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MASS TRANSPORT PROCESSES AND DEPOSITS, AND THEIR ROLE IN CONTINENTAL MARGIN DEVELOPMENT

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Project Summary

The goal of my research is to identify and document recognition criteria for mass transport complexes and their elements, to understand the factors that are involved in MTC initiation, duration, and termination, to assess the role they play in reservoir development, destruction and trap development, and to evaluate the potential anthropogenic implication of these catastrophic shelf edge processes. The study area, the eastern continental margin of Trinidad, is situated along the tectonically active oblique converging southeastern boundary of the Caribbean and South American plates and proximal to the Orinoco Delta. Factors that have contributed to gravitational instabilities in the shelf edge include high sedimentation accumulation rates, high frequency sea-level fluctuations during the Quaternary, frequent earthquakes, and the abundance of methane hydrate. This volatile mix of factors favor the formation of episodic gravity induced deposits that have affected thousands of square kilometers of the deep marine environment. Debris flows are the predominant type of gravity induced deposits in the area.

Nearly 10,000 square kilometers of three-dimensional seismic data covering the continental margin of the study area reveal multiple cycles of mass transport occurrence. Mapping of the shallowest units in the area has shown that individual gravity induced deposits can reach up to 250 meters (Fig 1) in thickness and occur over 100's of kilometer square areas. Maps that have been generated for the uppermost flow show significant basal scour, up to 33 meters deep generated during passage of the flow. Scours also show divergent patterns in map view indicating changes in the flow conditions. Flow scour erosional shadows around prominent seafloor mud volcanoes preserving evacuated strata on the downslope side of these obstructions. Internal architecture shows high amplitude discontinuous and chaotic seismic facies, and stacked thrust imbricates association with compressional bends in the flow path. The scale and occurrence frequency of these features suggest that they may form a significant threat to submarine installations and possibly generate tsunamigenic waves that can threaten shipping and coastal communities.

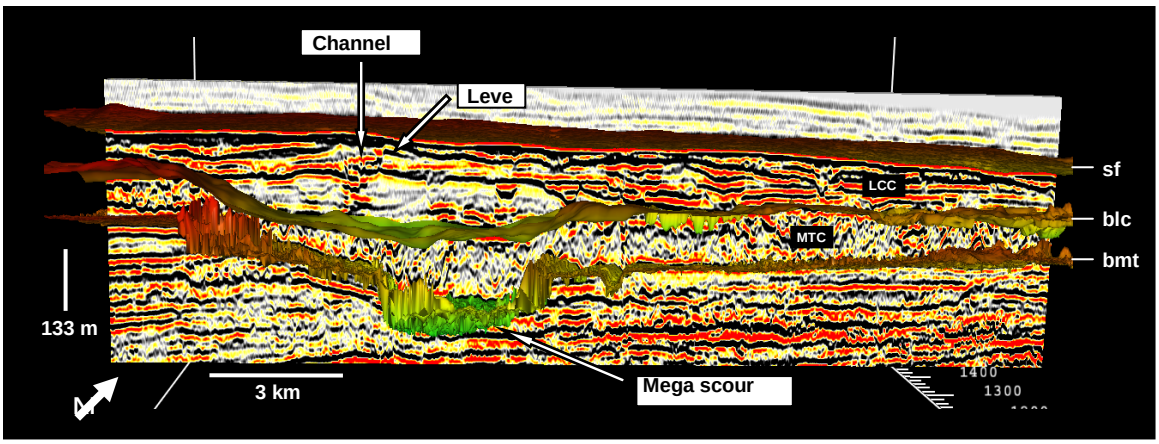

Fig 1 - 3D visualization of a northwest to southeast subvolume showing three main surfaces that define the shallowest depositional sequence in the deep-marine area of offshore Trinidad. MTC = mass-transport complex, LCC = levee-channel complex, bmt = base mass-transport complex, blc = base levee-channel complex, and sf = seafloor. Note differences in seismic character between MTC deposits, which are composed of chaotic, discontinuous, low-amplitude reflections and overlying LCC deposits, where high-amplitude and continuous reflectors are dominant.

