Comparing Salt Diapirs and Basins in the Northwestern Gulf of Mexico Along the Sigsbee Escarpment

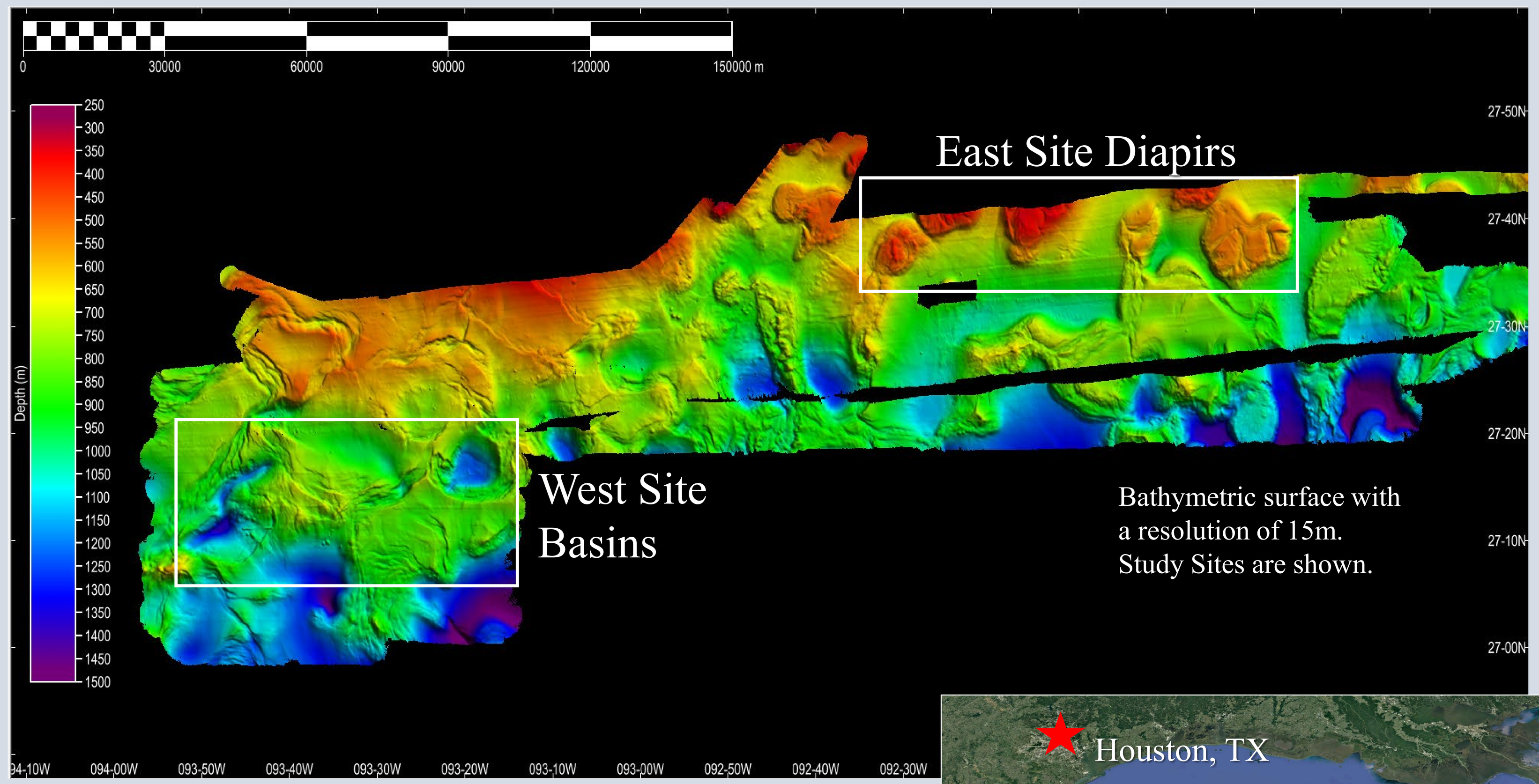
Tyler Bell and Dr. Leslie R. Sautter
Department of Geology and Environmental Geosciences, College of Charleston
belltt@g.cofc.edu and SautterL@cofc.edu

BACKGROUND

The Gulf of Mexico's geomorphology near to the continental margin and along the Sigsbee Escarpment is largely a result of salt deposits. Unlike lithogenic sediments, salt does not compact and when sediment accumulates on the seafloor covering the salt the pressure causes mounds (referred to as salt diapirs) to form, along with basins and ridges as the salt flows underneath the seafloor sediment (Stern, 2011).

