Satellite Imagery and Geological Interpretation of the Exumas, Great Bahama Bank - An Analog for Carbonate Sand Reservoirs

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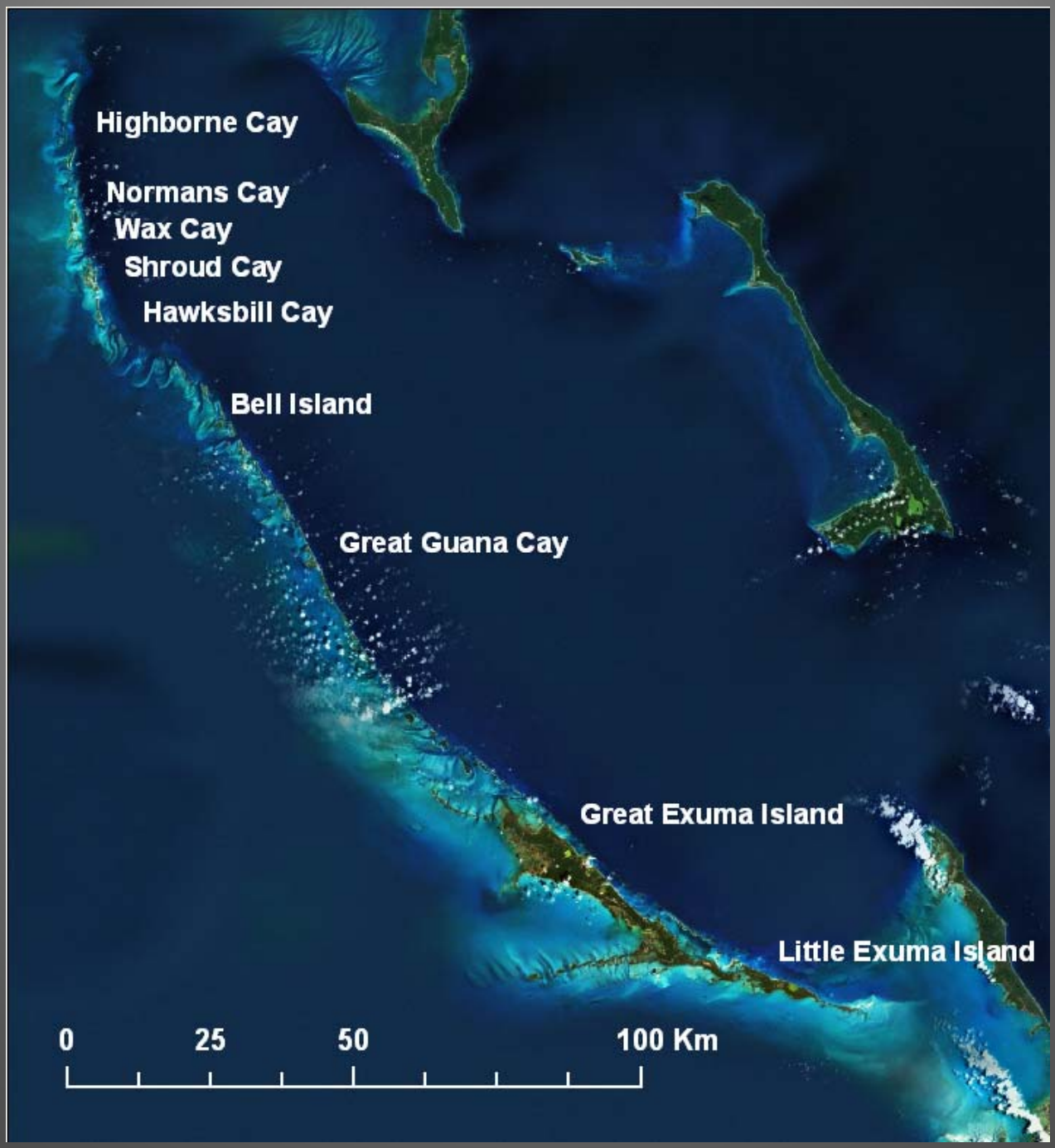
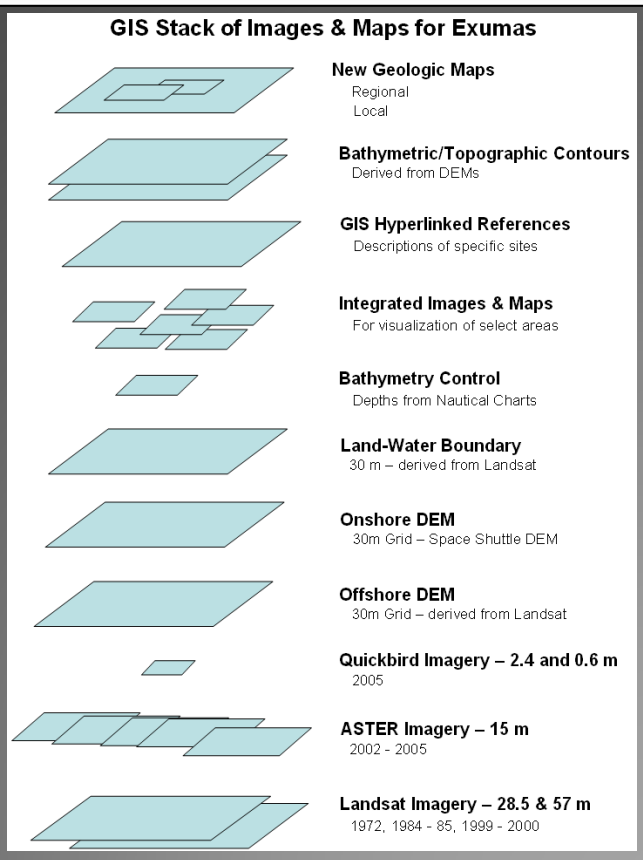
Rationale for Study

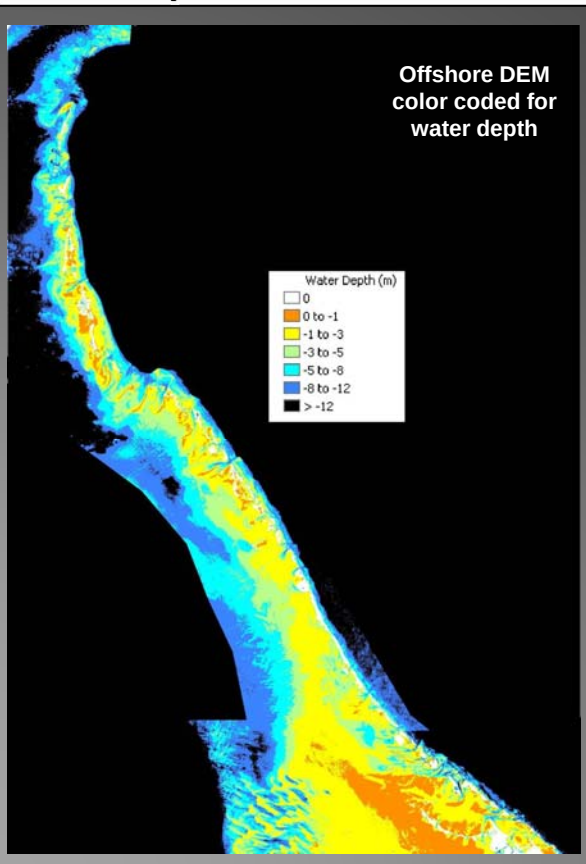
- The Exumas portion of Great Bahama Bank is an area of continuing interest to researchers in modern carbonates, an important training venue, and a valuable modern analog for understanding facies patterns in grainstone reservoirs.

