Characterizing Geomorphologic Features of a Northwestern Portion of the Blake Plateau, Southeast U.S. Continental Margin

Emanuel Byas and Dr. Leslie R. Sautter

Dept. of Geology and Environmental Geosciences, College of Charleston

NOAA Ship *Okeanos Explorer*

ABSTRACT

Multibeam bathymetric surveys were conducted on the southeast U.S. continental margin aboard the NOAA Ship *Okeanos Explorer* by the NOAA Office of Ocean Exploration and Research in May through July, 2018. The purpose of expedition EX1805 was to provide bathymetric data in support of the *Windows to the Deep 2018* expedition, for further exploration by the remotely operated vehicle (ROV) *Deep Discoverer* to analyze deep water coral, sponge, and other benthic-dwelling organisms' habitat. Area 5 of EX1805 is approximately 20 by 40 km and lies 135 km southeast of Charleston, South Carolina, on the northwest portion of the Blake Plateau, with water depths ranging from approximately 320 to 630 m. This area sits directly in the pathway of the Gulf Stream, and has distinct geomorphologic features such as a distinct scour, a few scarps, as well as some sub areas of tilted strata. The purpose of this study is to characterize and interpret various geomorphologic features within the study area by examining the bathymetry, slope, and surfaces. The scour, located to the north of the Study Area (Area 5), is likely an iceberg scour whose channel width increases as the iceberg progressed south. Scarps to the east of the Study Area appear as cliffs, and have a dramatic change in bathymetry. To the south, tilted strata sites were identified by comparing slope and aspect trends.

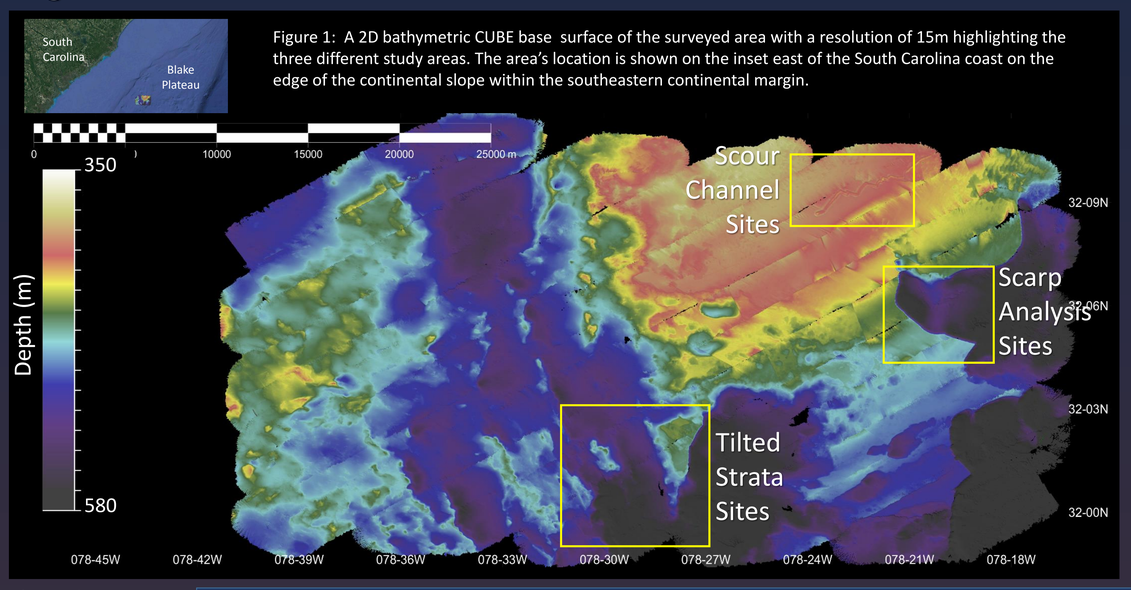


Figure 1: A 2D bathymetric CUBE base surface of the surveyed area with a resolution of 15m highlighting the three different study areas. The area's location is shown on the inset east of the South Carolina coast on the edge of the continental slope within the southeastern continental margin.