The area of study is approximately 320 km southeast of Houston, Texas along the Sigsbee Escarpment, where depths range from 250 to 1500 m. Mounds in this area are salt diapirs which are salt-cored features associated with gas hydrate and deep-sea oil seeps, giving the area a unique geomorphology (Ballard, 1970). The NOAA Ship *Okeanos Explorer* collected multibeam sonar data from the Northwestern Gulf of Mexico in 2014, mapping several mounds and basins within the area.

High resolution video and images were collected from ROV *Deep Discoverer* dives to obtain ground-truth of seabed characteristics within the study area. ROV dive video showed footage of methane seeps and pools of high salinity brine which contribute to the geomorphology of the mounds and basins. Previous studies within the area documented the diversity of deep-sea habitats and analyzed the geomorphology of escarpments and deep-sea canyons (Stern, 2011).



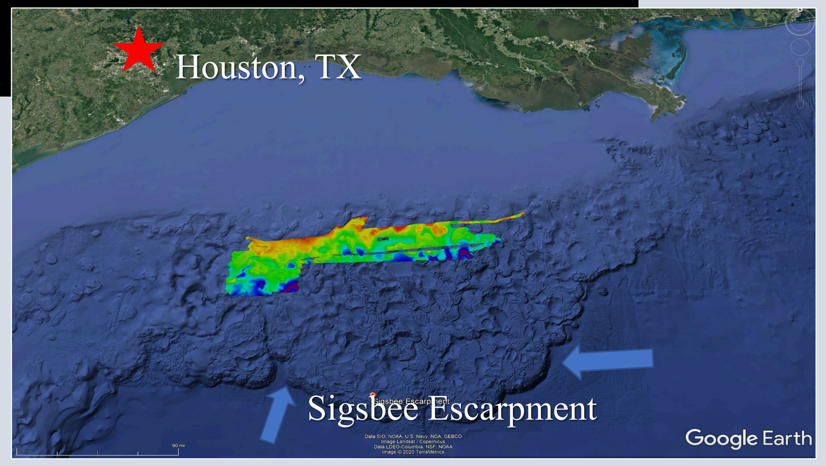


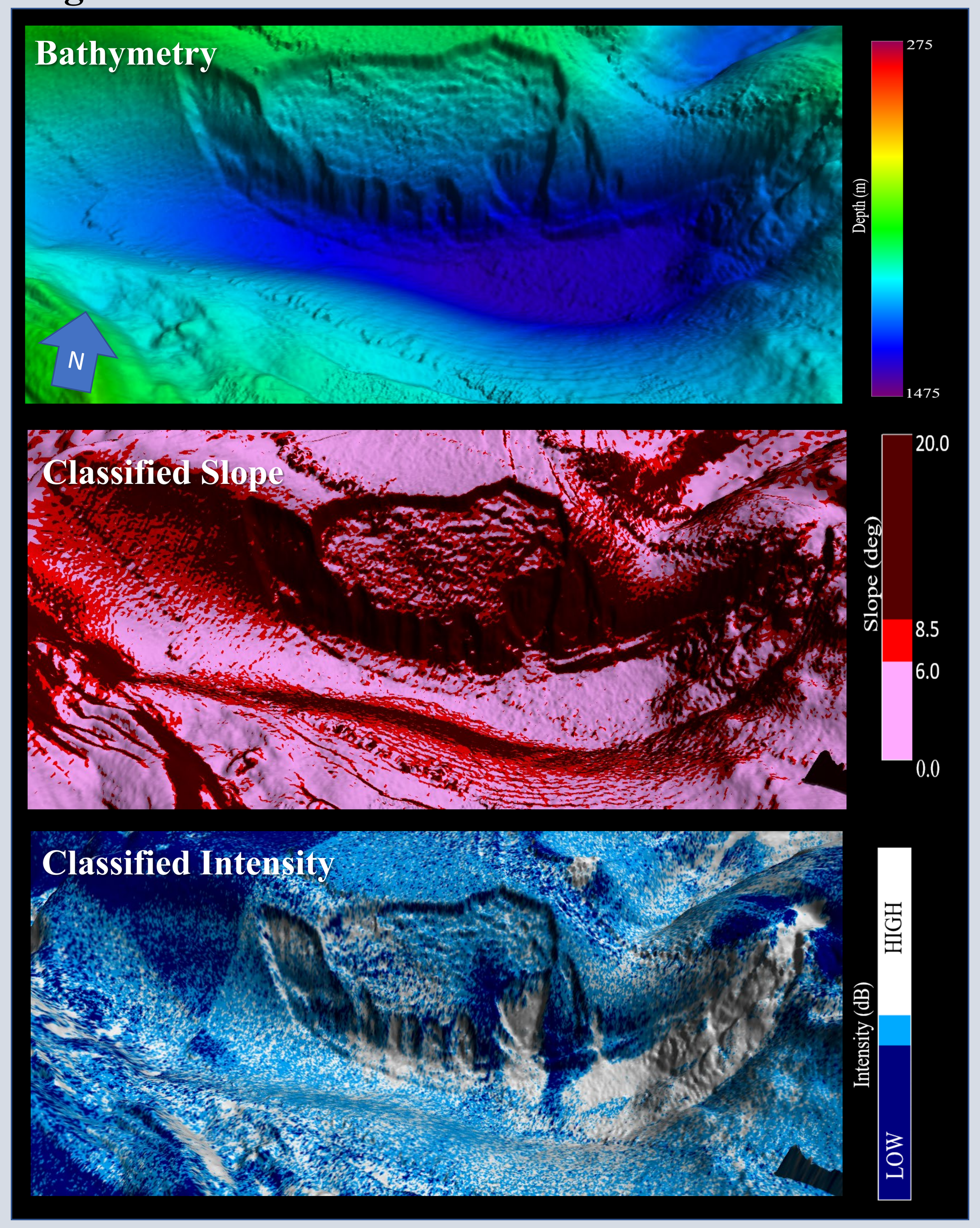