- We hope to promote this interest by making readily available a set of processed satellite images, an onshore/offshore digital elevation model (DEM), and numerous examples of how this data can be visualized and used with an emphasis on better characterization and modeling of carbonate reservoirs.

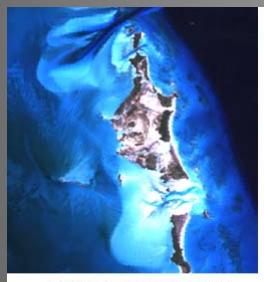


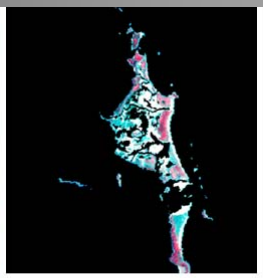
Exumas GIS, Images and Maps

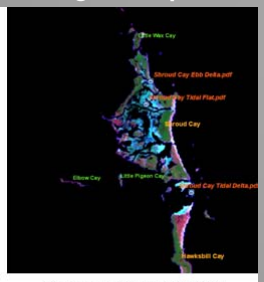




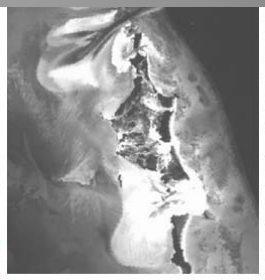
Overview of satellite images, maps and enhanced DEM in the Exumas GIS


1984 Natural Color Landsat

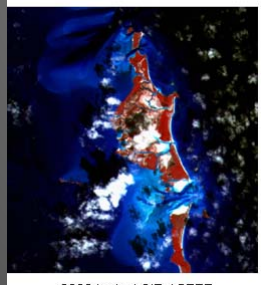

1984 onshore CIR Landsat

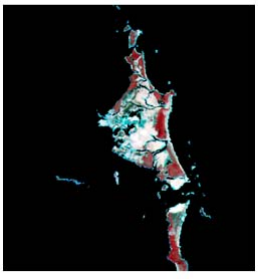

1984 Landsat with Locations and Reference Hyperlinks in GIS


1:31,250 Explorer Chart


1984 Landsat Band 1 (reflected blue light used for bathymetry model)


Offshore 2-m contours derived from Band 1 DEM – land masked black


2002 typical CIR ASTER

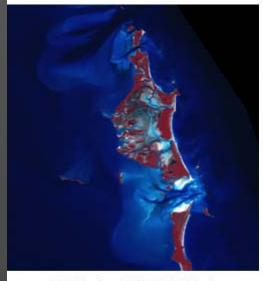

2002 onshore CIR ASTER

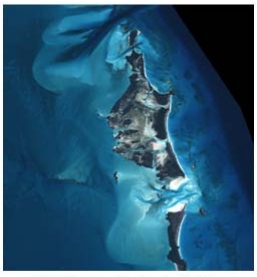

1984 Landsat Land Mask


1:25,000 Topographic Map (Bahamas LSD, 1969)