BACKGROUND

The southeast continental margin of the United States is unlike most other passive margins found on earth due to the additional extension of the continental slope known as the Blake Plateau. The plateau's extensiveness can be attributed to long-term mid-ocean spreading during the Atlantic Ocean's formation during the Cenozoic time period (Dillion, 1988). The NOAA Ship *Okeanos Explorer* was responsible for conducting two different missions that were part of the *Windows to the Deep 2018* expedition on the margin, including mapping surveys and remotely operated vehicle (ROV) dives. The expedition's mapping cruise EX1805 provided the data for bathymetric surfaces used for planning ROV *Deep Discoverer's* dive locations on EX1806. The expedition's purpose was to acquire a better understanding of benthic communities that reside on the margin, as well as compare regional seafloor geomorphology and interpret possible Gulf Stream influences. In June 2018 "Area 5" (here referred to as the Study Area), a 24 by 40 km zone 135 km east of Charleston, South Carolina was mapped with depths ranging from 310 to 640 m. The purpose of this research is to characterize and interpret various geomorphologic features within the newly mapped Study Area by examining the bathymetry, slope, and aspect surfaces, to determine which are worthy of future exploration.

METHODS

- The NOAA OER *Windows to the Deep 2018* expedition collected multibeam bathymetric data using a Kongsberg EM302 aboard the NOAA Ship *Okeanos Explorer* in June, 2018.
- Tracklines were brought into Qimera 1.7.1 post-processing software to begin the initial process of cleaning severe refraction artifacts using a medium spline correction, as well as the TU Delft Algorithm on a CUBE 11m BASE surface (Figs. 2a and 2b).
- Lines were exported in GSF format to CARIS HIPS and SIPS 11.0 software to construct a 15m CUBE surface.
- Further refraction editing was conducted using HIPS' refraction editor (Fig. 2C).
- Slope and Aspect bands for each of the surfaces were generated.
- Bathymetric profiles were created and used for interpretation of geomorphology.

