Characterizing Scarp Geomorphology of the Central Blake Plateau, Southeast U.S. Continental Margin

Savannah Evans and Dr. Leslie R. Sautter

Department of Geology and Environmental Geosciences, College of Charleston

College of Charleston — Department of Geology and Environmental Geosciences — BEAMS

evanssj@g.cofc.edu and SautterL@cofc.edu

METHODS

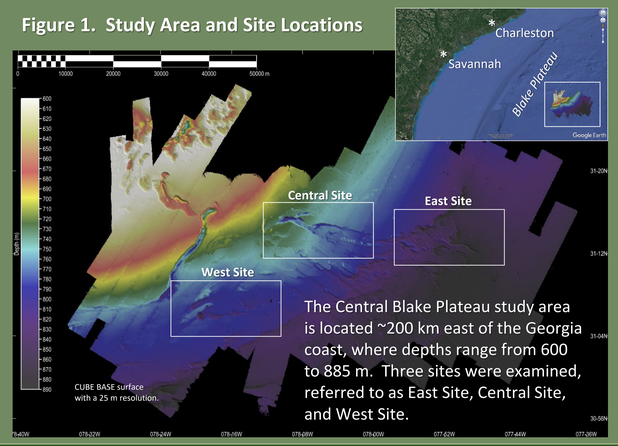
- Multibeam sonar data were collected by NOAA Ocean Exploration on cruise EX2107 (October 2021) from aboard the NOAA Ship *Okeanos Explorer*. A Kongsberg EM304 sonar was used.
- CARIS HIPS & SIPS 11.4 was used to post-process raw multibeam sonar data and to render 25 m and 40 m resolution CUBE bathymetric, slope, and aspect surfaces.
- Depth profiles were made to compare and characterize scarp geomorphology.
- Slopes and vertical relief were measured and compared.
- HD video footage from EX1903-Dive 08 collected by the ROV *Deep Discover* was used to examine similar scarps.

BACKGROUND

The Blake Plateau is mostly a flat expanse of the upper portion of the continental slope that has been sculpted by the Gulf Stream (Popenoe and Manheim, 2001, as cited in Ross, 2007). The plateau is located roughly 200 km off the southeastern US coast, where depths range from 500 to 1,200 m. Recent high-resolution mapping of Central Blake Plateau has revealed broad canyons with cliff-like scarps and hundreds of deep-sea coral mounds (Fig. 1). These canyons and scarps were likely formed originally by faulting and then by erosion from sediment-transporting turbidity currents (NOAA, 2013).

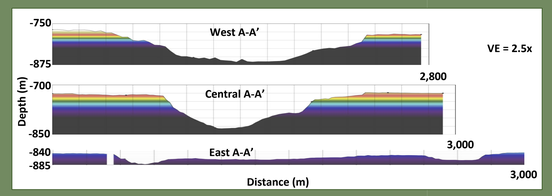
The NOAA Ship *Okeanos Explorer* collected multibeam sonar data in the Blake Plateau during the *Windows to the Deep 2021 Southeast U.S. ROV and Mapping* expedition (EX2107). Sonar data along with ROV *Deep Discover* dive footage from EX1903L2 were used to characterize geologic features and benthic habitats. The purpose of this study is to compare scarp geomorphology throughout three study sites, here referred to as West Site, Central Site, and East Site. Czwalina and Sautter (2020) examined several scarps in the same region, and there appears to be a trend relating the scarps' wall steepness to whether the wall's location is on the northern or southern side of the scarp. Though not the focus of the study, the 3D surfaces reveal northern rims to have steeper slopes than those of the southern rims.

Figure 1. Study Area and Site Locations



The Central Blake Plateau study area is located ~200 km east of the Georgia coast, where depths range from 600 to 885 m. Three sites were examined, referred to as East Site, Central Site, and West Site.