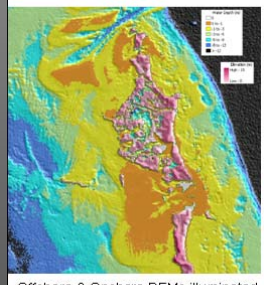

Space Shuttle (SRTM) DEM trimmed with Landsat land/water Mask

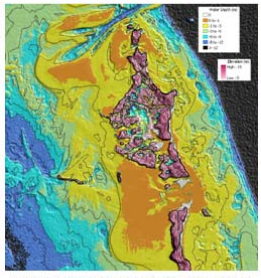

Onshore 2-m contours derived from Trimmed SRTM DEM


2005 typical CIR Quickbird


2005 Natural Color Quickbird

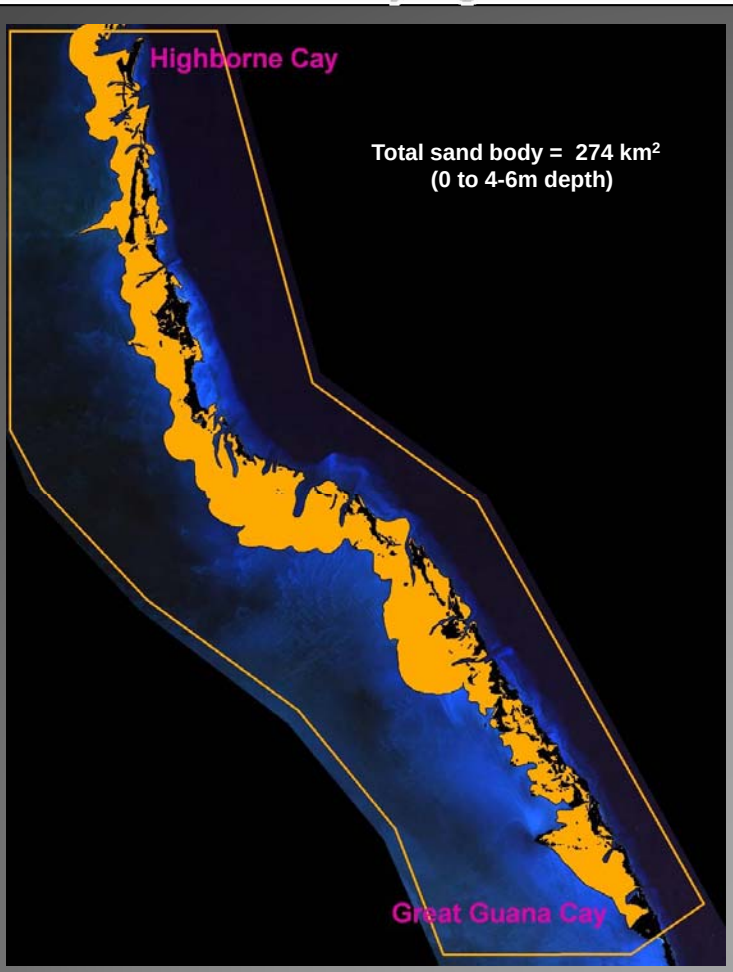

1984 Landsat Land-Water Boundary

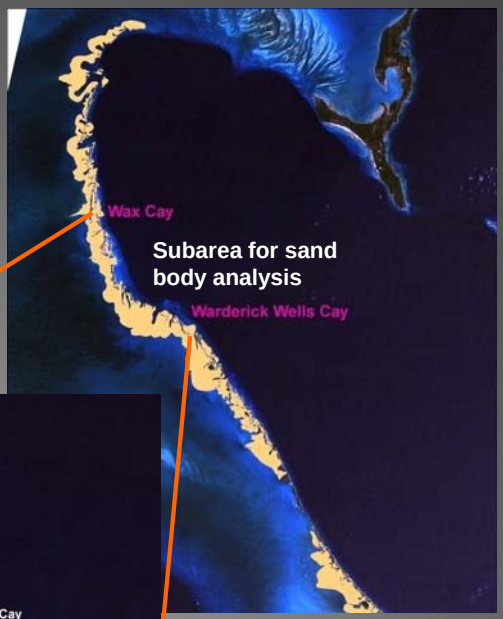

Offshore & Onshore DEMs illuminated from the NE and color-coded

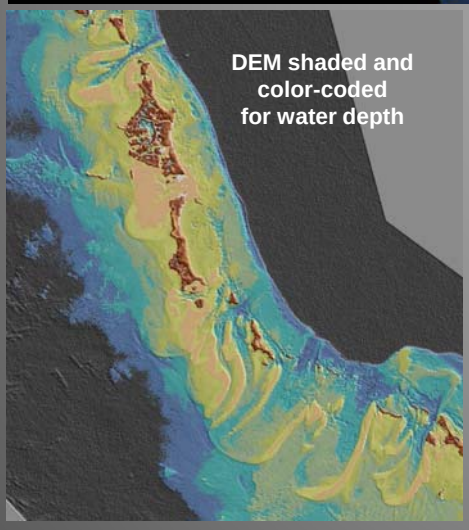

Offshore & Onshore DEMs illuminated and color-coded with derived contours

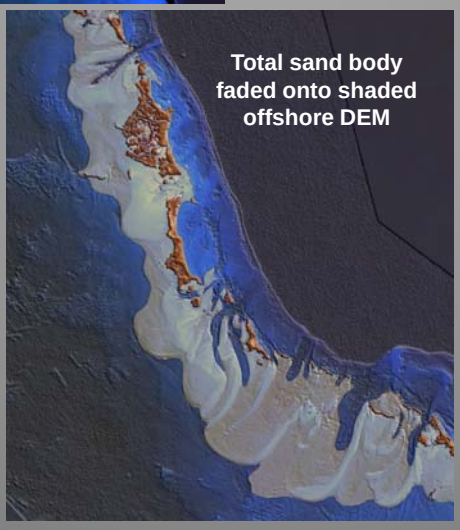

2005 Quickbird draped over shaded Offshore DEM

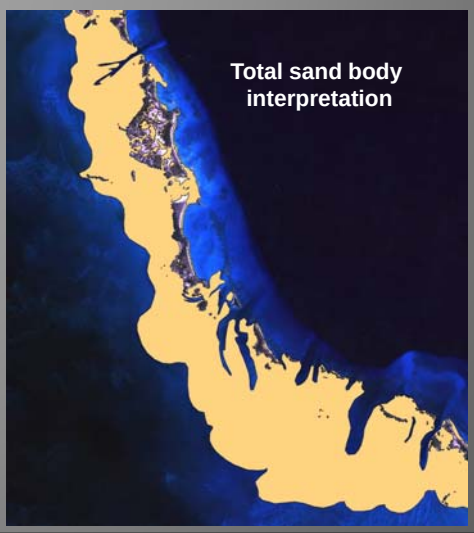
Analyzing the Total Sand Body (= Potential Reservoir)

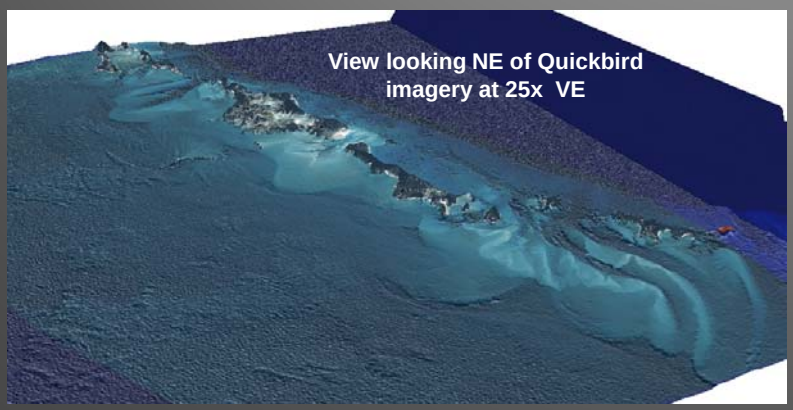


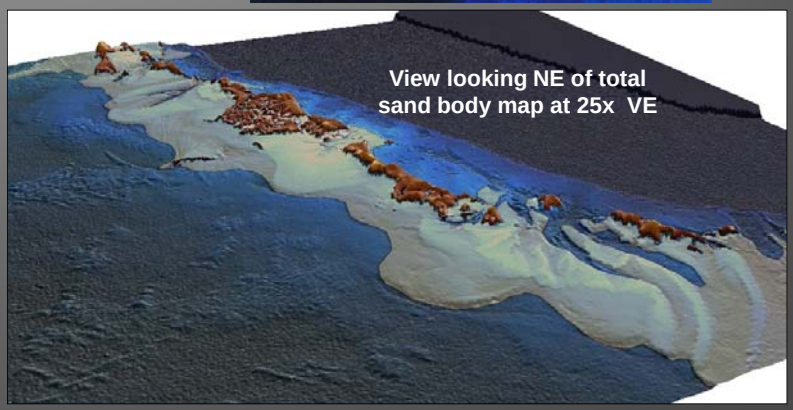




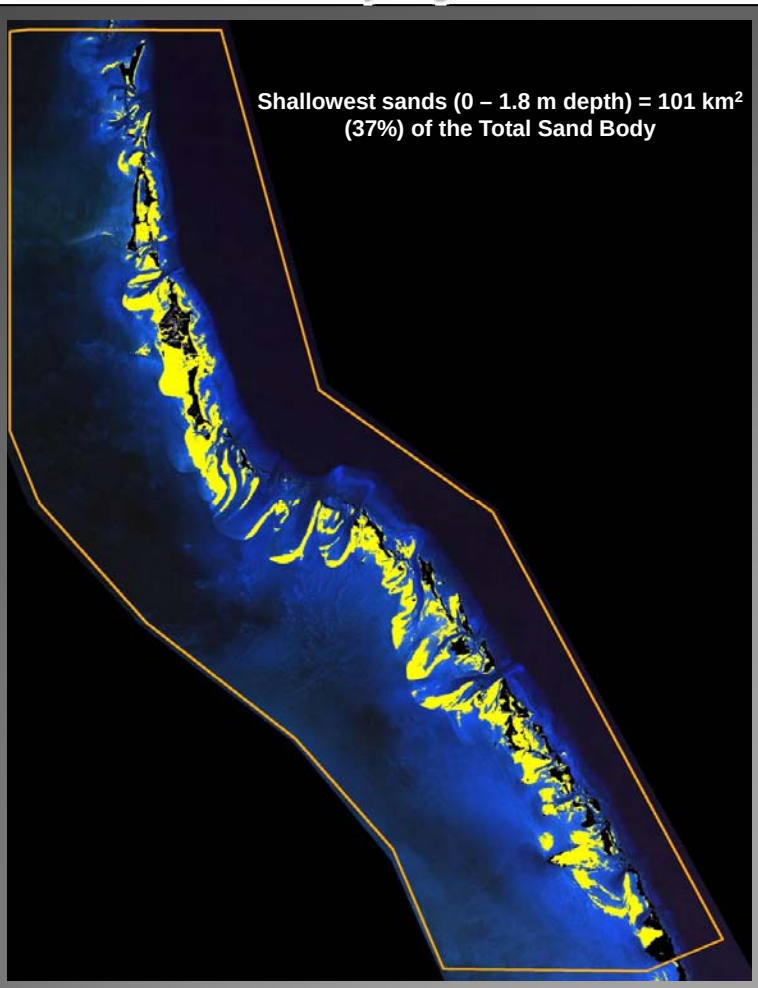


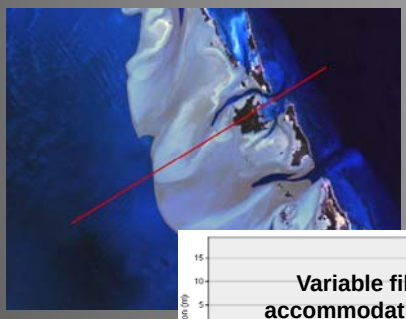


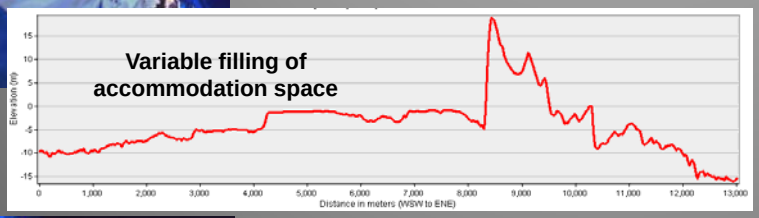


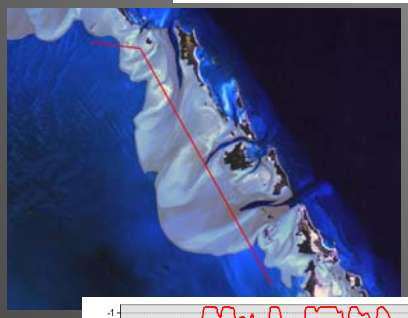


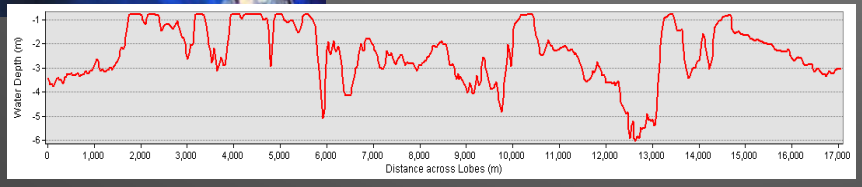
Analyzing the Shallowest Sands (= Best Reservoir)