Refraction Editing Process

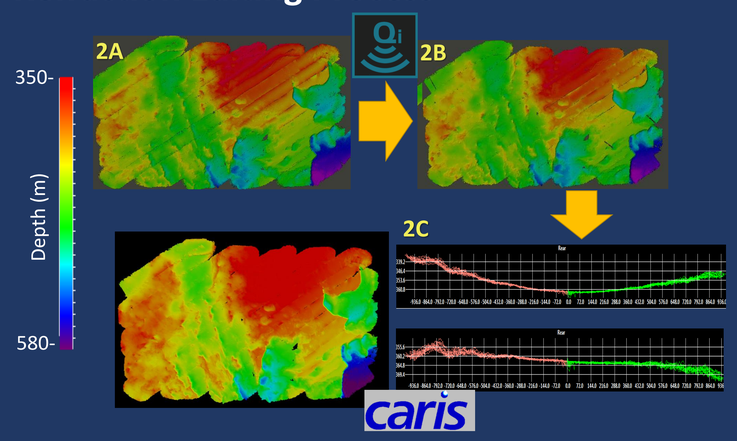
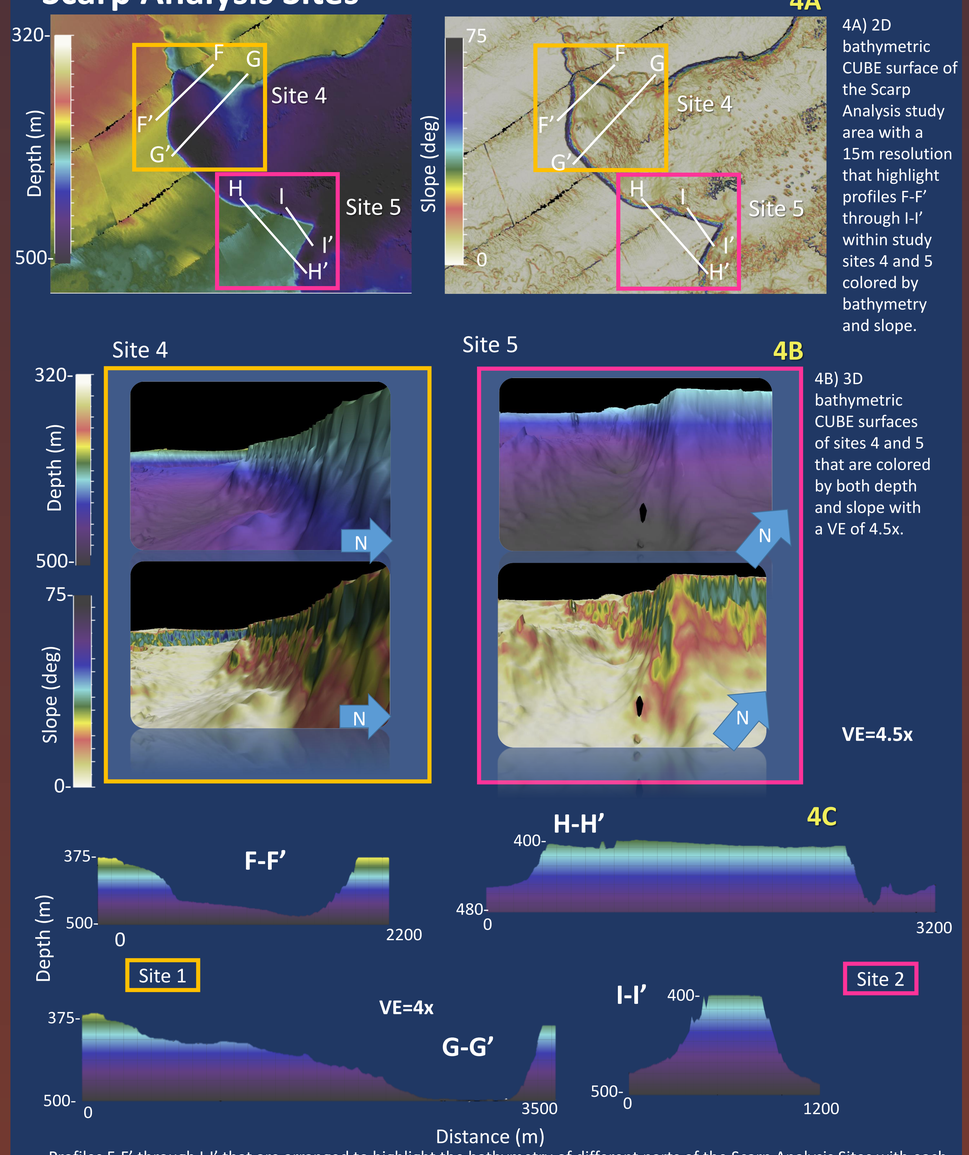


Figure 2:
2A) Uncleaned 2D bathymetric CUBE surface showing significant refraction issues (11 m resolution)
2B) Post-refraction editing and cleaned surface processed tools in Qimera 1.7.1.
2C) CARIS HIPS 11.0 Refraction Editor used to further correct refraction. (15 m resolution)

Scarp Analysis Sites

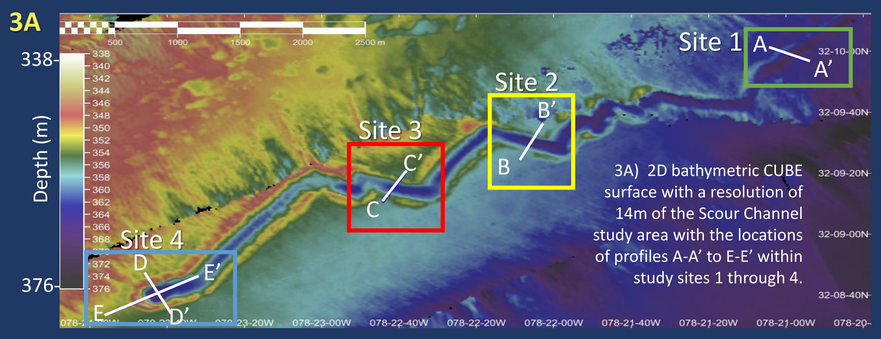


4A) 2D bathymetric CUBE surface of the Scarp Analysis study area with a 15m resolution that highlight profiles F-F' through I-I' within study sites 4 and 5 colored by bathymetry and slope.

