Multibeam Analysis of the De Soto Valley Formation in the Gulf of Mexico

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NOAA Ship *Okeanos Explorer*

Abstract

The De Soto Valley is located in the northeast portion of the Gulf of Mexico, approximately 100 km offshore of Pensacola, Florida. This S-shaped, submarine canyon exhibits many interesting features including a gentle slope, erosional and depositional features, as well as nearby salt diapirs. Although the area has been studied since the 1960s, the most recent mapping expedition was conducted in 2012 by The NOAA Ship *Okeanos Explorer,* with a Kongsberg EM302 multibeam sonar system. Using CARIS HIPS and SIPS 7.1 for post-processing of bathymetric and backscatter data, suspected hydrocarbon deposits regarding the evident diapirs were examined. The research will allow further exploration of the morphology and sediment characteristics in the De Soto Valley, benefiting both the economy, ecology and geological understanding of the region.

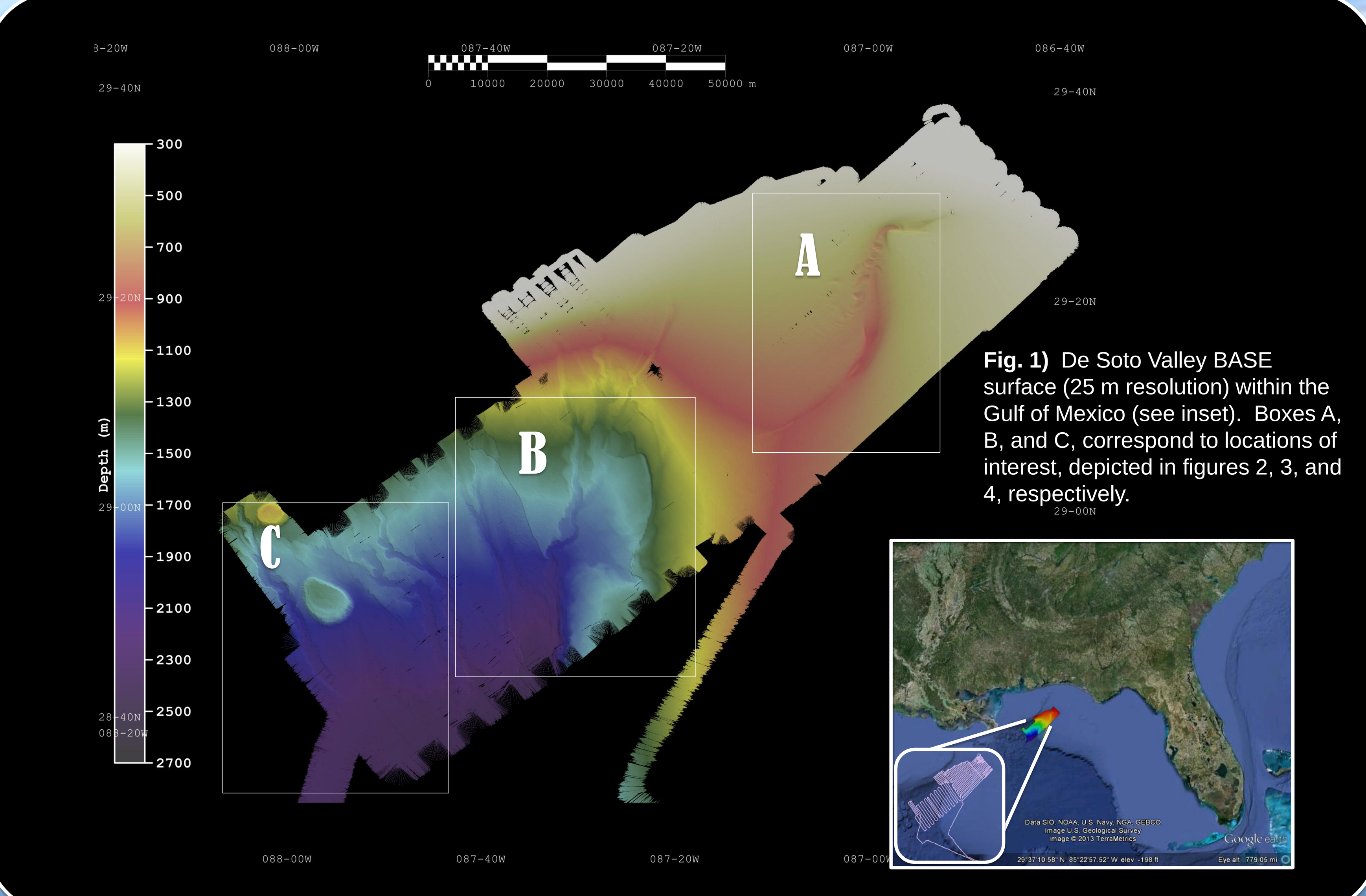


Fig. 1) De Soto Valley BASE surface (25 m resolution) within the Gulf of Mexico (see inset). Boxes A, B, and C, correspond to locations of interest, depicted in figures 2, 3, and 4, respectively.

Introduction

The De Soto Valley is a submarine canyon formed by depositional and erosional processes and cuts through the broad continental shelf and slope in the northwest portion of the Gulf of Mexico. Though it is one of the least studied areas in the Gulf, the valley is known to contain a variety of geologic features, biologic habitat, and potential hydrocarbon reserves.

The area studied spans a 100 to 2500 m depth range over a 150.6 km lateral field, with major depth changes occurring in the S- shaped De Soto Canyon and in the greater valley below the canyon formation. After exiting the De Soto canyon structure, the depth of the abyssal plain continues to drop very dramatically until reaching the Uchupi Dome, a salt diapir formation. Along this portion of the slope, several sharply defined escarpments are evident, probably formed as a result of basin drainage.

From the Pliocene to present day, minor salt diapirism has occurred providing hydrocarbon sources in the region and at least five salt domes have been identified (MacRae and Watkins, 1992), including the Uchupi Dome seen in this dataset. Because of these diapirs, the petroleum industry has studied the area for oil and natural potential. Some issues of extracting petroleum in this region include the challenging water depth (>1800 m), high infrastructure investments, sour crude quality, additional refining costs and low yield (Piles and Weimer, 2001). GeoBAR mosaics, and 3-Dimensional imaging created in CARIS HIPS and SIPS 7.1 provided insight into sediment type, and geomorphology of the region investigated, shedding light on the above relationships.