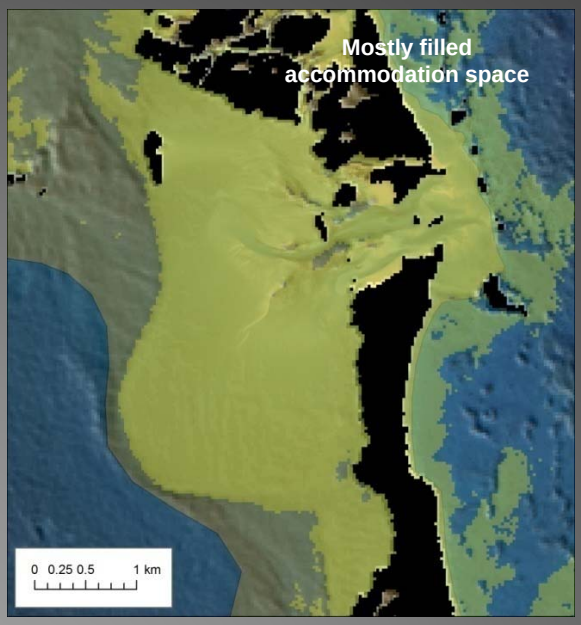


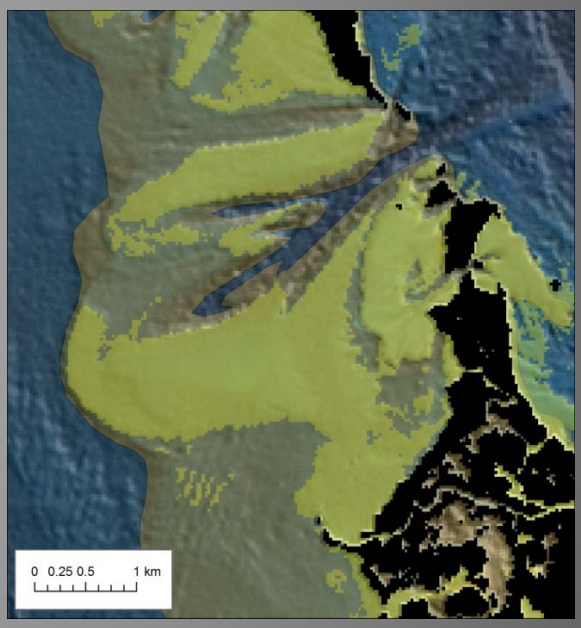


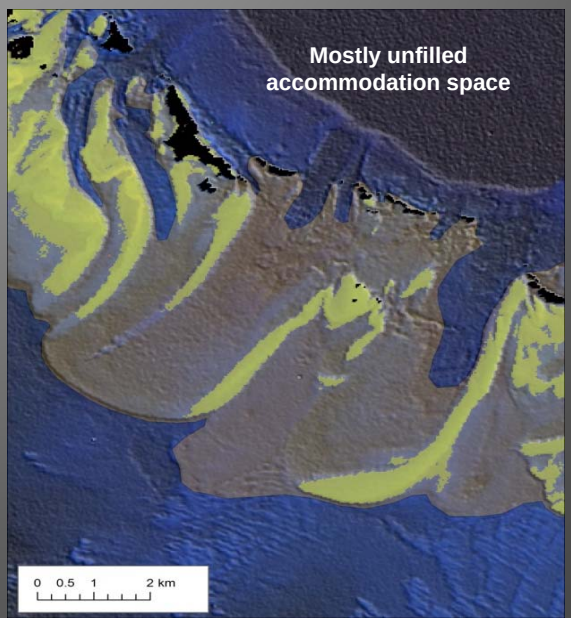




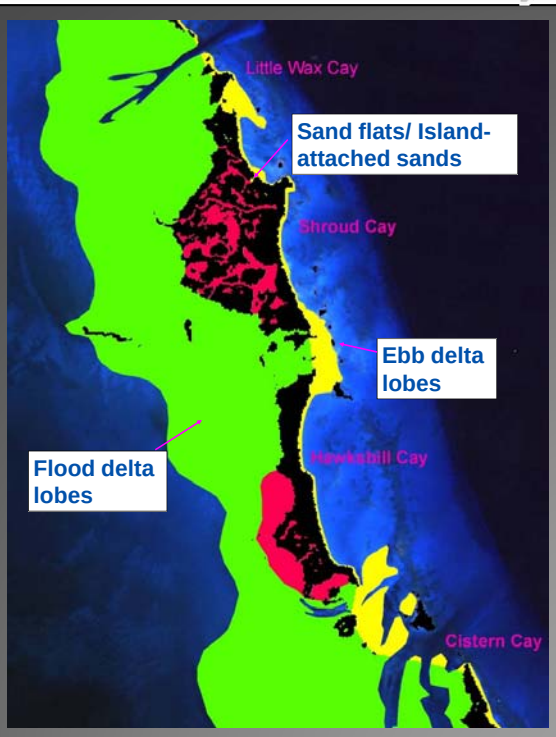
Shallowest sands (yellow) superimposed on total sand body map (gray) and Landsat image; islands shown as black.