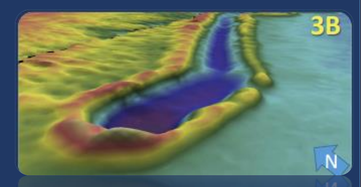
4B) 3D bathymetric CUBE surfaces of sites 4 and 5 that are colored by both depth and slope with a VE of 4.5x.

Profiles F-F' through I-I' that are arranged to highlight the bathymetry of different parts of the Scarp Analysis Sites with each of having a vertical exaggeration of 4.0x.

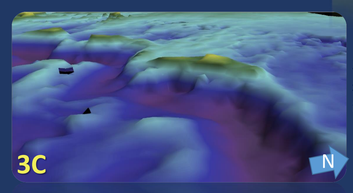
Scour Channel Sites



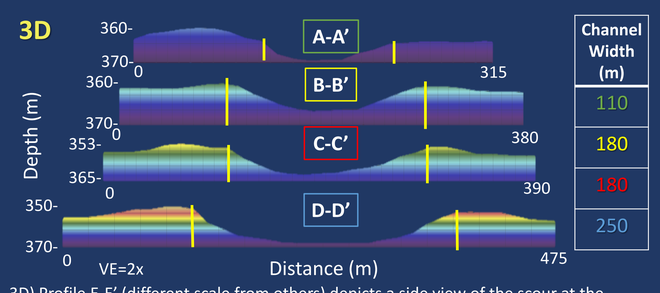
3A) 2D bathymetric CUBE surface with a resolution of 14m of the Scour Channel study area with the locations of profiles A-A' to E-E' within study sites 1 through 4.



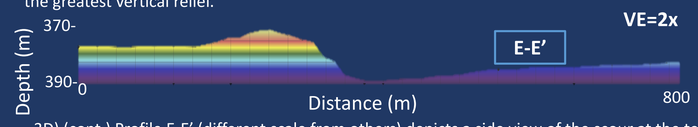
3B) Bathymetric 3D view looking northwest into scour channel that highlights the terminal end. Note the raised ridges at each side of the scour.



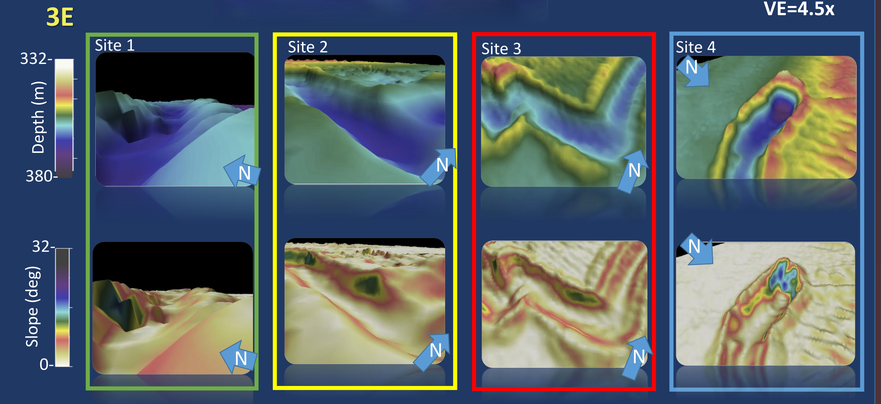
3C) Bathymetric 3D view looking slightly east of Site 2 that highlights the bending shape of the scour.



3D) Profile E-E' (different scale from others) depicts a side view of the scour at the termination point. VE=2.0x. As a side view of the terminal end of the scour, this highlight the greatest vertical relief.