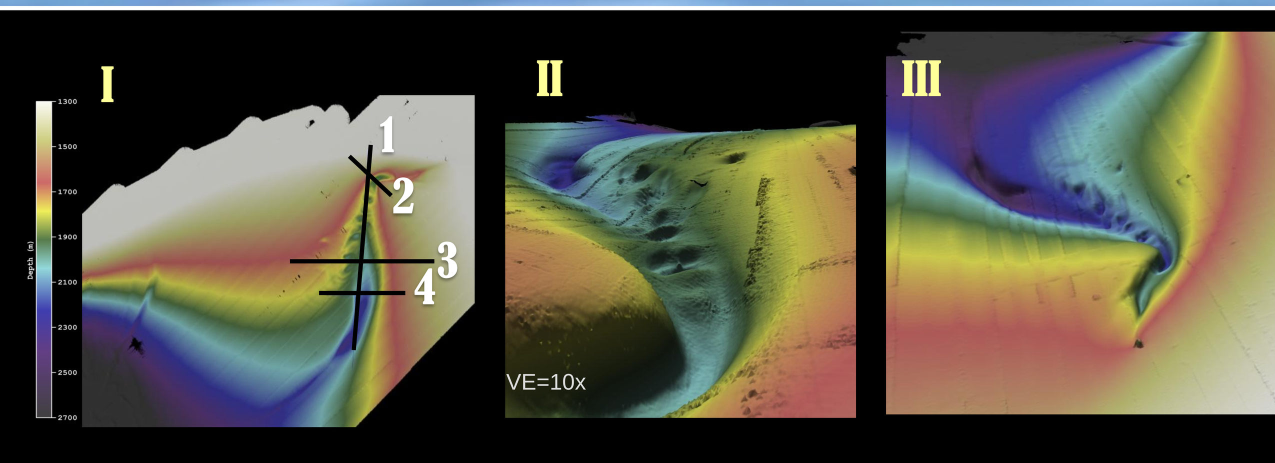
Methods

- Hydrographic survey data was collected by the NOAA Ship OKEANOS EXPLORER
- Multibeam data were collected from Feb.-Mar., 2012
- Sonar data collected by Kongsberg EM 302 multibeam collection device with a SIS acquisition system
- Data processed using CARIS HIPS 7.1
- CUBE BASE surface created with 25 m resolution
- Implemented backscatter data using Geocoder to create a mosaic to estimate sediment size and density.
- Target areas include morphological characteristics of the De Soto Canyon, "Knife