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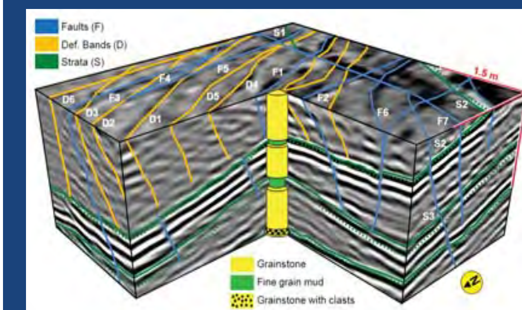


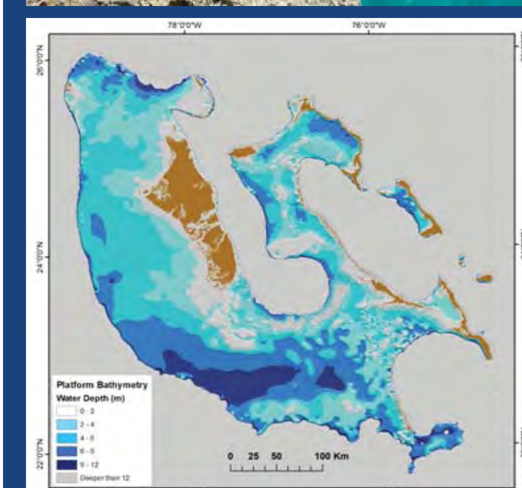


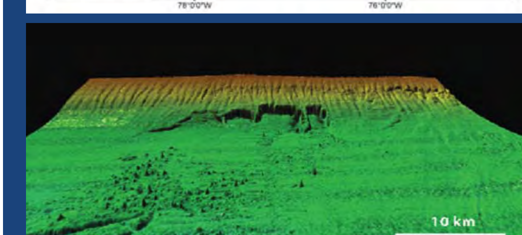


# Annual Review Meeting

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# GREAT BAHAMA BANK – EVALUATING WATER-DEPTH VARIATION AND MAPPING DEPOSITIONAL FACIES ON A "FLAT-TOPPED" ISOLATED CARBONATE PLATFORM

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## KEY FINDINGS

- New maps for bathymetric variation and facies distribution are created for Great Bahama Bank.
- The maps should facilitate better use of this isolated carbonate platform as an analog for both exploration- and reservoir-scale facies characterization.
- In addition, the maps highlight future research areas where "ground-truthing" is needed to further investigate facies patterns.

## SIGNIFICANCE

Great Bahama Bank (GBB) has long served as a frequently visited and well-studied example of a flat-topped, isolated carbonate platform. As such, GBB stands behind many of the models used to illustrate depositional facies variations which also serve as reservoir analogs. We have used Landsat ETM+ imagery and an extensive set of water depth measurements to critically evaluate the magnitude and patterns of bathymetry across GBB. We then integrated seafloor sample data to develop a depositional facies map that is more robust than previous versions.

## RESULTS

### *Bathymetric Map*

Figure 1, a map showing water-depth variation across GBB, was created from Landsat ETM+ imagery (a mosaic of 13 images) and an extensive set of water depth measurements (5,700 digitized soundings). Shorelines of islands were derived from the shortwave-infrared band 5 of the Landsat TM mosaic, as water is black and land is shades of gray. The edge of the platform was visually interpreted and digitized (with reference to soundings) as a 30 m contour from the blue light band 1 of the Landsat TM mosaic. The bathymetry depth model used the triangular irregular network (TIN) interpolation method to integrate the soundings, edge of platform contour, interpreted intermediate contours, and island shorelines. The TIN model was converted to a regular 150 m grid using the Interpolated Distance Weighting