Figure 1. Study Area and Site Locations

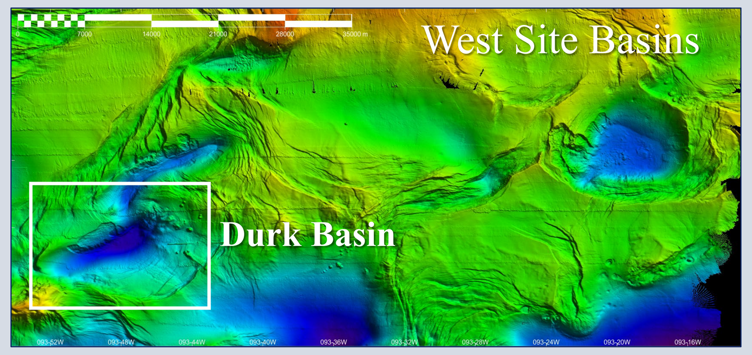
The study area is approximately 320 km from Houston, Texas along the top of the Sigsbee Escarpment. Within the study area are many geologic features including salt diapirs (East Site Diapirs) and basins (West Site Basins). Depths within these sites range between 275 and 1475 m.

METHODS

- The NOAA Ship *Okeanos Explorer* collected multibeam sonar data in the Gulf of Mexico in 2014 using a Kongsberg EM302 during the expedition EX1402L2.
- CARIS HIPS and SIPS 11.3 was used to process multibeam data to create a CUBE interpolated surface at 15 m resolution.
- 3D and 2D surfaces were created to compare and analyze study sites and features by bathymetry, slope, classified backscatter intensity.
- Depth profiles were generated using CARIS HIPS and SIPS 11.3.
- HD video and images from ROV *Deep Discoverer* dives were collected to ground-truth the sites within the study area. Two dives were used from 2014 and 2018 expeditions: EX1402L3-Dive02 and EX1803-Dive04.