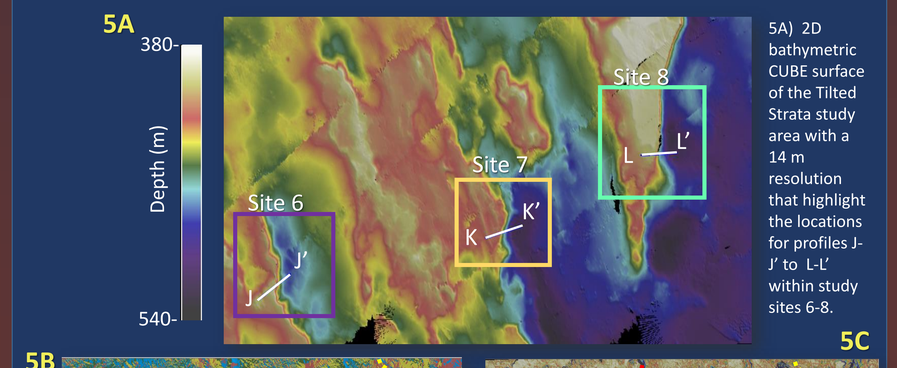


3D) (cont.) Profile E-E' (different scale from others) depicts a side view of the scour at the termination point. VE=2.0x. As a side view of the terminal end of the scour, this highlight the greatest vertical relief.

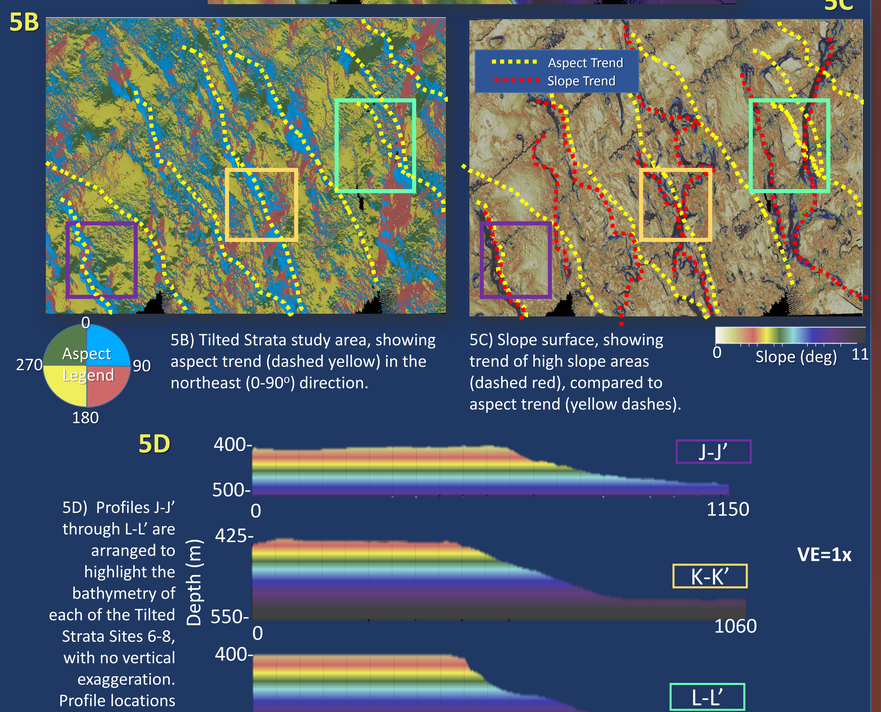


3E) Bathymetric 3D CUBE surfaces and slope surfaces of sites 1 through 4 (VE= 4.5x). Site 1 to site 4 highlights the progressive track of the scour.

Tilted Strata Sites



5A) 2D bathymetric CUBE surface of the Tilted Strata study area with a 14 m resolution that highlight the locations for profiles J-J' to L-L' within study sites 6-8.



5B) Tilted Strata study area, showing aspect trend (dashed yellow) in the northeast (0-90°) direction.

5C) Slope surface, showing trend of high slope areas (dashed red), compared to aspect trend (yellow dashes).

5D) Profiles J-J' through L-L' are arranged to highlight the bathymetry of each of the Tilted Strata Sites 6-8, with no vertical exaggeration. Profile locations shown in Fig. 5A.