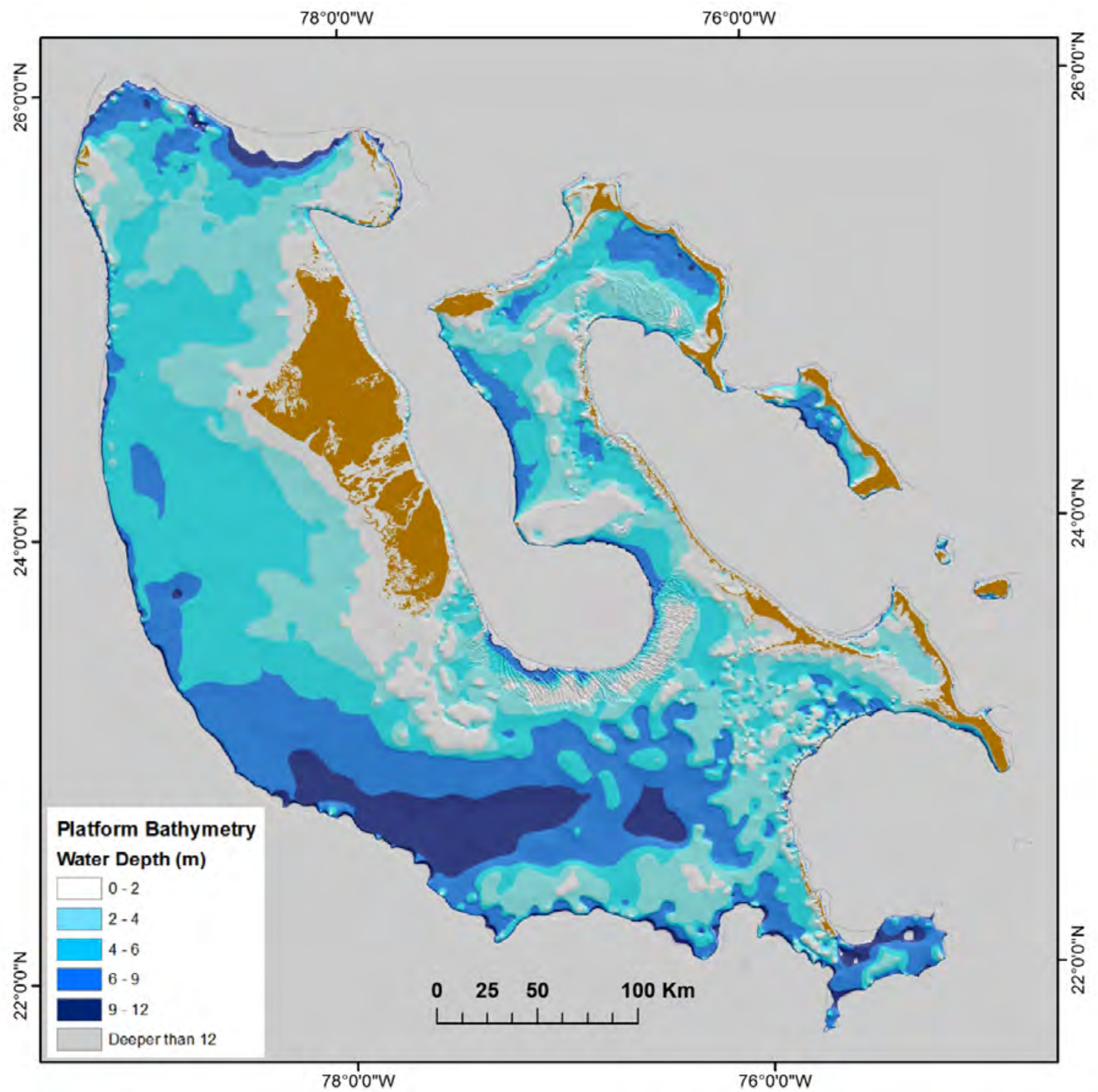


*Figure 1. Great Bahama Bank bathymetric digital elevation model based on soundings and Landsat imagery. Sources are a mosaic of 13 Landsat ETM+ scenes (Bands 1 and 5); 5,700 digitized soundings from Explorer Chart 1 "The Bahama Islands" with others @2010 Lewis Offshore Ltd.; and 191 soundings west of Andros Island from P. Swart, University of Miami – CSL. Steps taken to develop the map are described in the text.*

(IDW) method to facilitate visualization. The platform model supports 1:1,000,000-scale geologic interpretations and bathymetric profiling. The bathymetric map can be compared with those of Lee (2010) and Eberli (2013).