Figure 2. Durk Basin

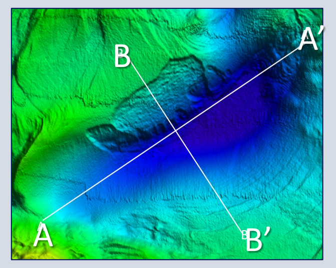




Durk Basin is an example of the geomorphology within West Site. It is characterized by having depths ranging from 1400 to 1000 m with steepest slopes (20°) found on the basin's north side. The basin floor has slopes <6.0°.
Backscatter intensity is highest on the slopes at the base of the basin wall, whereas low intensities occur on thebasin's floor.

(left) 3D images of Durk Basin used to compare bathymetry, classified slope, and classified backscatter intensity. VE=7.0x.

Durk Basin profile line locations (right) for profiles A-A' and B-B' (below). VE=3.3x.



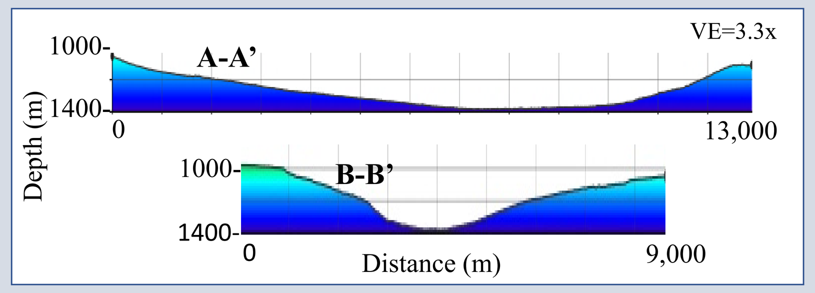
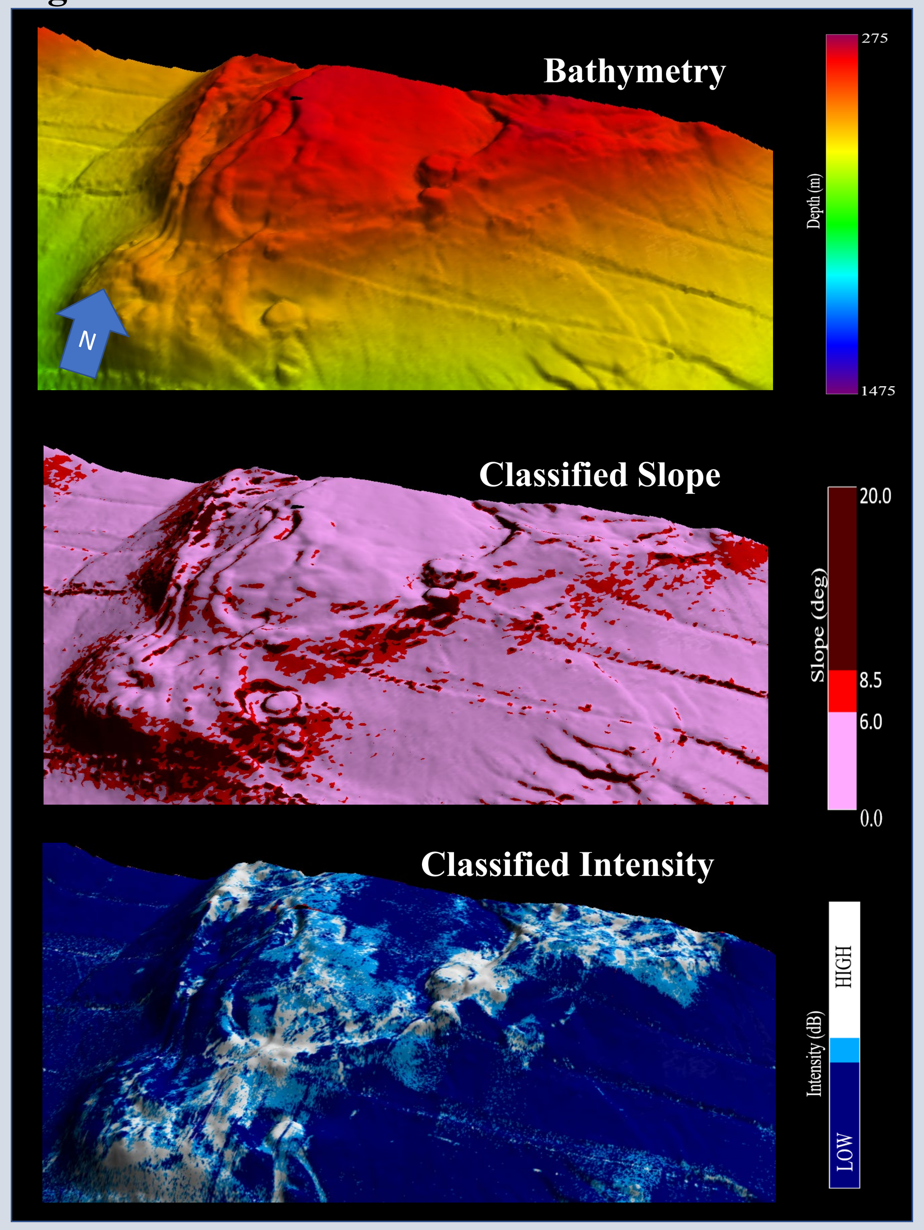
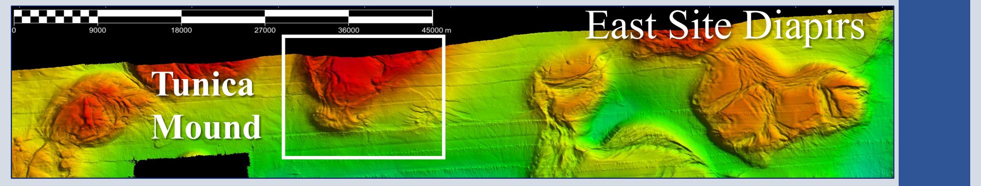


