Sedimentary Geology 317 (2015) 27–42

Contents lists available at ScienceDirect

Sedimentary Geology

journal homepage: www.elsevier.com/locate/sedgeo

Large-scale carbonate submarine mass-wasting along the northwestern slope of the Great Bahama Bank (Bahamas): Morphology, architecture, and mechanisms

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ARTICLE INFO

Article history:
Received 10 May 2014
Received in revised form 9 October 2014
Accepted 18 October 2014
Available online 28 October 2014

Keywords:
Carbonate submarine slope failure
Mass Transport Complex
Contourite drift
Great Bahama Bank
Seafloor morphology
Upper Cenozoic

ABSTRACT

Along the northwestern margin of the Great Bahama Bank (Bahamas), high-resolution multibeam bathymetry maps have revealed large escarpments, 80–100 m in height, and gigantic carbonate Mass Transport Complexes (MTCs), characterized by megablocks, several hundred to several thousand meters in size.

The present-day configuration of this mass-wasting deposit is the result of the specific basinal sedimentation of the GBB during the Neogene. Marginal sedimentation was produced by: (i) massive gravity-flow slope apron carbonates, feeding from the eastern prograding platform, including oversized MTCs; and (ii) thick, elongated, and muddier drift contourite flowing from south to north along the toe of slope. Four distinct MTCs (MTC-1 to -4) resulted from repeated slope failures in the Late Pliocene and the Pleistocene. These MTCs all glided along a common privileged décollement surface, dated Late Messinian–Early Pliocene, which coincided with a regional diagenetic key stratigraphic surface. The MTCs collapsed down from the steep mid- to upper-slope apron, partially draped the drift deposits, and flowed basinward over 10–20 km, extending over an area of approximately 400 km^2.

With the support of good-quality seismic reflection data, a detailed analysis was produced of the stratigraphic architecture of these MTCs, highlighting the high variability of the seismic facies from tabular bounded strata to chaotic patterns. The analysis of the facies demonstrated the internal stratigraphic complexity of the MTCs as well as that of the subsequent filling of the associated headwall scar-related depressions.

A depositional reconstitution of the MTCs is proposed from collapse initiation to final deposition, resulting in the present-day irregular seafloor morphology. The model accounts for the influence of the Early Pliocene drift-induced topography on the distribution and internal architecture of the successive MTCs. Most likely due to sedimentation rate increase, the contourite displayed lateral morphological variations, forming flat to mound-shaped features when upslope collapses occurred. Depending on lee-side steepness, it then acted either as secondary décollement ramp or as natural obstacle for mass-wasting deposits.

Strips of sharply-bounded chaotic facies preserved within the Pliocene contourite are interpreted as far-reaching fluid escape-related facies (thixotropy), resulting from frontal impact with the contourite at the toe of the MTCs. The MTCs are not unique mass-wasting carbonate deposits, as similar features with comparable dimensions have been reported in the geological record in the Bahamas and in other carbonate basins. However, they clearly illustrate a significant volume of sediment remobilization over short distances in carbonate slope environments.

1. Introduction

Recent technological improvements in submarine data acquisition and sub-surface mapping have revealed the broad diversity of mass-wasting morphological features on the seabeds of many continental margins (Mulder and Cochonat, 1996; Locat, 2001; Locat and Lee, 2002; Canals et al., 2004; Wilson et al., 2004; Gamberi et al., 2011). Many studies of carbonate slope architecture in both modern and ancient settings have demonstrated the common occurrence of such large-scale slope failures, which seem to play a significant role in the slope readjustment and morphological evolution of the carbonate platforms (Mullins et al., 1986, 1991; Mullins and Hine, 1989; Ross et al., 1994).

The frequency of slope failures, landslides, and gravity-flow deposits along the shelf edge and the slope is thought to be controlled either by internal or external factors, or both (e.g. tectonic to depositional slope oversteepening, seismicity, fabric and textural variation, tidal and wave water agitation, and sea level variations) (Hampton et al., 1996; Spence and Tucker, 1997). Upslope failure may trigger catastrophic gravity-flow transport and deposition along the slope to the toe of slope and basin, where it accumulates to form Mass Transport

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http://dx.doi.org/10.1016/j.sedgeo.2014.10.008
0037-0738/