Point" escarpment feature, and the Uchupi Dome salt diapir in the western region of focus.

Results

- The De Soto Canyon formation is S-shaped with scour marks through the mid-region.
- There is a "Knife Point" shaped escarpment formation in the mid-BASE surface with symmetrical escarpment faces descending with depth.
- The Uchupi Dome sits at the bottom of the BASE surface surrounded by smaller drainage channels

A De Soto Canyon



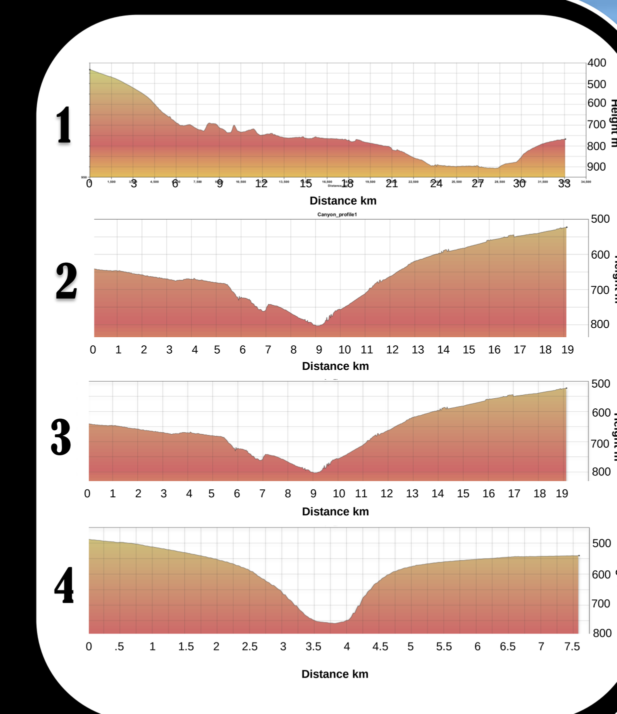
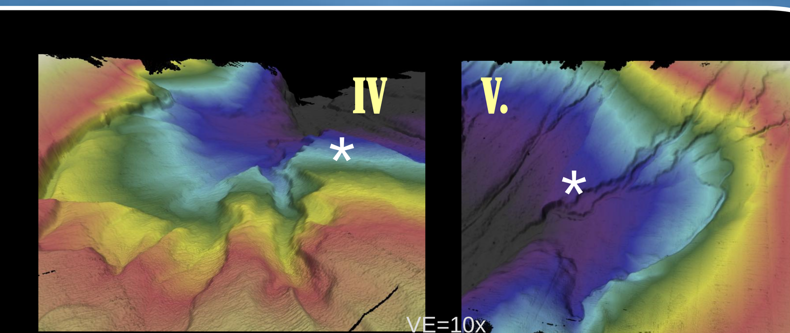
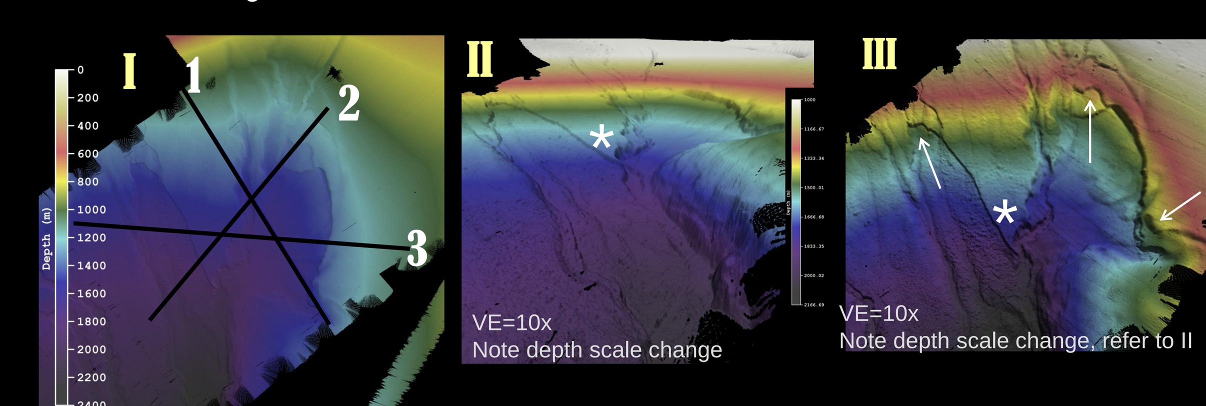