Figure 3. Tunica Mound

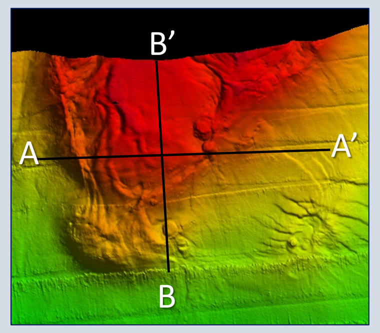




One of three diapirs of East Site examined, Tunica Mound has a vertical relief of 500 m and is at least 15 km long. Flanks are steepest (20°) on the south side, and backscatter intensity is highest on the south slope. Low intensities are found on the top of the mound. Several fractures are evident on the west side and near to the base of the diapir.

(left) 3D images of Tunica Mound using bathymetry, classified slope and classified backscatter intensity surfaces. VE=7.0x.

Tunica Mound profile line locations (right) for profiles A-A' and B-B' (below). VE=3.3x.



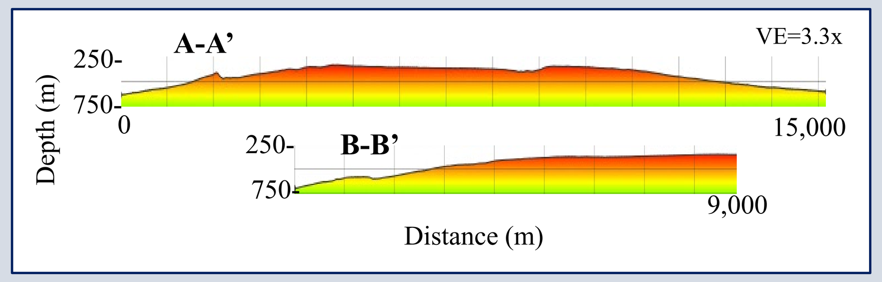
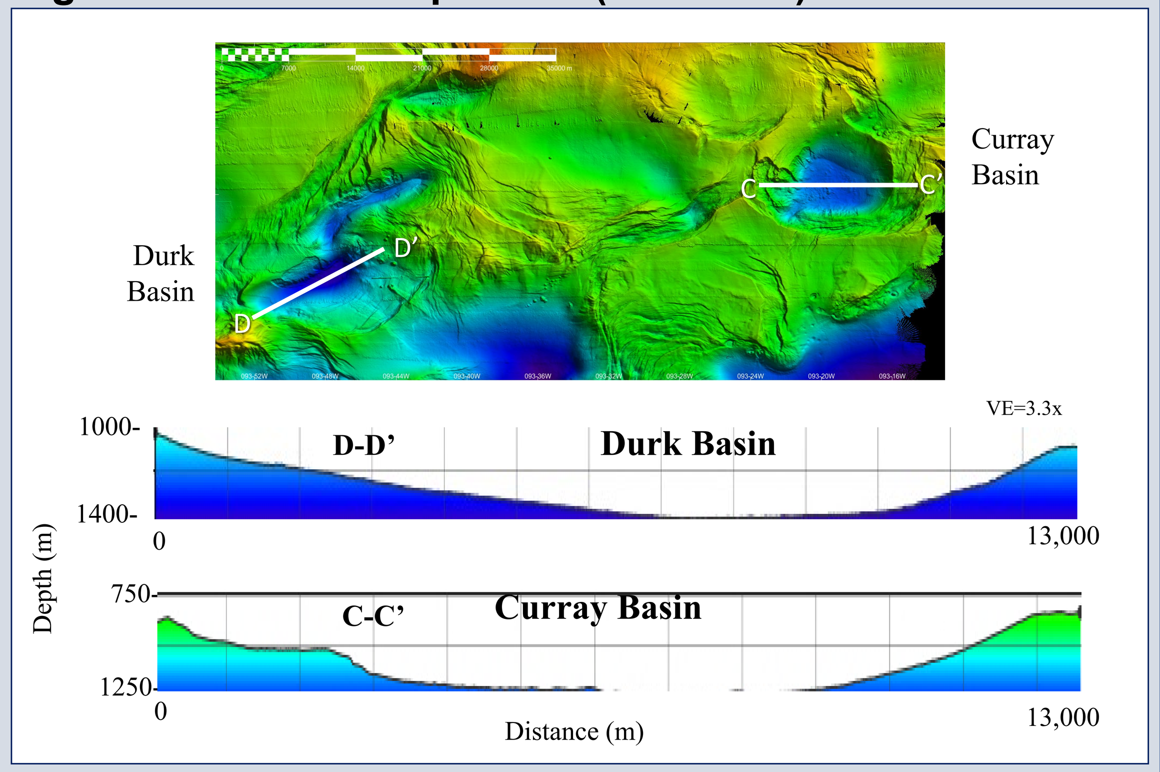
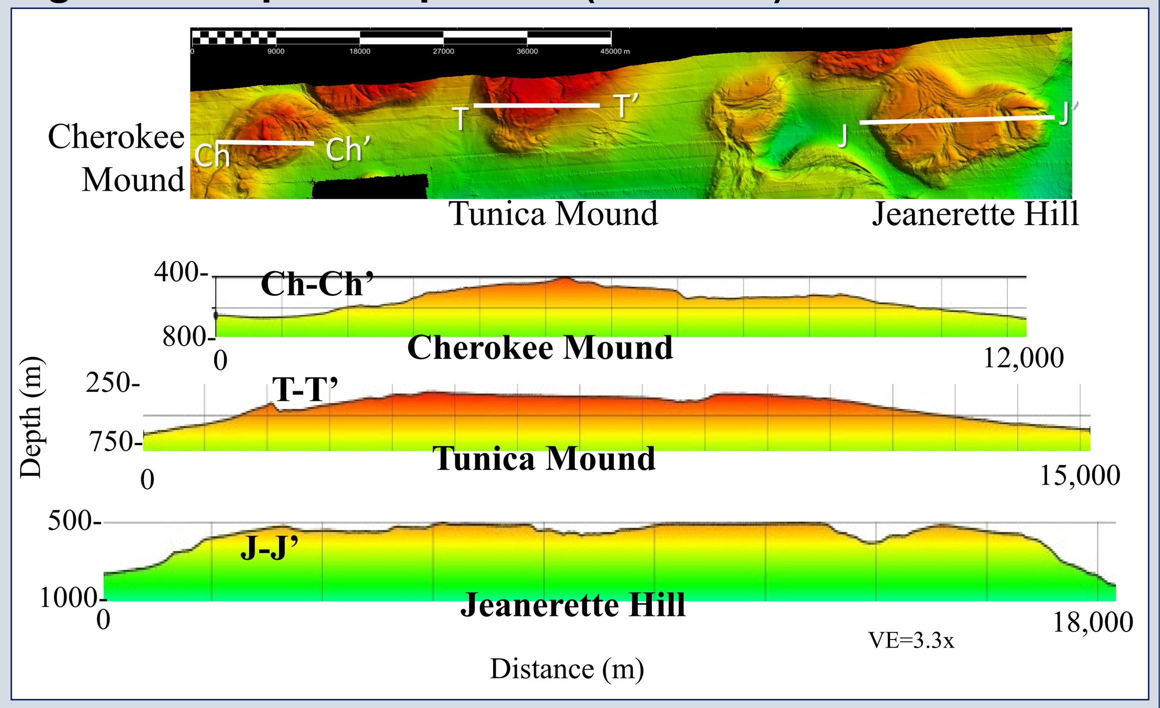