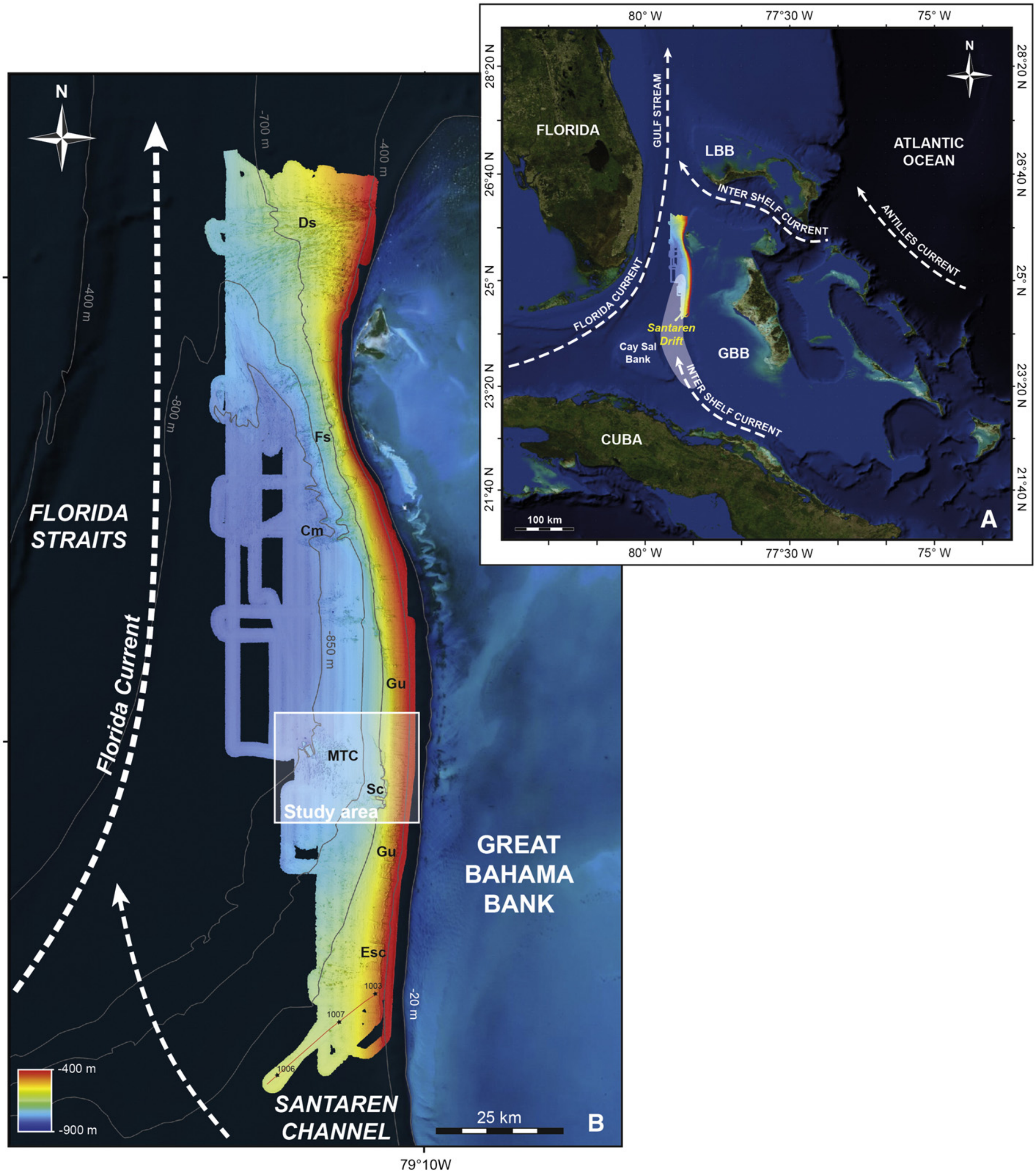

Fig. 1. A) Regional map showing the location of the study leg of the Carambar cruise, the trajectories of the main ocean currents (white dashed arrows) in the Bahamian Archipelago, and the location of the Santaren Drift along the northwestern slope of the Great Bahama Bank. B) Bathymetric map of the carbonate slope located to the northwest of GBB showing the principal morphological features: Ds: Downslope structures, Esc: Escarpment, Fs: Failure scars, Cn: Carbonate mounds, Gu: Gullies, SC: Scarp, MTC: Mass Transport Complex. The white box indicates the location of the study area. Note the southward location of the seismic section and Ocean Drilling Program Leg 166 drill sites 1003–1006 and 1007 (Eberli et al., 1997a) used in the stratigraphic and sedimentological correlations for this study.

Complexes (MTCs) which can have run-out distances of over 100 km in a short period of time (Bull et al., 2009).

Mass-wasting deposits from outcrops have been extensively studied, revealing the great variety of stratigraphic components and facies associations (Cook et al., 1972; Ferry and Flandrin, 1979; James, 1981; Johns et al., 1981; Floquet and Hennuy, 2001b; Savary, 2003; Savary and Ferry, 2004; Courjault, 2011; Courjault et al., 2011). Although some studies have used bathymetrical data and seismic reflection to document