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The Maldives, a giant isolated carbonate platform dominated by bottom currents

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ABSTRACT

The Maldives, a 900 km north-south trending paired chain of atolls that surround a ca. 100 km wide central basin (the Inner Sea) represent a giant isolated carbonate platform in the Indian Ocean. New reflection seismic, multibeam and acoustic Doppler current profiler data show that its development exhibits a distinct change from sea-level to mainly bottom current-controlled sedimentation at the end of the Middle Miocene. The post-Middle Miocene intra-basinal fill consists of 9 mega units that have been formed and shaped by strong bottom currents, entering the Inner Sea between the inter-atoll passages.

At the end of the Middle Miocene the Maldives represent a rimmed platform with the Inner Sea forming an empty bucket. A connection to the Indian Ocean existed only in the northeastern part of the platform, namely the Kardiva Channel. Probably concomitant with the onset of the Indian Monsoon, the current pattern around the Maldives changed significantly resulting in the formation of channels in the rimmed platform margin. The latter process was encouraged by local drowning of large platform parts and additionally, by bottom current forced submarine erosion that widened the channels to passages disintegrating the platform into separated atolls of different sizes. The reworked material was dumped into the Inner Sea where it formed large contourite fans. Along-slope bottom currents entering the Inner Sea from the north further redistributed the material leading to a southward shift of these sedimentary bodies. In this way the Inner Sea was filled from west to east (mega units 1–5). Starting with mega unit 6 the opening of a southern gateway introduced a prominent northward flow of bottom waters in the Inner Sea. It leads to the deposition of giant elongated drifts at the eastern flank of the basin, filling it from east to west. Because the current swept away most of the material around the atolls, the system was not able to prograde and the steady subsidence was compensated by aggradation. Accordingly, a fundamental characteristic of a current-controlled carbonate system is that aggradation occurs irrespective of platform sediment export or differently worded the rate of change in accommodation is always positive and greater than the rate of sediment supply.

ADCP measurements in the winter monsoon season show two water masses in the Inner Sea, one at the surface 0–150 m and a second below it that reaches its sea-floor. By the use of the grain size distribution of ODP leg 716 located in the Inner Sea as proxy for the flow intensity of the bottom water, we recognized an inverse proportional relationship to the monsoon strength from late Upper Miocene to present.

Some of the current-controlled deposits form sigmoidal prograding clinoforms, preferably at the edges of the atolls adjacent to the passages, where the velocity of the current entering the Inner Sea is high. The anatomy of these prograding wedges is similar to sea-level controlled clinoforms described for large isolated carbonate platforms in the sequence stratigraphic concept; however our results document, that they are not influenced by sea-level fluctuations. Because of the high current velocities involved in their deposition, they predominately consist of coarse sand sized carbonate fragments exhibiting large pore space and high permeability. Therefore these drift deposits comprise a possible exploration target.

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1. Introduction

The Maldives are a large N–S elongated isolated carbonate platform southwest of the southern tip of India. It consists of a double row of atolls extending from the Kolumadulu Atoll in the South to the Miladummadulu Atoll in the North (Fig. 1). The Maldives grow on a ca. 900 km long and 100–125 km wide submarine ridge and enclose a basin, the Inner Sea, which is 300–350 m deep in the South and deepens in the North to 700 m (Kardiva Channel, Fig. 1). The external slopes of the entire platform are very steep, rapidly reaching bathyal and abyssal depths of the Indian Ocean. The Maldives can be classified as T carbonate factory after Schlager (2005).

The geological evolution of the Maldives was intensively studied by Backman et al. (1988), Aubert and Droxler (1992, 1996), Purdy and Bertram (1993) and Belopolsky and Droxler (2003, 2004a,b) based on lower resolution commercial seismic data and industrial wells NMA-1 and ARI-1 from Elf Aquitaine and Shell as well as on ODP Site 716 (Fig. 1). In the framework of the NEOMA (*Neo*gene of the *Ma*ldives) project the Maldives were revisited to study the Neogene evolution of the Maldives by the means of high-resolution reflection seismic profiling, multibeam, acoustic Doppler profiler (ADCP) data and core samples. The cruise was conducted at the beginning of the winter monsoon season in December 2007. Especially the obtained seismic data provided new insight in the Miocene to present development of the carbonate platform. The latter time interval was sparsely studied by the former investigators, mainly because of the lack of adequate high-resolution seismic data. The seismic facies and architecture of the deposits flanking the internal margin of the neritic platform document a significant current control of the entire depo-system that is well-known for many siliciclastic continental margin settings but not reported so far for carbonate depositional settings.