Figure 4. Basin Comparison (West Site)



Basins are most likely a result of the movement of salt beneath the seafloor. High salinity brine pools may be present within these basins, the result of salt dissolution from the seafloor. Methane seeps are also common in these areas, occurring from cracks in the seafloor above oil-producing deposits.

Figure 5. Diapir Comparison (East Site)



Diapir mound profiles (shown at the same scale as Fig. 4 basins) illustrate several fractures, indicating extension likely caused by diapiric expansion as well as weathering and erosion of the mound flanks. Sediment covering the salt diapirs does not compact like normal sediment, so the stress extensions most likely result in runoff of sediment from the mound. Jeanerette Hill is the tallest of the diapirs studied and has the greatest surface area. The shapes and sizes of these structures varies and shows little sign of uniformity.

Figure 6. ROV Images

The goals of the 2018 NOAA expedition were to survey the geological areas in the Gulf of Mexico that have not been studied heavily along with analyzing habitat of deep-sea coral and other biological life. The ROV *Deep Discover* filmed many cold seeps which can be methane or high salinity brines that seep from the seafloor (NOAA, 2018). These cold seeps emit carbon which many seafloor organism feed on, making the biological diversity near these seeps unique.

ROV *Deep Discover* EX1803-Dive04 shows unconsolidated sediment along steep slopes of basins within West Site.

(right) River of brine and cold seeps.

Contact between highly saline brine and regular ocean water. Salt on the seafloor surface begins to dissolve and form these "brine pools" in the deeper basin areas.

DISCUSSION and CONCLUSIONS

Although similar, these diapir mounds as well as the basins vary in size and shape, likely due to the salt deposits located beneath the seabed surface. Salt does not compact like typical sediments; therefore the mounds are shaped by the shifting of salt beneath the surface of the seafloor. The extension fractures evident in each of the diapirs is most likely the result of the diapir expansion and resultant sedimental runoff via bottom currents. Similar features surrounding the basins could be unconsolidated sediment slowly sinking into the basins.
ROV *Deep Discover* video footage and images showed the potential for many undiscovered cold seeps which produce methane and hydrogen sulfide and high salinity brine pools. Some benthic communities thrive in these areas due to the output of carbon which is consumed by some organisms living around the seeps (NOAA,2018). It is important to study these areas to observe the biological ecosystems based around the unique geological features in the area. Also, oil and gas exploration are often associated with salt mounds and methane seeps, so these areas have an economic interest as well. Comparing the geologic features within each study site allows for better understanding of the geomorphology.

REFERENCES

Ballard, R.D. and Uchupi, E, 1970, Morphology and Quaternary History of the Continental Shelf of the Gulf Coast of the United States, Bulletin of Marine Science, volume 20, p. 547-559.
Stern, R.J., Anthony, E.Y., Minghua Ren, Lock, E.B., Norton, I, Jun-Ichi Kimura, Takashi Miyazaki, Takeshi Hanyu, Qing Chang, and Yuka Hirahara, 2011, Southern Louisiana salt dome xenoliths: First glimpse of Jurassic (ca. 160 ma)Gulf of Mexico Crust, Geological Society of America, Geology, p. 315-318.
NOAA, 2018, https://oceanexplorer.noaa.gov/okeanos/explorations/ex1803/logs/summary/welcome.html

ACKNOWLEDGEMENTS

Many thanks to the CofC BEAMS Program in the Dept. of Geology and Environmental Geosciences, and to the School of Sciences and Mathematics. Support to attend this meeting was generously provided by the Matt Christie BEAMS Support Fund.