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Origin and architecture of a Mass Transport Complex on the northwest slope of Little Bahama Bank (Bahamas): Relations between off-bank transport, bottom current sedimentation and submarine landslides

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ABSTRACT

The analysis of the sedimentary dynamics of the carbonate slope of the northwest part of Little Bahama Bank (LBB, Bahamas) reveals a complex interaction between slope destabilisations, off-bank sediment export and longitudinal transport, the latter being driven by the Antilles and the Florida currents, at the northern end of the Florida Strait. Their combined action since the middle Miocene resulted in an extensional growth slope, previously called 'LBB Drift' (Mullins et al., 1980). Deposition within this extensional growth slope is dominated by either platform-derived downslope sedimentation or bottom current sedimentation. The latter induces the formation of a plastered drift, showing both upslope and downslope migrations, which do not correspond to the 'LBB Drift' as described by Mullins et al. (1980). Interestingly, a large submarine landslide affects the upper part of this plastered drift, and displays a complex and striking geomorphology on the seafloor. A new high-quality multibeam echosounder and seismic dataset allowed a detailed characterisation of the architecture of this Mass Transport Complex (MTC). A 44 km-long circular incision at 275 m and 460 m water depths, with a steep external edge (from 40 to 70 m high), forms the only present day evidence of this ancient MTC. It comprises confined Mass Transport Deposits (MTDs), which are delimited by frontal and lateral edges that developed inside the plastered drift. The top of this plastered drift is marked by a major erosional surface, most likely induced by an increase in oceanic current circulation. Channelised geometries, laterally associated with overspill deposits, developed within the depression induced by the MTC, and are an additional evidence of bottom current activity in this area. In addition, recent pockmarks are visible on the seafloor in front of the circular scarp of the MTC and probably relate to fluid escape, originating from the underlying MTDs' compressional area.

All these features seen on the northwest slope of LBB bring new understanding on MTC sedimentary processes and associated morphologies in carbonate slope settings. Furthermore, this study highlights the interplay between off-bank transport, oceanic circulation and mass flow processes, which are seen as key processes in the shaping of Bahamian slopes and in their sedimentary dynamics.

1. Introduction

During the last decades, both academic and industrial studies of turbidite systems have been mostly focused on siliciclastic systems, neglecting carbonate gravity systems as they are often considered to have a poor reservoir and hydrocarbon potential. Carbonate turbidite systems differ from the frequent point-source siliciclastic systems because of their linear sediment input source, which predominantly depends on the carbonate production on the platform, whereas siliciclastic systems are usually controlled by continental relief erosion and river discharge (Mullins and Cook, 1986; Mullins et al., 1984). Hitherto, several studies on ancient systems (*e.g.* Betzler et al., 1999; Borgomano, 2000; Eberli et al., 1997; Janson et al., 2011; Phelps and Kerans, 2007; Playton et al., 2010; Savary and Ferry, 2004; Vecsei and Sanders, 1997) revealed some general features of resedimentation systems on carbonate slopes. However, detailed morphologies, architecture, sedimentary processes and controlling parameters of resedimented carbonates remain poorly documented and understood. Improving our knowledge of these systems implies the study of modern carbonate slopes, such as the Bahamian slopes. This present-day analog offers the opportunity to characterise sedimentation processes across a continuous platform to basin transect during the Quaternary. In addition, the Bahamas are one of the best-studied modern carbonate systems (Bergman et al., 2010) and hence provide a solid framework regarding their overall geological setting and knowledge on sedimentation processes.

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Bahamian slope environments are influenced by three major controlling factors: (1) sediment transport from the platform which is directly related to carbonate production. Deep sediments of the Bahamas show a mixture of pelagic and platform-derived materiel called 'periplatform ooze' (Schlager and James, 1978). The input of platform-derived material is thought to be higher during highstands in sea level, because the carbonate production is more prolific when the platform top is flooded (*i.e.*, 'highstand shedding', Droxler and Schlager, 1985; Schlager et al., 1994); (2) bottom currents form several contourite drifts along the Strait of Florida (Anselmetti et al., 2000; Mullins et al., 1980, 1987). These sedimentary bodies are associated with channels (called 'moats') and small-scale contourite-related sedimentary structures, such as sediment waves (Bergman, 2005); and (3) mechanical destabilisation of the slope is at the origin of numerous slides and bypass structures, such as gullies or canyons (Crevello and Schlager, 1980; Ginsburg et al., 1991; Mullins et al., 1984; Wilson and Roberts, 1995). These common sediment failures, expressed at different spatial and time scales along the deep sea Bahamian slopes, are associated with the overall prograding/aggrading trend of the Bahamian slopes since the Cenozoic (Eberli and Ginsburg, 1989; Harwood and Towers, 1988).