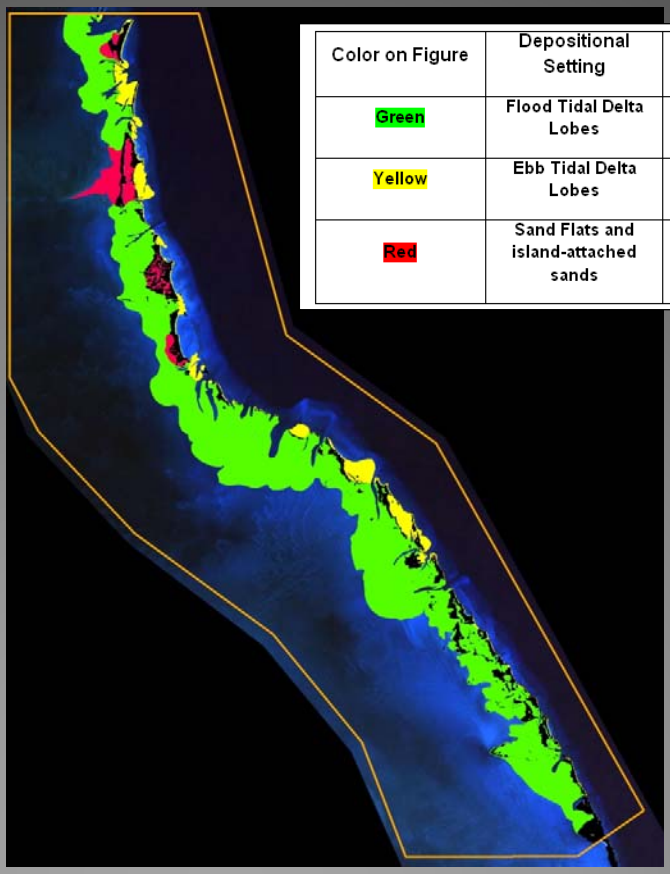






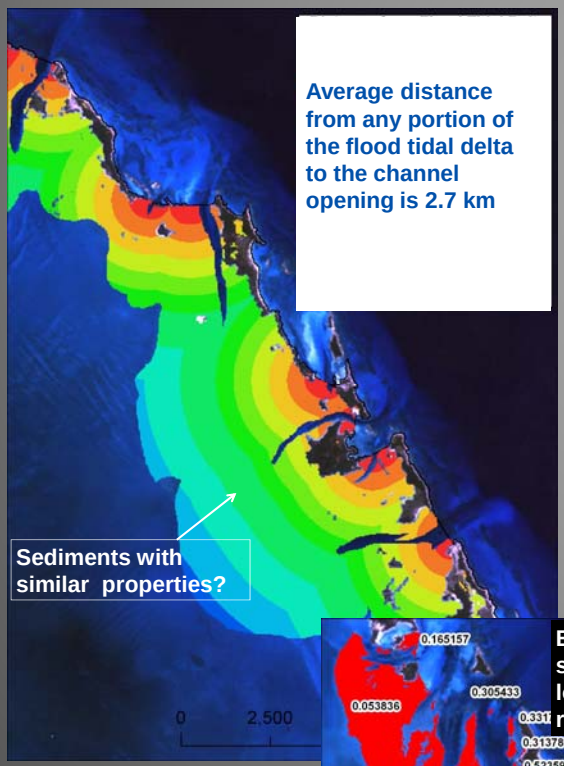
Analyzing the Sand Body by Environment





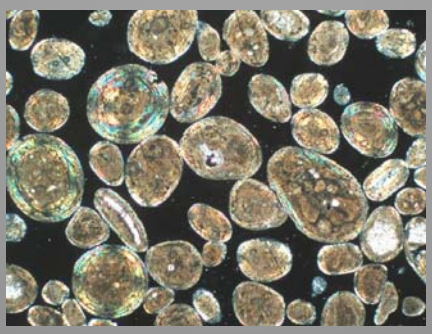
Color on Figure	Depositional Setting	Area (km²)	Area (%)
Green	Flood Tidal Delta Lobes	273.2	85.3
Yellow	Ebb Tidal Delta Lobes	29.6	9.2
Red	Sand Flats and island-attached sands	17.4	5.4

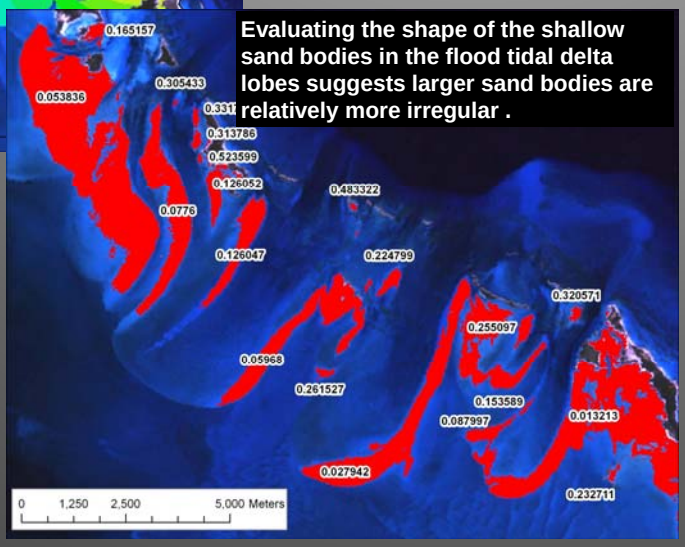
Flood tidal delta lobes comprise 85% of the total sand body



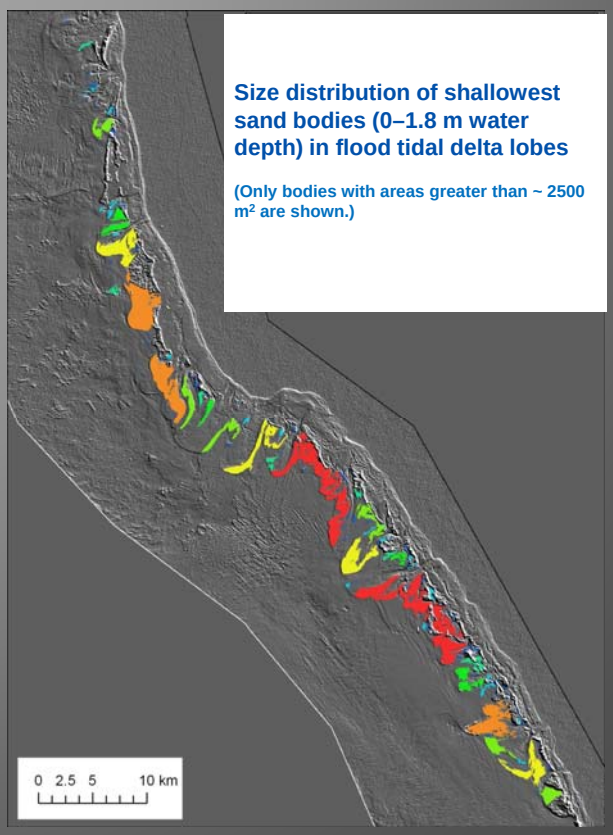
Average distance from any portion of the flood tidal delta to the channel opening is 2.7 km

Sediments with similar properties?





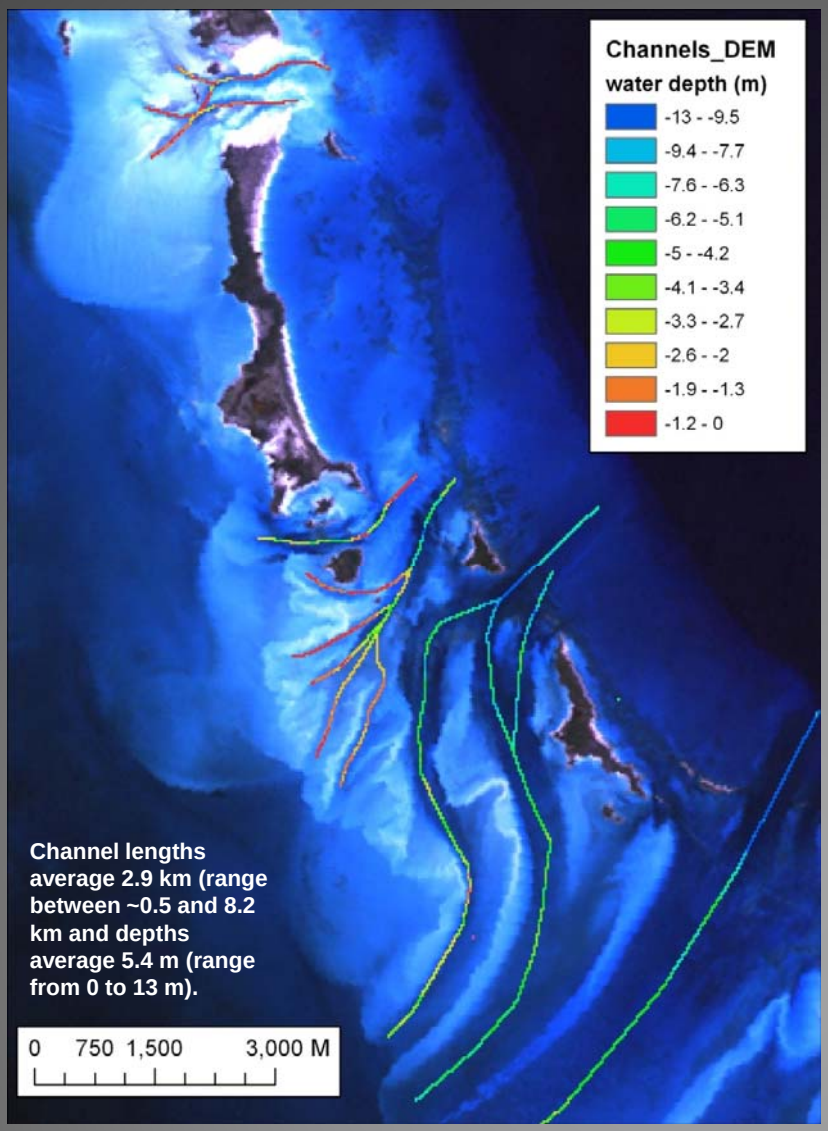
Evaluating the shape of the shallow sand bodies in the flood tidal delta lobes suggests larger sand bodies are relatively more irregular .

