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Carbonate delta drift: A new sediment drift type

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ABSTRACT

Based on high-resolution reflection seismic and core data from IODP Expedition 359 we present a new channel-related drift type attached to a carbonate platform slope, which we termed delta drift. Like a river delta, it is comprised of several stacked lobes and connected to a point source. The delta drifts were deposited at the exit of two gateways that connect the Inner Sea of the Maldives carbonate platform with the open ocean. The channels served as conduits focusing and accelerating the water flow; Entrained material was deposited at their mouth where the flows relaxed. The lobe-shaped calcareous sediment drifts must have formed under persistent water through flow. Sediment supply was relatively high and continuous, resulting in an average sedimentation rate of 17 cm ka^{-1}. The two delta drifts occupy 342 and 384 km^2, respectively; with a depositional relief of

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approximately 500 m. They have a sigmoidal clinoform reflection pattern with a particular convex upward bending of the foresets. In the Maldives the drift onset marks the transition from a sea-level controlled to a progressively current dominated depositional regime. This major event occurred in the Serravallian about 13 Ma ago, leading to the partial drowning of the carbonate platform and the creation of shallow seaways. The initial bank-enclosed topography resembles an "empty bucket" geometry which is rapidly filled by the drift sediments that aggrade and prograde into the basin. Thereby the depositional environment of the delta drifts changes from deep water (> 500) to shallow-water conditions at their topsets, indicated by the overall coarsening upward trend in grain size and the presence of shallow water large benthic foraminifers at their top.

1. Introduction

Current-controlled carbonate deposits have so far not been systematically investigated in contrast to their intensively studied siliciclastic counterparts (Faugères et al., 1999; Stow et al., 2002b; Viana and Rebesco, 2007; Rebesco and Camerlenghi, 2008; Rebesco et al., 2014). Several studies, however, document their importance, especially in tropical carbonate platforms (Anselmetti et al., 2000; Betzler et al., 2009, 2013, 2014; Isern et al., 2004; Eberli et al., 2010; Lüdmann et al., 2012, 2013). For the Maldives, Lüdmann et al. (2013) demonstrated that since the Middle Miocene carbonate sedimentation in the Inner Sea was dominated by ocean currents entering the archipelago interior via gateways between the atolls. This situation resulted in the deposition of 10 mega-drift sequences. This is in contrast to the standard sequence stratigraphic model that describes carbonate platform geometry and depositional setting as a response to relative sea-level changes (Schlager, 2005 and references therein). Recent studies show that sea-level-controlled highstand shedding plays an essential role in sediment supply; However, currents could be the main agent transporting carbonate debris from the platform top and distributing it to the surrounding margins (Betzler et al., 2013, 2014, 2015; Lüdmann et al., 2013).

The Maldives, a large N-S elongated isolated carbonate platform southwest of the southern tip of India, are situated on an approximately 900 km long and 100 to 125 km wide submarine ridge consisting of a double row of atolls enclosing a deep basin, the Inner Sea (Fig. 1). It can be considered as a type locality for calcareous drift deposits. Here, in the deep water realm of the Inner Sea giant elongated drift bodies formed with geometric and seismic characteristics comparable to their siliciclastic counter parts with a typical mounded geometry and an associated moat (Lüdmann et al., 2013). Based on geometries depicted in reflection seismic profiles, we identified a new calcareous drift type at the mouth of the gateways. These drifts have a lobe-shaped external geometry with a clinoformal, prograding internal reflection configuration. We named the new sediment drifts delta drifts because they have much in common with river or tidal deltas. In 2015, during IODP Expedition 359 two platform-to-basin transects were drilled north and south of Goidhoo Atoll as well as in the Inner Sea (Betzler et al., 2016a, 2017, 2018). The cores and well logs through the delta drift deposits provide the sedimentological and stratigraphic data for the comprehensive analysis of the new drift type that is presented here (Fig. 1). This research presents new diagnostic criteria that allow the classification of carbonate sediment drifts and provide the base for further detailed studies of its sedimentological characteristics and facies associations. Results from this research will also potentially provide depositional models that could lead to a re-evaluation of carbonate deposits elsewhere and in the geological record that meet the new diagnostic criteria.

2. Geological background

The Maldives carbonate platform rests on a 55–57 Myrs old volcanic ridge. The Inner Sea basin, which is 300 to 350 m deep on average, is underlain by a fault-controlled en-echelon graben system (Purdy and Bertram, 1993; Aubert and Droxler, 1996) (Fig. 1). Reconstruction of the long term evolution of the Maldives was based on seismic data and industrial wells NMA-1 and ARI-1 from Elf Aquitaine and Shell as well as scientific drillholes of ODP leg 115 (Backman et al., 1988; Aubert and Droxler, 1992, 1996; Purdy and Bertram, 1993; Belopolsky and Droxler, 2003, 2004), and on the M74/4 cruise data (Betzler et al.,

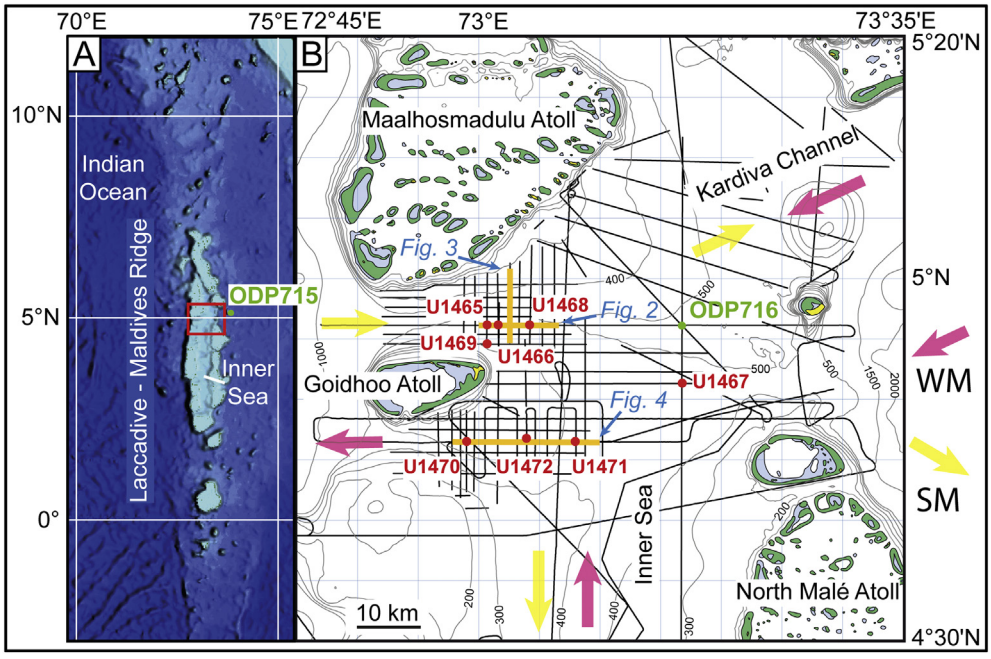

Fig. 1. A) Map of the study area (red box) in the northern part of the Maldives. B) Distribution of seismic lines (black lines) and the location of IODP Expedition 359 Sites as well as ODP Site 716 and 715. Indicated is the general present bottom current pattern below a water depth of about 200 m (compiled after Lüdmann et al., 2013). Example seismic profiles are marked in orange. Present reefs are color-coded (yellow: island; blue: reef; green: 10–100 fathoms). WM: winter monsoon; SW: summer monsoon. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)