The objective of this study is to characterise the Mass Transport Complex (MTC) located on the northwest end of Little Bahama Bank (LBB), between 275 m and 460 m water depths, *c*. 10 km away from the top of the platform. At the present day, this MTC is partially buried and only a large head scarp 44 km long is visible on the sea bottom. However, its internal architecture, comprising several Mass Transport Deposits (MTDs), is revealed by the analysis of high resolution (HR) multichannel seismic lines. The latter provide details on the internal stratigraphy of an LBB extensional growth slope, which is built by both platform-derived downslope sedimentation and bottom current sedimentation since the Middle Miocene. The studied MTC is located in the upper part of a plastered drift and the infill of the associated depression seems to be influenced by bottom current circulation. In this paper, we provide a detailed characterisation of this MTC and discuss the potential linkages between off-bank transport, bottom current circulation and slope failures in the context of a leeward-carbonate slope.

2. Study area: general setting

The study area is located on the northern slope of LBB, at the northern extremity of the Bahamas (Fig. 1). LBB is the second largest isolated platform of the Bahamas (about 250 km long). It faces the Atlantic Ocean to the North, towards which it opens to the Blake Plateau. It is bordered to the east by the Blake Bahama Escarpment, to the west by the Strait of Florida and in the south by the NW and NE Providence Channel, which separates it from Great Bahama Bank (GBB) (Fig. 1).

2.1. Platform environment and platform margin

Along the windward open ocean margin of LBB, several Pleistocene eolianite islands (*i.e.* 'Cays') are associated with tidal delta oolitic shoals (Rankey and Reeder, 2011; Reeder and Rankey, 2008, 2009) (Fig. 2).

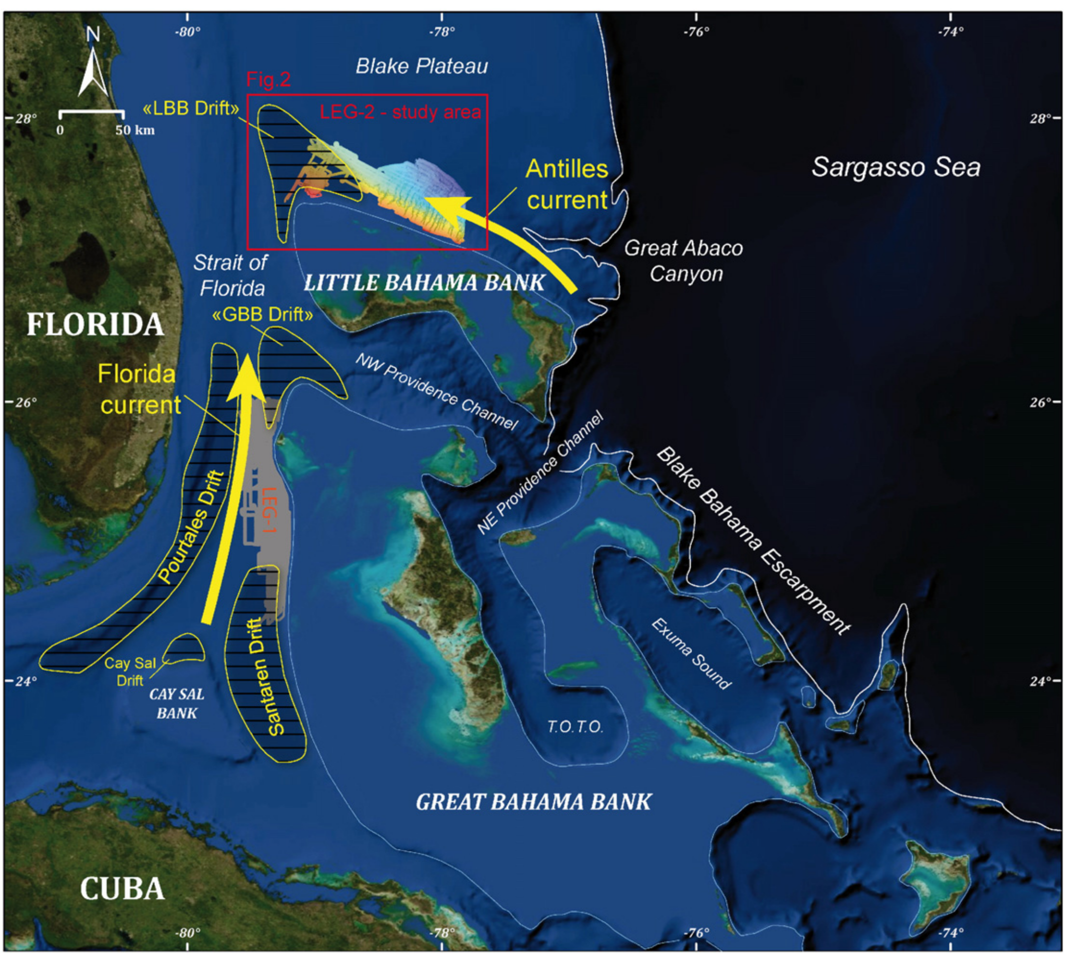

Fig. 1. Satellite image of the Bahamas, with locations of the Leg 2 (study area, Fig. 2) and Leg 1 of the Carambar cruise. The study area is influenced by two main oceanic currents, the Antilles Current, circulating along the northern slope of Little Bahamas Bank (LBB) and the Florida Current at the end of the Strait of Florida. Their combined action induces the onset of several contourite drifts.
Satellite image of the Bahamas is from © 2011 Microsoft Corporation and its data suppliers. The currents are redrawn from Mullins et al., (1980) and Bergman (2005).