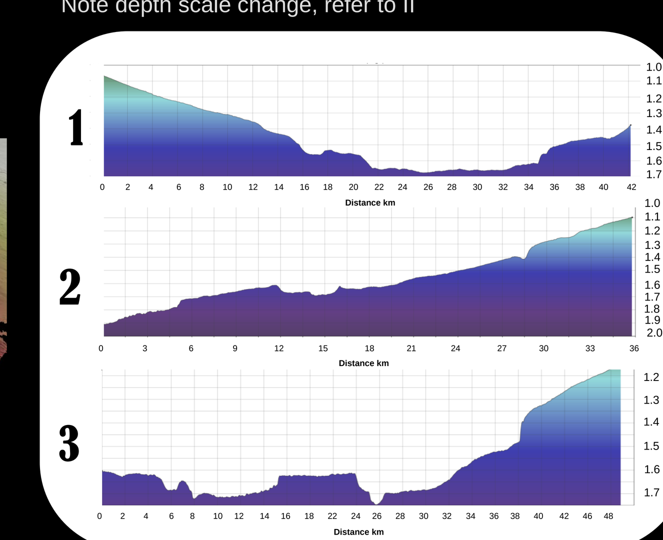
Fig. 2)
I. 2D view of the De Soto Canyon portion, showing locations of profiles 1-4
II. 3D view of De Soto Canyon looking west from the interior showing scours from water current.
III. De Soto canyon looking west.
Profiles 1 through 4 show the canyon profile in cross sections as well as following the deepest linear axis of the canyon.

B "Knife Point" Escarpment

Fig. 3)
I. 2D view of the "Knife Point" escarpment showing locations of profiles 1, 2 and 3.
II. View of escarpment looking north (upslope) from bottom showing bathtub ring like erosion on the steep cliff face, bottom right hand of the image.
III. Aerial view (southwest) of the "Knife Point" feature emphasizing symmetry in erosion. Notable symmetry marked with arrows.
IV. View looking across "Knife Point" in a southwest direction.
V. Side view (southeast) of drainage patterns of the De Soto valley and regression evidence along "Knife Point" formation.
Profiles 1 through three show the depth variance of the escarpment formation over a 43 km region.