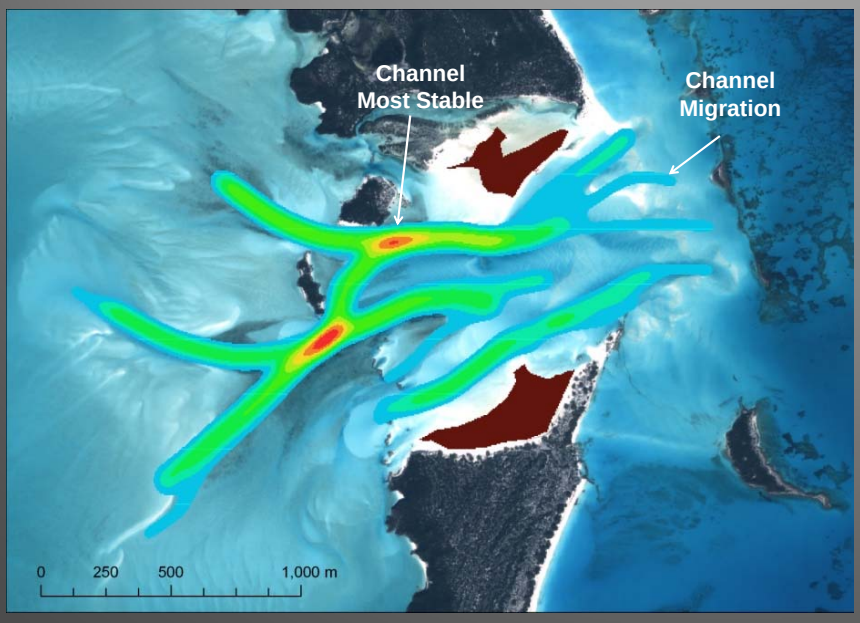


Size distribution of shallowest sand bodies (0–1.8 m water depth) in flood tidal delta lobes

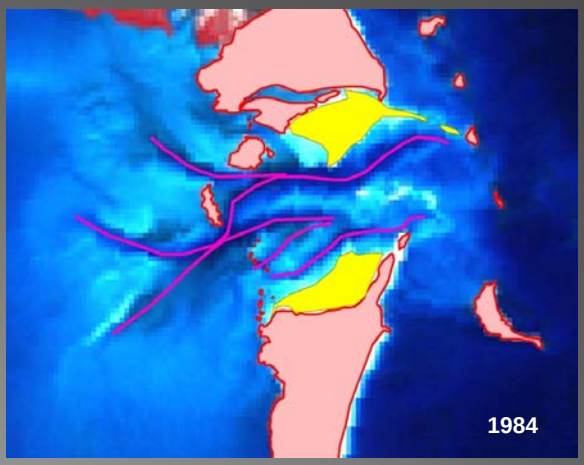
(Only bodies with areas greater than ~ 2500 m² are shown.)

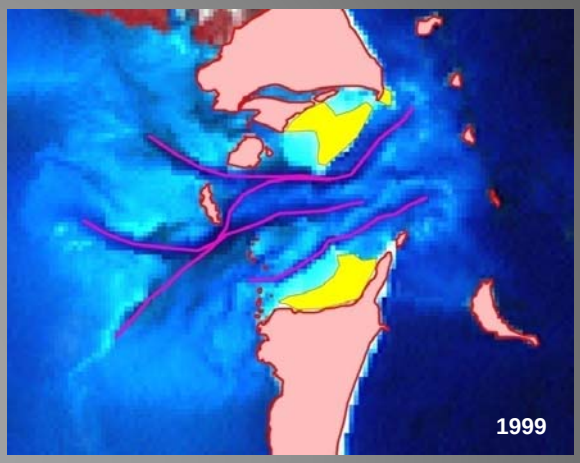
Analyzing Tidal Channels (= Potential Compartmentalization)

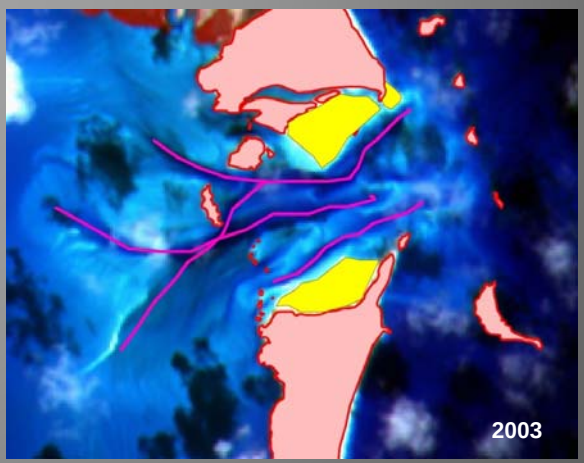


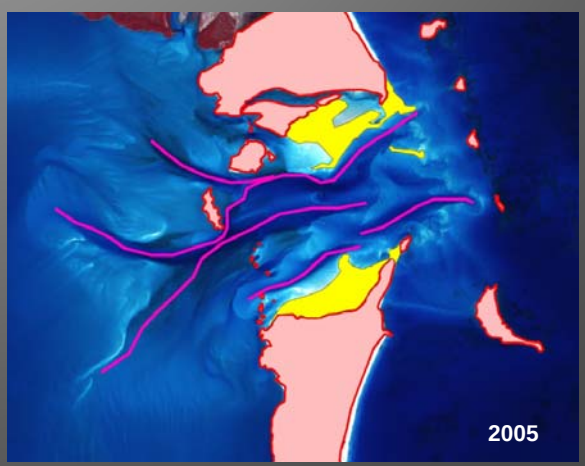


Changes in channels and emergent sand bars/beaches









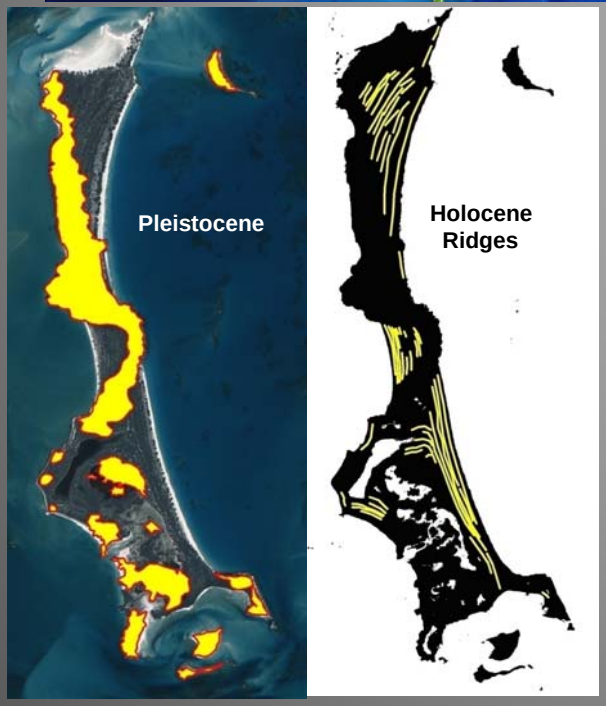
Analyzing Islands (= Diagenesis & Heterogeneity)

