise 74/4 was to unravel the record of these changes in order to investigate the response of the platform to such processes. The better knowledge of these tropical carbonates will not only provide new data about the climate and palaeo-oceanographic evolution of the tropics, but also new models for the seismic stratigraphy of such bodies and sedimentological models for carbonate platform slope deposits. The project will also provide new data for the controversial discussion about the process of carbonate platform drowning and its controlling mechanisms, because on the Maldives, reef atolls and drowned atolls coexist. The research performed during the cruise encompasses seismic and hydroacoustic profiling as well as direct sampling of the sea floor.

## **Cruise narrative:**

RV METEOR sailed from Malé harbor (Maldives) at 10 a.m. local time on Friday, November 30, after 3 days in port for exchange of scientific devices, scientists and crew members. There was no transit time to the first research area, because Malé is situated within this area, and hydroacoustic surveying began immediately in the lagoon of Malé atoll. This provided some time for the seismic reflection team to finish the preparations of the seismic tools and the seismic lab, before setting out both, the short analogue and the long digital streamer, at 22.38 p.m. the same day. The first two days of the cruise were then dedicated to seismic and hydroacoustic surveys. The survey track was planned to achieve an overview of major structures in the entire working area and to cross the locations of the ODP drill site 916 and the ARI-1 well. The major finding of this survey is the occurrence of major periplatform drift wedges lining the Maldives atolls. Currents affect sediments down to water depth of 400 m in the channels separating the Inner Sea from the Indian Ocean, and triggering formation of large fields of submarine dunes.

In the early morning of the third of December, the long digital streamer was taken on deck, and at 8.17 am the METEOR entered Male atoll measuring a seismic profile in the lagoon with the short streamer. The end of the profile was reached after crossing the track of a former seismic section measured by Shell during the 1980s. After taking out the short streamer of the water, the METEOR sailed back into the Inner Sea to begin sedimentological sampling with a grab sampler, a box corer, and a piston corer. The first piston core retrieved has a length of 10 m with a complete recovery. Sediment sampled is a relatively coarse-grained greenish periplatform ooze without any lithified intervals. Thus it was decided to extend the coring device to 15 m for further coring locations. During the first days of the cruise, tests of the navigational devices were performed, and the fourth of December, the METEOR approached Male harbor to allow technicians to disembark, and for minor administrative work related to the travel permits for the Maldives archipelago.

Scientific operations were resumed after a very short break of a few hours only and an intense coring and grab sampling operation was performed until December 7, when a multibeam survey of a field of giant pockmarks in the Inner Sea was initiated. These pockmarks were discovered during the first geophysical surveys of the cruise

and the goal of the survey was to produce a high-resolution map of the sea floor over a area of more than 400 km<sup>2</sup>. This map shows that pockmarks have a diameter of up to 1500 m and a depth of up to 180 m. The survey data indicate that several generations of pockmarks occur, and that there are several states of preservation. Some of these bodies have flat bottoms and relatively steep walls, whereas some pockmark floors are covered by slumps. High frequency hydroacoustic data suggest that the pockmarks are presently not active. Many of the pockmarks correlate vertically with faults and pinnacles previously interpreted as patch reefs of late-Oligocene / early-Miocene age. A part of the pockmarks are grouped along the strike of deep routed faults in the volcanic basement. Some pockmarks reveal underlying bright spots. Most of the bright spots can be correlated with one particular sedimentary sequence. Other pockmarks are underlain by high amplitude reflection packages interpreted as diagenetic fronts or gas-filled porous carbonates. Bright spots and high amplitude reflection packages are more abundant in the central axis of the Inner Sea and above the eastern flank of an N-S striking graben within the volcanic basement, where the oldest syn-rift sediments are present. The bases of the pockmarks correlate with particular sequences which suggest that the pockmark activity, i.e. fluid escape, occurred in distinct phases. The data give strong evidence that the seismic signatures of the (biogenic) carbonate deposits are partly overprinted by diagenetic processes and the migration of fluids or volatiles.