C Uchupi Dome

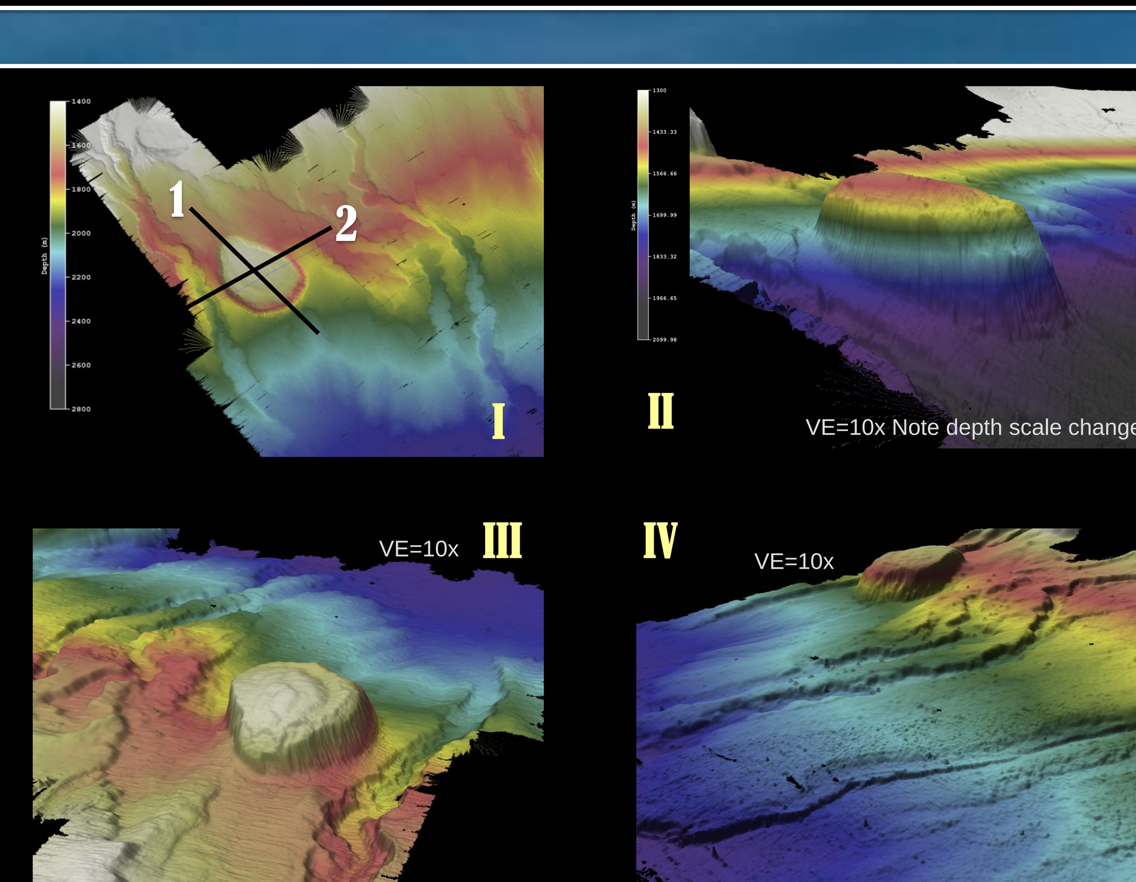
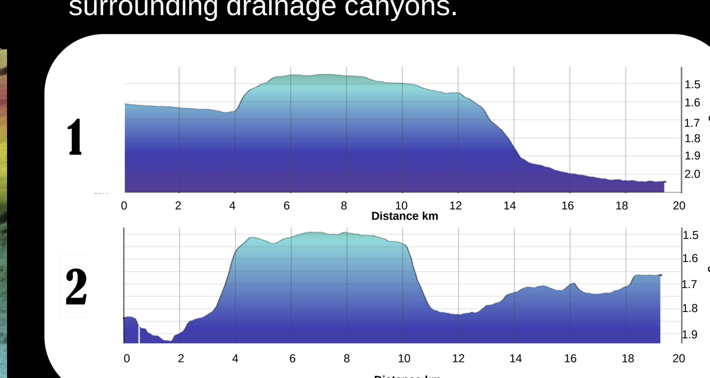