2. General setting and background

2.1. Geology and tectonics

The base of the Maldives is a 55–57 Myrs old volcanic ridge. Its centre comprises a fault-controlled en echelon graben system. Many of the faults terminate slightly above or on top of the volcanics, only a few reach Oligocene to lower Miocene strata (Purdy and Bertram, 1993; Aubert and Droxler, 1996). Generally, they are characterized by small displacements with little evidence of fault

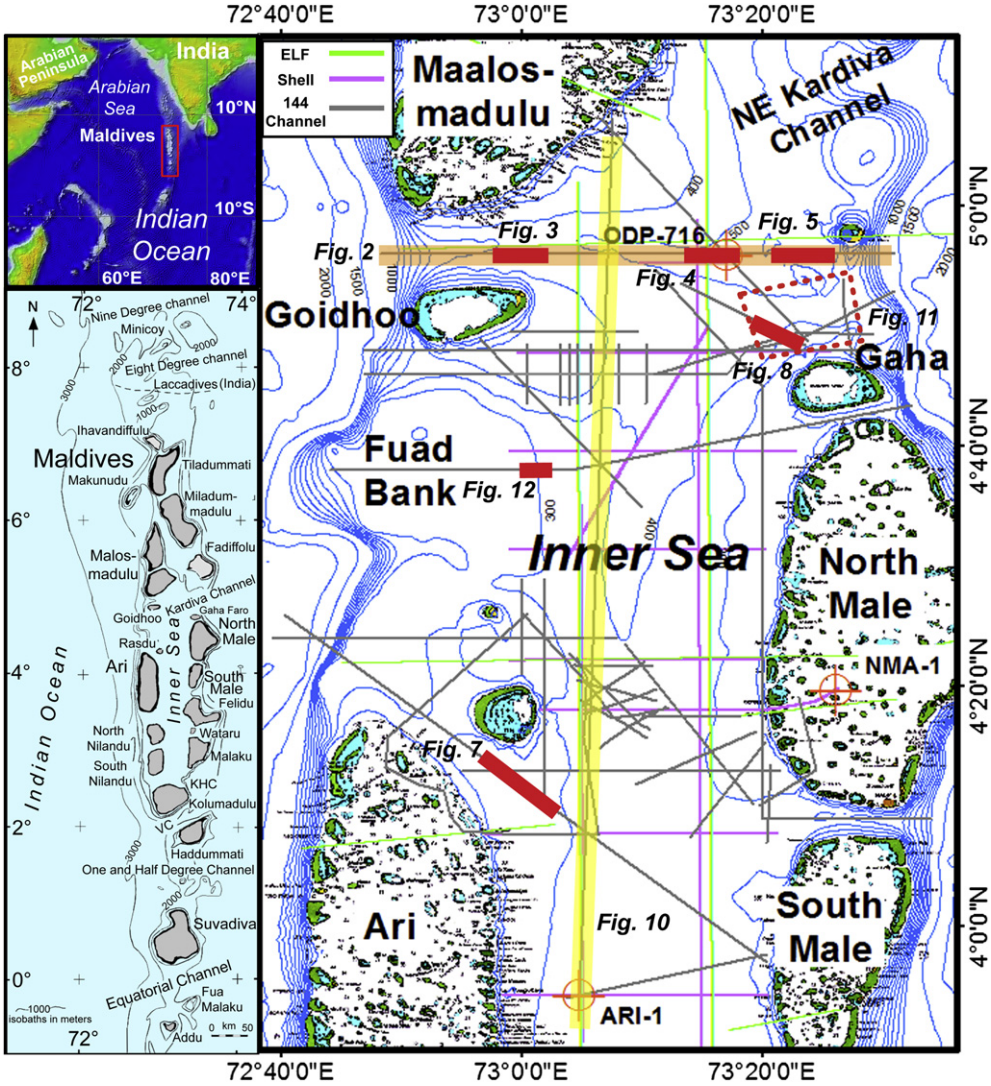

Figure 1. Map of the study area in the northern part of the Maldives. Indicated are the example profiles and the ODP well 716 as well as the commercial wells ARI-1 and NMA-1. Insets show the geographical setting and the names of atolls and major channels. VC = Veimandu Channel; KHC = KudaHuvadu Channel.