On December 9, at 10.49 am, the METEOR entered Ari Atoll from the north with both streamers deployed to measure a seismic profile through this shallow-water part of the platform. The ship followed a carefully planned track in between the smaller atolls of the lagoon, and at 1.35 pm, the ship leaved the shallow waters bound east. The parasound profiles within the Ari atoll showed a very thin to absent sediment cover, and therefore we decided to cancel a planned sampling and coring program in this area.

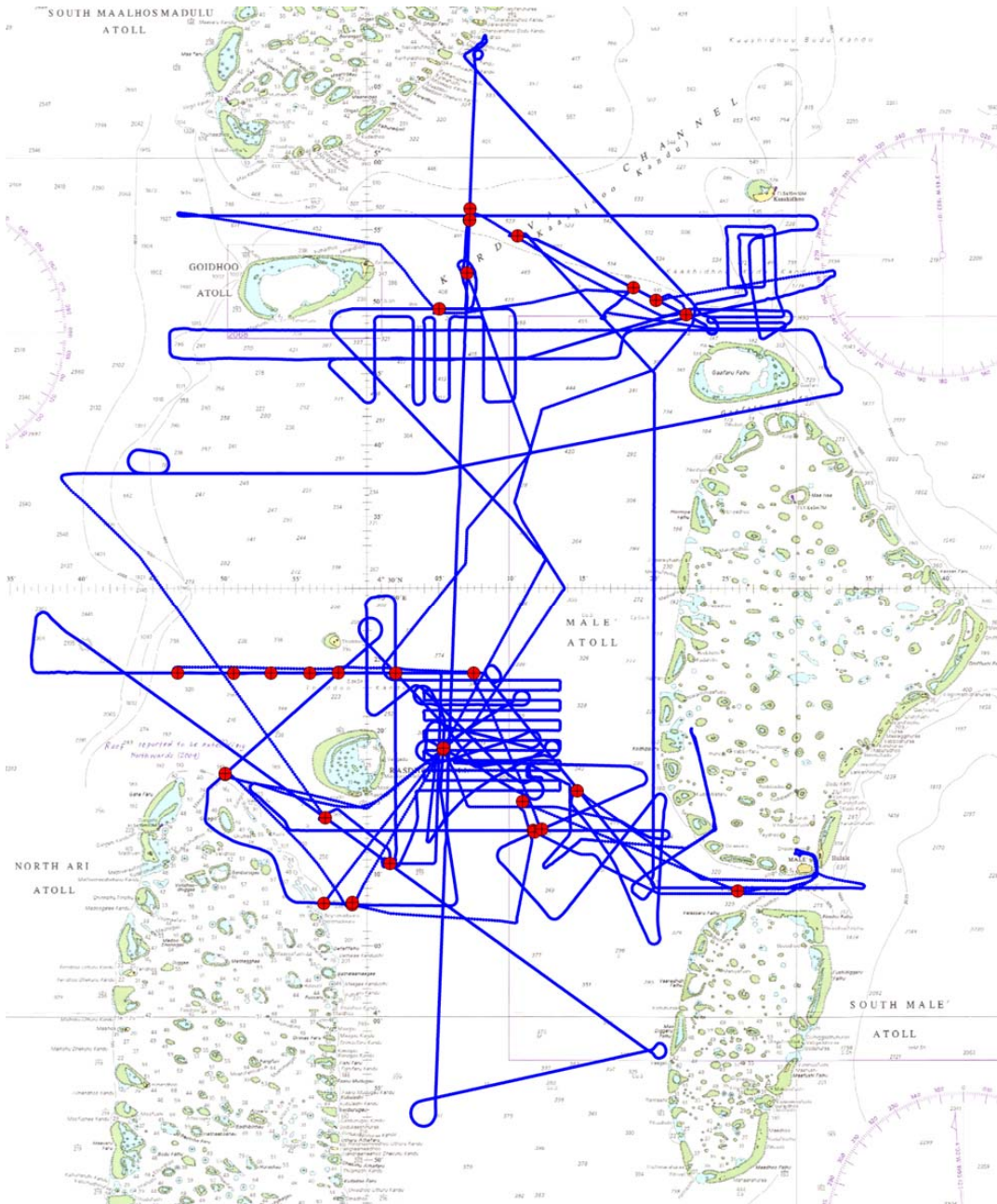
One of the objectives of the cruise M 74/4 was to produce a site survey data set for an IODP proposal. The goal of IODP drilling in the Maldives carbonate platform is to address unanswered, challenging, and essential questions on the timing and amplitude of the Oligocene and Neogene eustatic sea-level fluctuations, and to complement the results of past and ongoing research programs on sea-level changes. On December 11, a dedicated seismic survey was performed, with a grid of seismic lines covering the area of the previously defined potential drilling locations. The survey later was extended to image west – east running transects through the northern part of the working area. The seismic data measured have an excellent quality and will not only support the IODP proposal, but also allow deciphering of the younger geological history of the Maldives carbonate platform in great detail. The data allow subdividing the evolution of the carbonate platform into a series of steps, marking phase of expansion and retraction of the areas of shallow water carbonate formation. At a certain time of the younger episodes of platform growth, occurrence of submarine dunes mark the onset of bottom current intensification. An exact age assignment of this process will be performed during future research, after the processing of the seismic data and a correlation to existing well data.