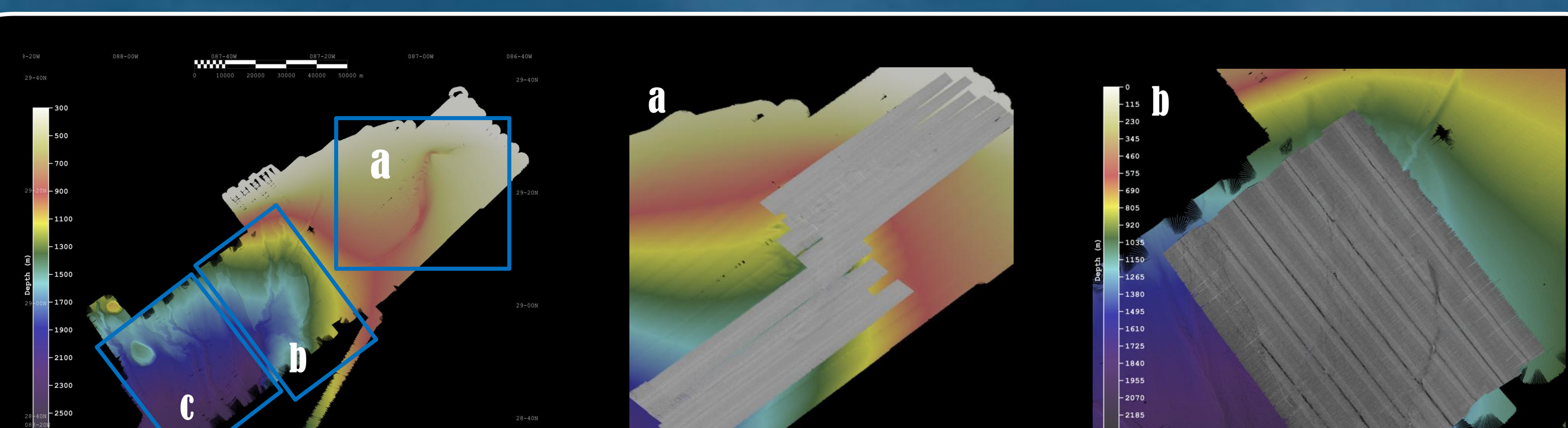
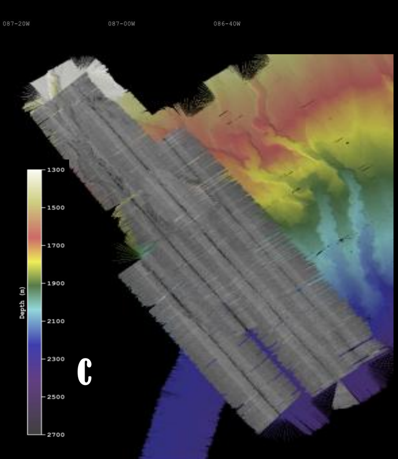