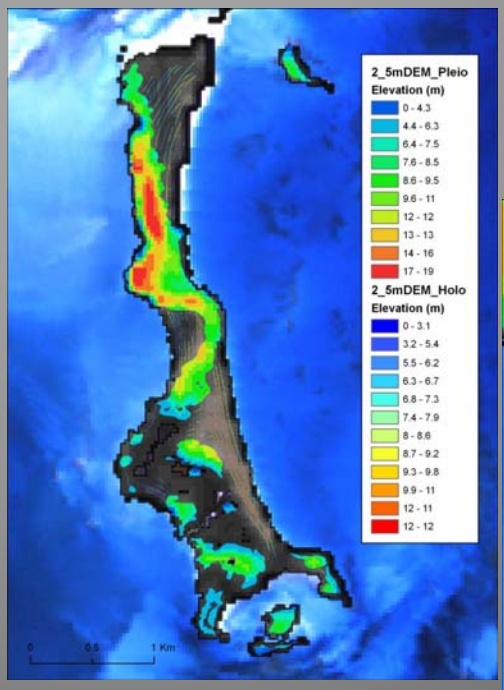
		Area (m^2 and %)	
Tidal Channel or Pond	Blue	712,552	9.1
Water Saturated Intertidal	Light Blue	819,360	10.5
Unvegetated Intertidal or Beach	Light Gray	532,045	6.8
Lightly Vegetation Intertidal	Light Green	1,431,510	18.3
Densely Vegetated Intertidal	Orange	873,919	11.2
Supratidal with Microbial Cover	Red	759,842	9.7
Densely Vegetated Supratidal	Green	2,700,046	34.5
TOTAL		7,829,274	100.0

Sand Flat Mapping Using Spectral Classification

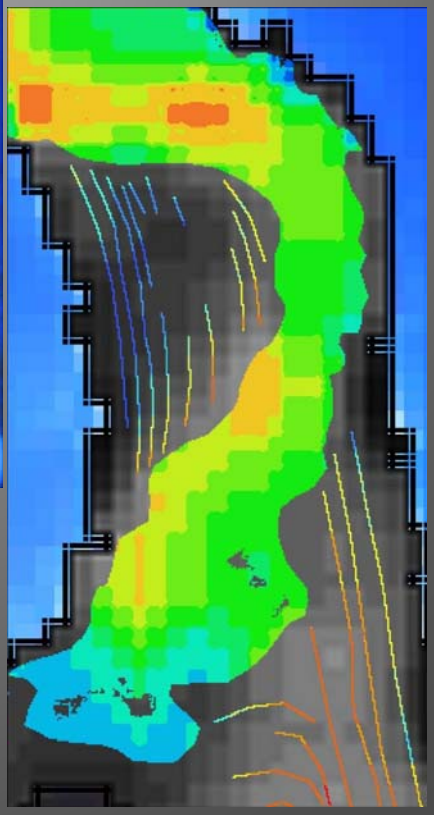
Analysis of Island Topography

Analysis of Island Age





Holocene ridges have elevations from near sea level to 12 m (mean elevation of 7.7m) while Pleistocene landforms have elevations from near sea level to 19 m (mean elevation of 9.3m)

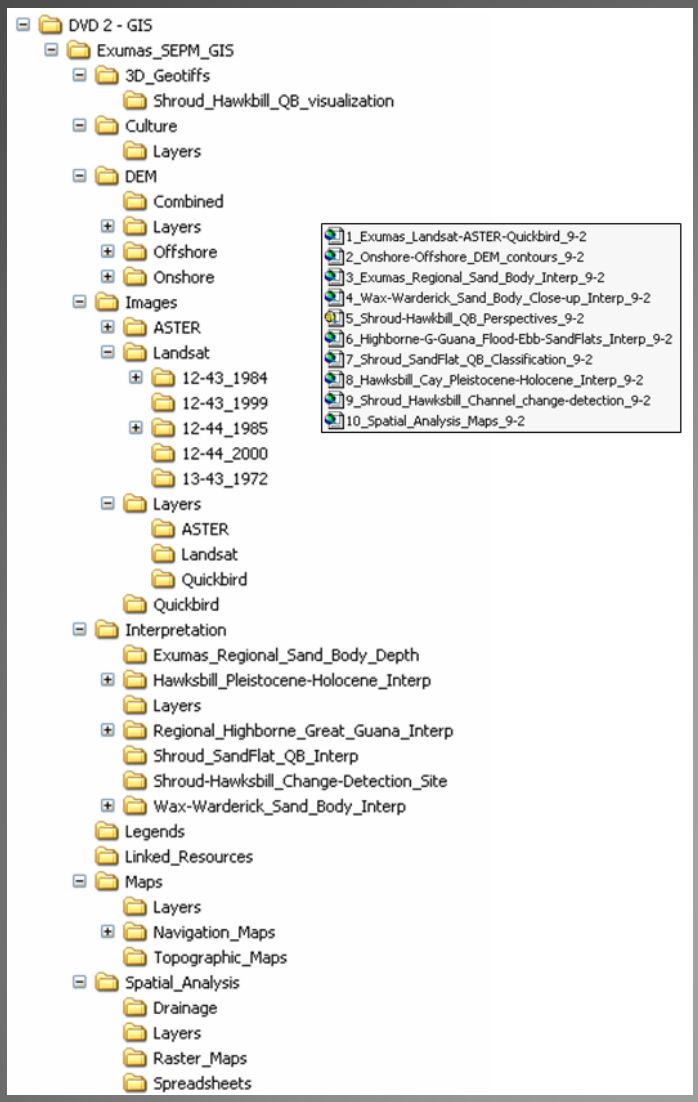


Pleistocene & Holocene Statistics

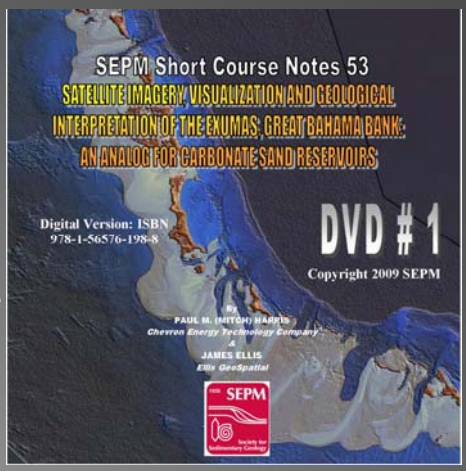
Hawksbill Cay

Land Area	**2.8 km^2**
Pleistocene	**1.07 km^2 (38%)**
Holocene	**1.73 km^2 (62%)**
Holocene Ridges	**17.6 km total length ; ~320 m average length**