Results and Interpretations

Scour Channel Sites:

- The width of the scour channel increases, from north to south, the deepest part of the channel is around 365 m (fig. 3D).
- The southernmost site is the terminal end of the scour has the greatest vertical relief of 20 m.
- Interpretation: Based on the scour's geomorphology, it is evident that the area was carved by a free drifting iceberg just prior to the last glacial period (Jakobsson et al., 2012), which had a sea level that was around 120 m below current level (Fairbanks, 1989), and occurred approximately 18,000 years ago. The iceberg must have drifted from wave or wind currents, creating a number a straight grooves in the soft sediment (Linch et al., 2012). Previously studied iceberg scours have been known to be preserved in water depths no greater than 500 m, hundreds of meters wide, and tens of meters deep, which is also true about the scour interpreted for this project.

Scarp Analysis Sites:

- Most of the seafloor for these sites, has slopes between 0 and 8°, while most of the scarps have slopes that are greater than 10° (fig. 4A). The scarps cause a dramatic change in bathymetry in an area that appears as relatively steep drop-offs, particularly when exaggerated (fig. 4B)
- Interpretation: Long-term rifting has been occurring in the Atlantic Ocean since the beginning of its formation around 136 MYA. As the ocean crust diverges, a series of normal faults result, causing blocks of crust to subside due to gravity (Juliani, 2019).

Tilted Strata Sites:

- There is a trend of similarly dipping bathymetry in this area, where aspect ranges between 0 and 90° (fig. 5b). When colored by slope, there are linear patterns with slopes above 8° that follow a similar pattern to the aspect trend (fig. 5C)
- Interpretation: Since it is apparent that the slope trend follows a similar path as the aspect trend, it can be assumed that these are exposed beds of the same strata.

Conclusions

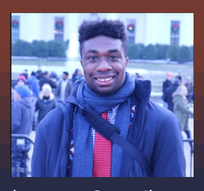
A variety of unique geomorphologic features occurs in this newly mapped area of the Blake Plateau. An iceberg was the likely cause of the Scour Channel Sites, determined by the channel morphology which matches previously studied areas. As a result of the Atlantic Ocean's long-term spreading, it would be no surprise to find numerous other scarps in other areas throughout different basins. Finally, not only are there exposed strata at different depths in this Study Area, but these layers are tilted with fault-produced scarps trending similarly. Because of the severe refraction issue, backscatter intensity was not accounted for this project, so future mapping surveys maybe considered for further exploration in order to further understand the type of sediment that may be present in this area, as well as High-relief areas that may be a potential for hosting benthic habitats.

REFERENCES

- Dillon, W. P., & Popenoe, P. (1988). The Blake Plateau Basin and Carolina Trough. *The Atlantic Continental Margin,* 291-328. doi:10.1130/dnag-gna-i2.291
- Jakobsson, M., Vogt, P., Mayer, L., and Armstrong, A., 2012, Multibeam bathymetric and sediment profiler evidences for ice grounding and crater on the Chukchi and Beaufort borderland, Arctic Ocean: Quaternary International, v. 279-280, p. 506–507, doi: 10.1016/j.quaint.2012.08.1741.
- Juliani, C., 2019, Automated discrimination of fault scarps along an Arctic mid-ocean ridge using neural networks: Computers & Geosciences, v. 124, p. 27–36, doi: 10.1016/j.cageo.2018.12.010.
- Linch, L.D., Meer, J.J.V.D., and Menzies, J., 2012, Micromorphology of iceberg scour in clays: Glacial Lake Agassiz, Manitoba, Canada: Quaternary Science Reviews, v. 55, p. 125–144, doi: 10.1016/j.quascirev.2012.07.008.

ACKNOWLEDGEMENTS

This research would not have been possible without the necessary tools and data supplied by the hardworking men and women of the Windows to the Deep 2018 expedition team. Many thanks to Dr. Leslie Sautter, for her continued support in my training towards the field of oceanography, as well as my fellow BEAMers for their continued support. Additionally, many thanks goes out to Josh Mode of CARIS for his vital contributions to the BEAMS Program, as well as Samm Bruce of QPS for her help with my exposure to Qimera. Finally, we would like to thank both QPS and CARIS for their continued Academic Partnerships, and the support from the CofC School of Science & Math and Department of Geology. This project was conducted as part of the College of Charleston BEAMS Program.



byasmre@gmail.com

Contact Me!