Fig. 4)
I. 2D view of the Uchupi Diapir section, showing locations of profiles 1 and 2.
II. Diapir viewed looking north (upslope). The depth scale has been adjusted to show the range of this formation.
III. View looking to the southeast (downslope), showing drainage channels along both sides.
IV. De Soto Valley floor east (viewed looking west) of the diapir, showing drainage channels.
Profiles 1 and 2 show the 20m wide (east-west) plateau shape of the salt dome formation as well as the surrounding drainage canyons.



Backscatter





Backscatter data using GeoCoder for grain size analysis supports evidence that regional drainage from the Mississippi Delta influence the variability of sediment in the region in regards to depth and location.

Fig. 5) Backscatter mosaic data for the De Soto Valley.
A.) The De Soto Canyon formation exhibits the most variance in sediment of anywhere in the De Soto valley given the turbidity and associated eddies that influences the region.
B.)The "Knife Point" escarpment formation shows slightly finer sediment than the valley floor, but still little variance. The bottom of the escarpment is composed of finer sediment most likely due to erosional processes.
C.) The Uchupi Dome shows variance in sediment type from valley floor (mud) to its top, though on the diapir sediment appears to be fine to coarse grained due to slumping on the diapir and Mississippi delta interaction.

Discussion

The De Soto Valley (and associated Canyon) is a unique topographic feature shaped by erosion, deposition and the presence of salt diapirs. After analyzing the bathymetry and data collected from the *Okeanos Explorer*, we found the bottom depths of the De Soto Canyon range from 300 to1000 m and roughly 42.7 km on a linear axis from the head to foot. The canyon shows scours (Fig. 2, I.) in the mid-region indicating it was carved by turbidity current (Harbinson,1968), and the S-shape appears to be from transgression and regression of sea level as no related erosion manifests at the canyon foot currently, indicating that regressive water flow carved the canyon while transgressing seas levels deposited sediments overlaying canyon drainage. Three specific features of the North/South trending Canyon (Fig. 2, II.) structures have been noted: The Northern bank, Southern bank, and Eastern/Western slopes. The northern bank is an ancient shoreline (Harbinson,1968) and the canyon itself was carved as the ocean's sea level rose and fell over time. The Southern bank is an ancient buried salt formation (Pyles, 2001) . The Eastern and Western slopes of the canyon were formed in conjunction, with erosion delivering sediment from the east and depositing it on the western border (Pyles, 2001).

Other features in the focus region include the sharp, pointed escarpment feature, referred to here as the "Knife Point" escarpment. Due to the symmetrical relationship of the escarpments (Fig. 3) transgression most likely carved these as well. As seafloor drops ,the escarpment gains depth within the valley, as observed by a series of symmetrical erosional features and bathtub ring-like marks in the valley. The similarity in shape of these erosional features suggests they formed under similar marine conditions, and their receding depth indicates a regressing sea level (Fig. 3,II, III) .

Diapirs, in the De Soto valley are interpreted as salt domes due to size, shape, fault characteristics and associated salt domes in close proximity to those to the west in the Mississippi delta proper . The specific dome studied in our area was the Uchupi Dome. This dome measured 6.4 km (north-south) by 9.3 km (west-east). The Uchupi Dome has a potential for hydrocarbon extraction (Harbinson,1968) but may be too deep for efficient extraction in conjunction with lower yield than surrounding areas, although oil and gas platforms are located in the De Soto Valley region. The surrounding channels (Fig. 4, III., IV.) are from ancient Mississippi River delta drainage, when lower sea levels would have brought the river closer to the De Soto valley region (Catuneanu, 2006).

References

Catuneanu, O., 2006, "Principles of sequence stratigraphy." Elsevier, p. 198.

Gardner, J. V., Calder, B. R., Hughes-Clarke, J.E., Mayer, L.A., Elston, G, 2007. *Geomorphology* v. 89 , p. 370-390.

Wei, C.L., Rowe, G.T., Escobar-Briones, E., Nunnally, C., Soliman, Y., Eillis, N., 2012, Standing stocks and body size of deep-sea macrofauna: Predicting the baseline of 2010 *Deepwater Horizon* oil spill in the northern Gulf of Mexico, *Deep Sea Research Part I*, v. 69, p. 82-99

MacRae, G., Watkins, J., 1992, *Marine and Petroleum Geology,* v. 9 Issue 5.p 501-504.

Pyles D.R, Wiemer, P., 2001. *Stratigraphic and Tectonic Framework of the De Soto Canyon and Lloyd Ridge Protraction Areas, North Eastern Deep Gulf of Mexico: Implications for the Petroleum System and Potential Play Types.* GCSSEPM Foundation 21st annual research conference for petroleum systems of deep water basins, December 2-5.

Acknowledgments

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