As defined by a 30 m water depth contour, GBB extends over 103,000 km$^2$. The maximum variation in depth-elevation over this vast platform extends from the 30 m contour to the highest Pleistocene eolianite ridge of 63 m on Cat Island, but as islands occupy only 8%, or 8,000 km$^2$, of GBB, we focus here on the bathymetric variation. 60%, or 61,400 $km^2$, of GBB lies in 5 m or less of water. This includes areas where accommodation space has been nearly filled by carbonate sand accumulations, e.g., Tongue of the Ocean, Schooners, Exumas, Joulters, and the Cat Cay sand complexes, but also includes vast portions of the northern portion of GBB surrounding Andros Island and the New Providence Platform to the west of the Exuma Islands. The 40% of GBB lying in greater than 5 m of water occurs mainly in an east-west trending portion of the southern platform.

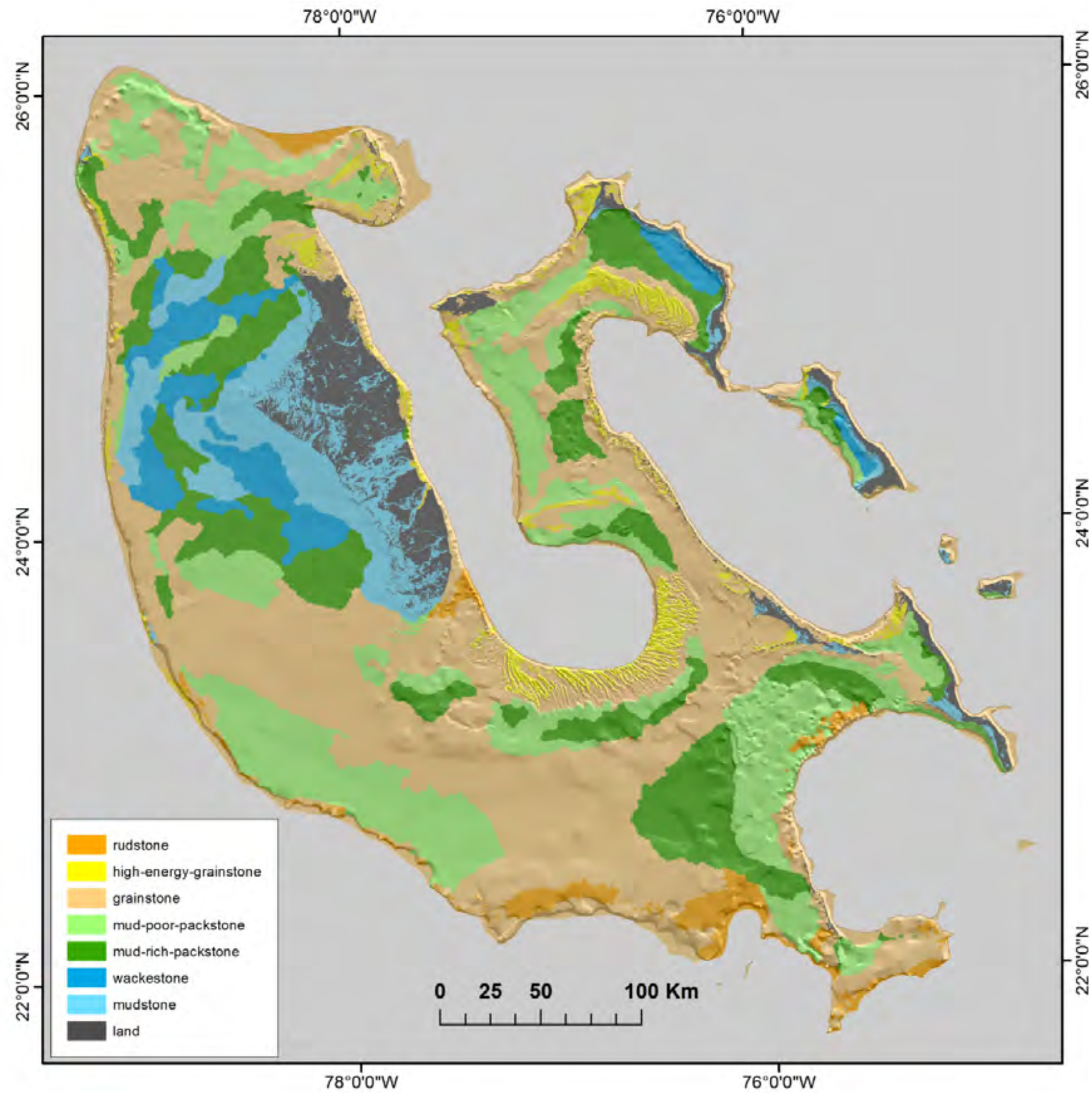


*Figure 2. Great Bahama Bank map of depositional facies based on seafloor sample data compiled into ArcGIS, integrated with the Landsat mosaic, and analyzed with eCognition. Sources are 13 Landsat ETM+ scenes (Bands 1 and 5); 275 GPS-constrained samples west of Andros Island described by Reijmer et al. (2009); and 21 GPS-located samples from immediately north and south of Andros Island collected by the National Coral Reef Institute. Steps taken to develop the map are described in the text.*

### *Depositional Facies Map*

Seafloor sample data was compiled into ArcGIS, integrated with the Landsat mosaic, and analyzed with eCognition to develop a depositional facies map (Figure 2) that is more robust than previous versions (Ginsburg et al., 1958; Newell et al., 1959; Purdy, 1963a, 1963b; Traverse and Ginsburg, 1966; Ball, 1967; Enos, 1974; Reijmer et al., 2009; Kaczmarek et al., 2010). For the portion of the GBB lying west of Andros Island, the facies map was generated by pairing an extensive set of GPS-constrained field observations and samples (n=275; Reijmer et al., 2009) with computer and manual interpretation of the Landsat imagery. Twenty-one samples collected by the National Coral Reef Institute immediately north and south of Andros provided additional control points for the mapping. For the remainder of the platform, where we lacked such rigorous ground-control, the Landsat imagery was segmented into lithotopes - interpreted to be distinct bodies of uniform sediment - using a combination of edge detection, spectral and textural analysis, and manual editing. A map was then developed by assigning lithotopes to facies classes on the basis of lessons derived from the portion of the platform for which we had rigorous conditioning.