To measure the directions and the strength of the recent currents affecting the Inner Sea, continuous measurements with the shipboard vertical profiling ACDP (Acoustic Current Doppler Profiler) were performed during the cruise. Currents are strongest along the flanks of the atolls and in the deep Inner Sea, where a northward flow was

measured. The surface water flow in the Inner Sea is directed towards the south. In the channel separating north from South Malé atoll, the current flows out of the Inner Sea. Average current velocities are 10 cm/s.

In total, 13 piston cores ranging in length between 10 and 15 m, 1 gravity core, 10 box cores and 19 grab samples were acquired in the northern Inner Sea of the Maldives. The research area is bounded in the East by North Male and Gaafaru Falu Atoll and on the west side by North Ari, Rasdhoo, Goidhoo Atoll, and Fuad Bank. Five subareas were identified: (1) southwest slope of North Male Atoll, (2) northeast slope of Ari and Rashdoo atolls, (3) eastern slope of Goidhoo, (4) northwest of Gaafaru Falu atoll, and (5) pockmark areas east of Rasdhoo atoll. The cores were already all described during the transit from the Maldives to Mauritius and scanned for downcore colour and lightness variations. A preliminary stratigraphy based on a tentative correlation of lightness downcore variations and published benthic oxygen isotope stack was developed. The highest sedimentation rates were observed on the slope of North Male Atoll, 5.5 to 6 cm/ky. Intermediate rates were found on the northeast slope of North Ari atoll with 3.0 to 3.5 cm/ky. Lowest rates were observed in the core north of Gaafaru Falu atoll with 1.5 cm/ky. In the core northwest of Gaafaru Falu low sedimentation rates can be explained by its location on the toe a well developed sand drift. Sediments contain pelagic and benthic components as well as shallow water derived grains. Finest sediments were found in between the North Male Atoll and the North Ari atoll. Grab samples and the cores showed a coarsening of the sediments within areas with strong current activity like between Rashdoo and North Ari atolls as well as Thoddoo Channel. The muddiest sediments encountered in box cores and cores were recovered from the pockmarks, where the tsunamite of the 2004 Indian Ocean tsunami was found. Further onshore sedimentological analyzes are aimed to resolve such aspects as the reconstruction of the latest sea-level changes which affected the evolution of the Maldives carbonate platform, or to unravel the youngest climatic history. Sedimentological research will also allow to document if there were changes in the strength of bottom currents affecting the formation of the drift wedges.

The station work of the cruise M 74/4 ended on December 14 at 9.03 am and the transit to Port Louis in Mauritius began, where the ship arrived after a very successful cruise on December 21 in the late afternoon. Transit time was intensely used by the different working group for a first data assessment and to conclude all preliminary sedimentological descriptions.



Trackline of the R/V Meteor in the Maldives archipelago during cruise M 74/4 with locations of sedimentological samples.