Ongoing work will include (1) mapping and assessing older MTCs along the study margin, (2) the study of causal mechanisms associated to MTC formation and development, and (3) the recollection of MTC morphometric parameters (area, volume, thickness and length of the deposits) from different continental margins including the GOM, this information will be use to compare and contrast deposits in different stratigraphic and tectonic settings.

Motivation for the Study

Mass-transport complexes (MTC's) form a large stratigraphic component of many ancient and modern deep-water margins around the world. In some settings, up to 70% of the entire slope and deep-water stratigraphic column is composed of MTC's and associated deposits (Maslin *et al.*, 2004). The prevalence of these mass failure processes represents a significant threat to the security of continental slope and deep-marine engineered installations (Hoffman *et al.*, 2004; Pirmez *et al.*, 2004; Shipp *et al.*, 2004) and can have a significant impact on financial aspects of hydrocarbon exploration and development in deep-water locations. In addition, these processes pose a significant hazard to near-shore navigation and coastal communities. Along similar lines, recent interest in global warming has prompted a large number of climatologic researchers to consider the influence of catastrophic landslides in episodic release of methane into the atmosphere (Haq, 1993, 1995; Kvenvolden, 1993; Maslin *et al.*, 1998, 2004). Destabilization of pressure/temperature regimes by changing water temperatures, shifting ocean currents, or lowering sea level can cause melting of frozen clathrates and initiate failures along marine margins. Paleomarine landslides and mass failures can themselves cause disruption of the pressure/temperature conditions that maintain stable frozen methane in large portions of the world's continental margins, resulting in release of these gases (Maslin *et al.*, 2004). Ancient MTC deposits (slides, slumps and debris flows) also pose a problem for hydrocarbon exploration and development in deep-water facies. These units typically have low porosities and permeabilities (Shipp *et al.*, 2004), and their episodic and recurrent nature in many basins of the world means that they can form significant baffles and barriers to fluid flow deep-water facies stratigraphic sections.

The erosiveness of mass-movement processes can result in deep and widely dispersed truncation and removal of underlying primary target, levee-channel or sheet sand reservoirs. Because of anthropogenic impacts of engineering safety issues and growing exploration in setting typified by these types of deposits, there is a need for better understanding of the processes and nature of these complex units and the processes that cause them.

Relevance of the Study

The combination of conventional hydrocarbon resources and unconventional sources in the form of gas hydrates make the southeastern Caribbean region one of the premier exploration and development regions of the world (Wood, 2000; Wood, 2001). The high sediment accumulation and preservation allow a degree of stratigraphic resolution seen in few other basins in the world (Wood, 2000). Extensive data coverage and high data quality allow spatial and temporal resolution of the stratigraphy and structure where deep water basins less mature in their exploration history offer only fragments of the regional picture. This basin offers the opportunity to see truly source-to-sink systems on a temporal scale un-afforded in other settings. It is critical that we take advantage of this opportunity to impact our understanding of the nature of the deposits and processes that drive deep water basin development. Such understanding will have implications for deep water and shallow coastal margins around the world, including the deep water region of the GOM. In addition, this system allows us to examine the influence that depositional-dip parallel, transpressive tectonic structures and shallow mobile shales have on gravity deposited basin fills. This is in contrast to many other deep water gravity deposit settings around the world such as those in offshore Morocco and Brunei (McGilvery and Cook, 2003), and in the offshore region of the Niger Delta (Weber, 1987), where the deposits are impinging perpendicular to the structural grain. Finally, there are few margins characterized by thick and pervasive hydrates that contain as temporally detailed a stratigraphic record and the spatially pervasive data coverage to potentially resolve the interrelationship between margin failures and hydrate occurrence.

Results of this research will impact our understanding of:

1.- The role that sediment supply, sea level changes and tectonics play in deep-water basin development.

2.- The nature and morphology of deep marine reservoirs.

3.- Morphology, driving mechanisms and impact of catastrophic debris flows in deep water settings.

4.- The anthropogenic impact that mass transport deposits can play in margins around the world, including their incidence as a tsunamigenic risk factor for coastal communities as well as a geotechnical hazard for submarine installations such as pipelines and communication lines.

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