Figure 6. Comparative profiles



(above) Flat plains drop into relatively steep scarps in all sites. West Site's scarp, while more circular than the other sites' scarps, is the least symmetric cross-canyon. Central Site's scarp has steeper walls than the scarps of other two sites. East Site contains two scarps that have erosion in between. It may be forming a circular scarp like in West Site.

(right) Profiles A-A' for each site (blue lines) illustrate geomorphology across canyons. Profiles B-B' through E-E' (yellow lines) indicate northern rims, and profiles S-S' through U-U' depict southern rims.

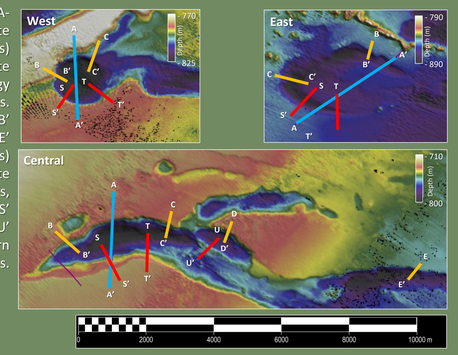
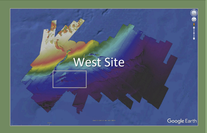
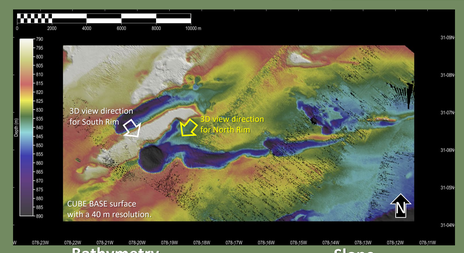


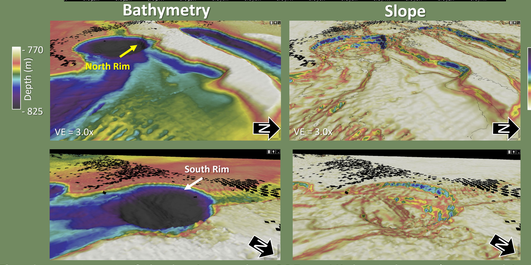
Figure 2. West Site

West Site of the study area ranges from 770 to 825 m depth. It has a notably circular depression and a small plateau between it and another scarp but is otherwise surrounded by a flat surface.



Note that depth scales vary among sites

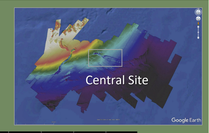




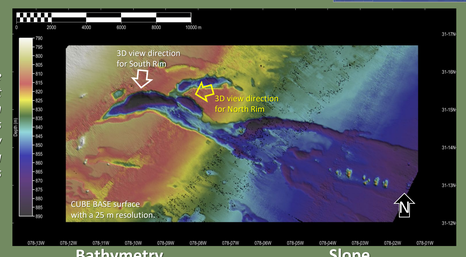
The deepest part of the basin reaches 825 m. Highest slopes (approaching 25º) are on the northern rim where the edge of the depression meets the plateau. The southern rim is more of a gradual rise but has similar maximum slopes. The basin is almost perfectly circular, but there appears to be a channel running northwest to southeast.

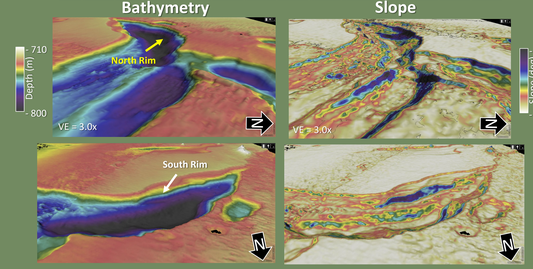
Figure 3. Central Site

Central Site ranges in depth from 710 to 800 m. The scarp in this area is a deep gash that has wall slopes of almost 25 º. Smaller scarps surround it.