Of particular importance is the detailed and generalized distributions of muddier lithologies (mudstones, wackestones, and mud-rich packstones) and grainier lithologies (mud-poor packstones, grainstones, and rudstones) shown by our mapping relative to that of previous maps. GBB is essentially a very grainy platform with muddier accumulations only in the lee of substantial island barriers; in this regard Andros Island, which is the largest island on GBB, exerts a direct control over the muddiest portion of GBB. Mudstones, wackestones, and mud-rich packstones cover 8%, 5%, and 14%, respectively, of the GBB platform top. By contrast, mud-poor packstones, grainstones, and rudstones account for 20%, 45%, and 3%, respectively. Of the 45% of the platform-top classified as grainstone, only 3% is composed of “high-energy” deposits characterized by the development of sandbar complexes.

## INTERPRETATION AND IMPLICATIONS

The bathymetric patterns shown in Figure 1 are important as a potential primary control over flooding history, filling (accommodation) history, and the resultant depositional facies patterns. Bathymetric profiles across GBB highlight the irregular filling of accommodation space and graphically emphasize the challenges that occur in correlating depositional cycles of variable thickness across a platform. Perspective views with variable shading and vertical exaggeration improve our visualization of the bathymetric variation and the influence it had during Holocene flooding.

The diversity and size of facies bodies shown on Figure 2 are broadly the same on the eastern and western limb of the GBB platform, though the narrower eastern limb, the New Providence Platform, hosts a higher prevalence of high energy grainstones. The most abrupt lateral facies changes are observed leeward of islands, areas which also hold the highest diversity in facies type. The seabed map also reveals the northern half of the platform to host a more heterogeneous facies mosaic than the south half, a difference likely related to the greater prevalence of islands. There is a clear trend that the widest portion of the platform, which lies to the south of the TOTO and lacks islands, hosts the most continuous expanses of grainstone. The prevalence of rudstone increases from north to south in step with an increase in water depth.

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