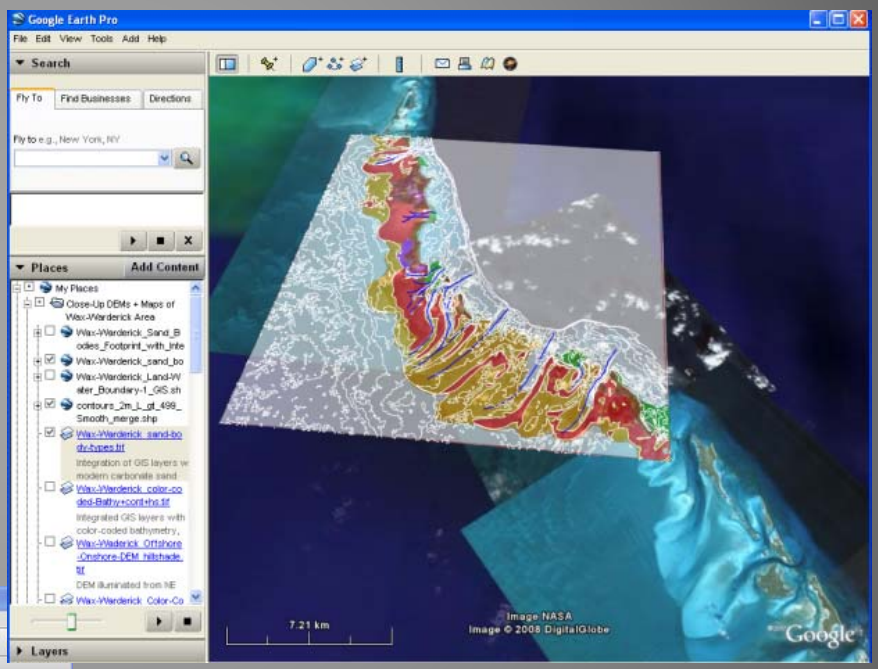
Knowledge Transfer

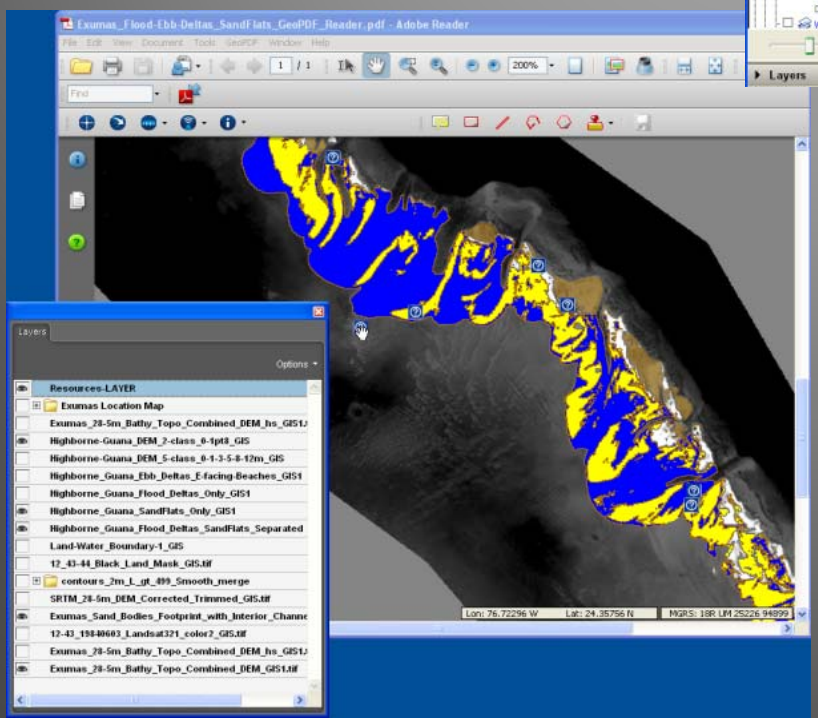


Full-resolution satellite imagery and maps in GIS format (with ESRI ArcGIS 9.2 mxd and sdx project files), GeoPDFs, and GoogleEarth images are available as part of a digital publication from SEPM. The organization of the digital files is shown to the left.



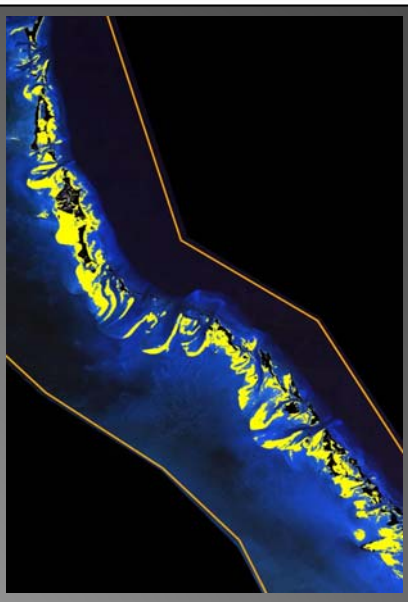
A GIS layer transferred out of the GIS and displayed in GoogleEarth.





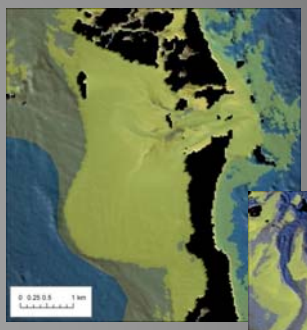
The GIS stack of geologic maps transferred out of the GIS and into Adobe Reader using GeoPDF, enabling image and map comparison, location, measurement, and interpretation to be done outside of GIS.

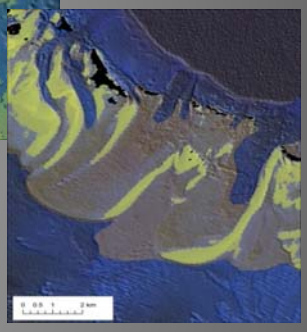
Summary Points



Exploration-Scale Insight

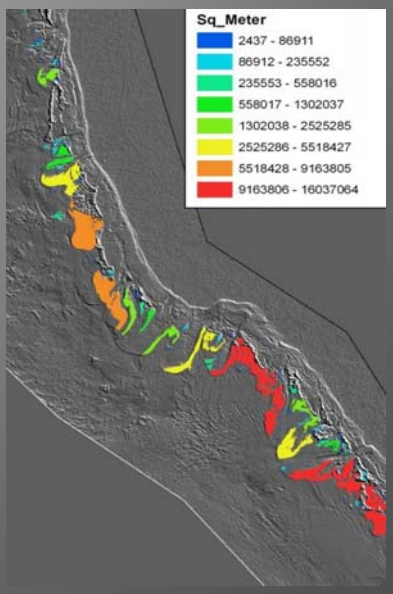
- Exumas show spatial variability of depositional facies and early diagenetic overprint that create stratigraphic traps and reservoir heterogeneity
- A linear belt of mostly ooid sand, approximately 5-10 km wide and 170 km long, paralleling the platform and set back from the platform margin
- 37% of the sands are forming in the shallowest waters and would likely have the best reservoir quality
- The largest facies aerially are flood tidal delta lobes extending several kilometers onto the platform





Reservoir Heterogeneity Insight

- Small-scale patterns of heterogeneity are controlled by islands and tidal channels and their influence on the focusing of tidal and wind energy
- Where islands and channels are complex, bankward-directed lobes of sand are not uniform in their development and have their shallowest portions as sinuous, linear features
- Elsewhere, the islands and channels are more regular and the active shoals between are organized into better-formed and more uniformly shallow flood tidal deltas



Reservoir Modeling Insight

Quantitative relations like the following are essential for building facies-based models:

- Shallowest sands comprise 37% of the total sand body
- Larger deposits of “shallowest sands” are up to ~8 km^2
- Larger sand bodies are more irregular in shape than smaller ones
- Flood tidal delta lobes represent 85% of the total sand body
- 52% of the shallowest sand bodies have areas greater than ~2500 m^2 and 8% are larger than 100,000 m^2
- These largest deposits are highly sinuous and maintain connectivity
- Tidal channels, which may potentially isolate or compartmentalize reservoir zones, average 2.9 km in length

Chevron