Note that depth scales vary among sites

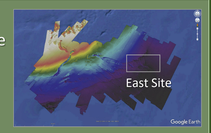




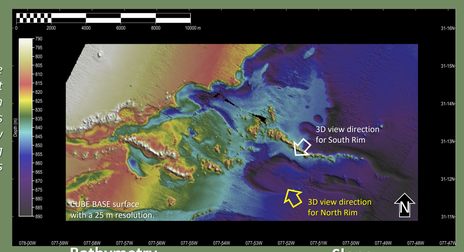
The scarp generally has steeper slopes on its northern wall where angles reach 25º, but there is one portion of the southern rim that reaches 25º as well. The vertical relief of 100 m is greater here than scarps of the other study sites. These scarps are sudden dips in an entirely flat surface.

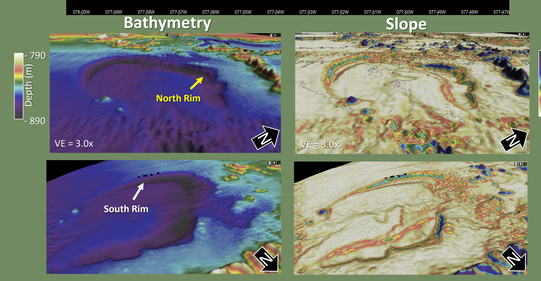
Figure 4. East Site

East Site includes a horseshoe-shaped feature made of two scarps that are surrounded by a flat surface. This area includes several deep-sea coral mound chains and signs of erosion. Depths range from 790 to 890 m deep.



Note that depth scales vary among sites

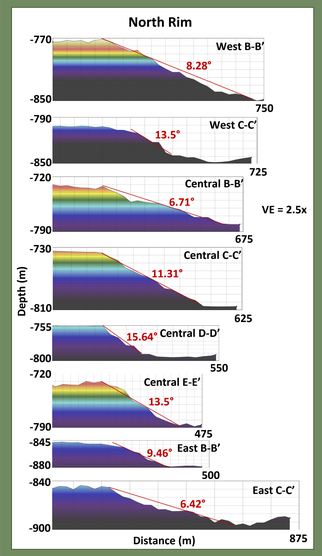




The steepest slope (25º) is on the northwestern rim of the northernmost scarp. The southern rims rise more gradually, a trend that is similar among all study sites. Erosion appears to be occurring on each side of the basin.

(below) Scarp depth profiles illustrate that while the northern rims tend to have long and relatively continuous stretches of similar slope from scarp ledge to its base, southern rims tend to be terraced, made up of both very high slopes (8.53 – 23.96 º) and low slopes (0.41 – 1.91º). This trend is present at all sites.

VE=2.5x. Note that depth color scales vary by site.



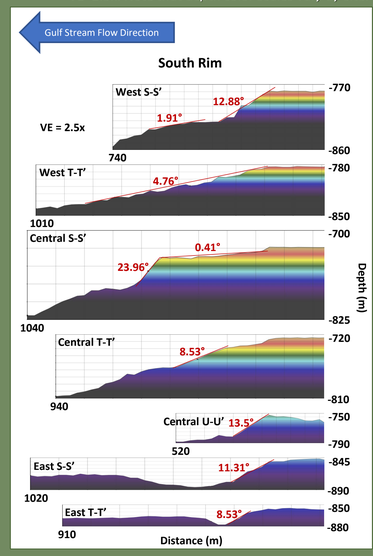
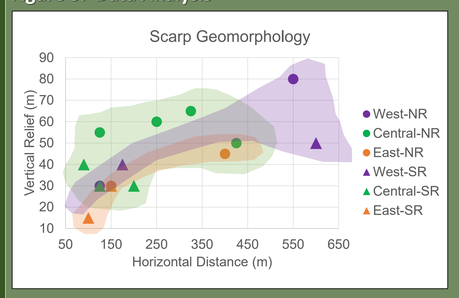


Figure 5. Data Analysis



(left) North rims (circles) have higher vertical reliefs than south rims (triangles).

(right) Central Site (green bars) has the three steepest slopes, between 13.5 and 23.96 º. Most slopes range from 4.76 to 13.5 º.

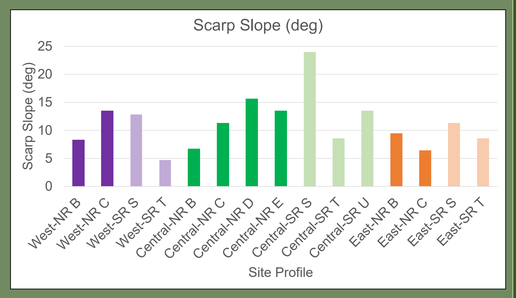
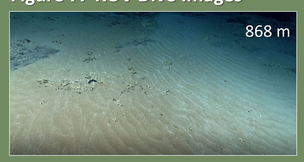
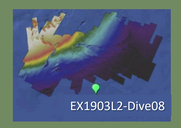


Figure 7. ROV Dive Images





Czwalina and Sautter (2020) used HD video collected by the ROV Deep Discoverer from EX1903L2-Dive 08, located just outside of the study area. Footage reveals wide, flat stretches of unconsolidated sediments with ripple marks at shallower depths and slopes covered in rocky rubble at deeper depths.

SUMMARY

Data collected from the bathymetric and slope surfaces revealed a key difference between the northern and southern rims. Where the northern rims tend to be steep dips in the flat expanse around the scarps, the southern rims tend to have more gradual or terraced edges. The southern rims are also made up of both the steepest and gentlest slopes in smaller sections whereas the northern rims tend to have a moderately high slope from top to bottom.

The vertical reliefs of the northern rims range from 30 to 80 m while southern rims only range from 15 to 50 m. Bathymetric surfaces and scarp depth profiles examined by Czwalina and Sautter (2020)'s show that four additional scarps from the Central Blake Plateau south of our study also have steep northern rims with more gradual slopes on their southern rims.

The flat plains surrounding the scarps are made up of sandy unconsolidated sediments with ripple marks whereas the scarps are harder substrate and rocky rubble, which is likely due to the faulting. Scarp profiles on the north vs. south rims of these canyons indicate that the faulting that formed the canyons exposed the northern scarp rims to further erosion from the north-flowing Gulf Stream. The stream likely hits the northern rims and smooths them out while the southern rims are protected by the angle. Therefore, the terracing of the flat-laying rock layers from the original faulting is still visible in the southern rims.

REFERENCES

- Czwalina, S. and Sautter, L. 2020. Analysis of Scarp Geomorphology Along the Southeast Continental Margin of the Blake Plateau. (CofC BEAMS Program)
- Popenoe, P. & Manheim, F.T.. (2001). Origin and history of the Charleston Bump - Geological formations, currents, bottom conditions, and their relationship to wreckfish habitats on the Blake Plateau. American Fisheries Society Symposium. 25. 43-94.
- Ross, S.W. 2007. Unique deep-water ecosystems off the southeastern United States. *Oceanography* 20(4):130–139, https://doi.org/10.5670/oceanog.2007.13.
- US Department of Commerce, NOAA (2013, June 1). *What is a turbidity current?* NOAA's National Ocean Service. Retrieved March 20, 2022, from https://oceanservice.noaa.gov/facts/turbidity.html#:~:text=A%20turbidity%20current%20is%20a,slopes%2C%20and%20other%20geological%20disturbances.

ACKNOWLEDGEMENTS

This research would not have been possible without NOAA OER and the crew of the NOAA Ship *Okeanos Explorer*. Additionally, we would like to thank CARIS for Academic Partnership, and the support from the CofC School of Science & Math and Dept. of Geology and Environmental Geosciences. This project was conducted as a part of the College of Charleston BEAMS Program. Support to attend this meeting was generously provided by the Matt Christie BEAMS Support Fund.