Bathymetry of Cayman Trench, between the Cayman Ridge and Nicaragua Rise

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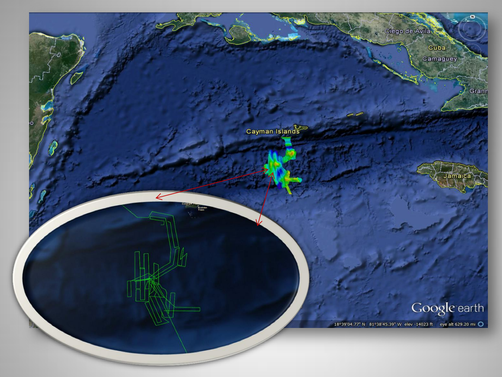


Figure 1. The Cayman Trench is located due South of the Cayman Islands, between the Cayman Ridge to the North and the Nicaragua Ridge to the South.

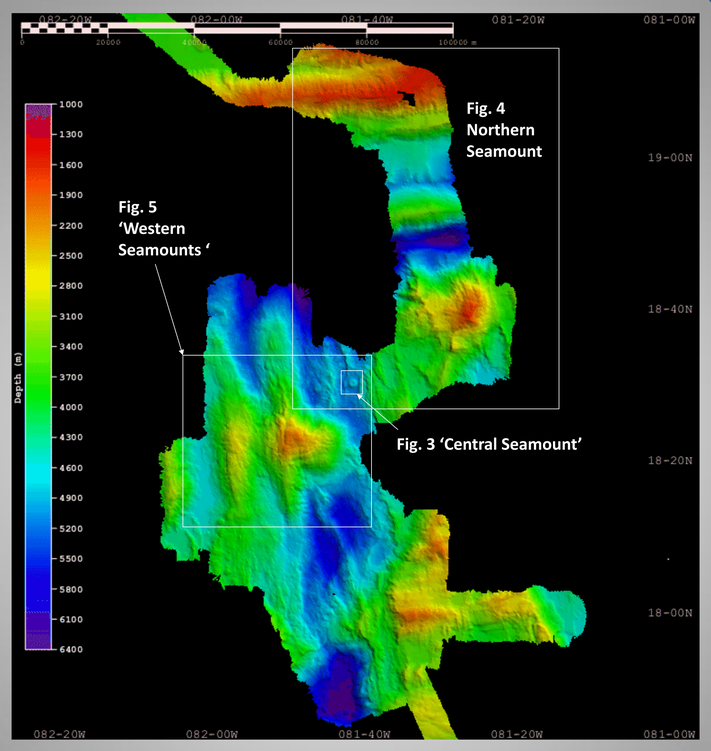


Figure 2. 2-D representation of the BASE surface of Cayman Trench. White boxes show locations for Figures 3-5.

ABSTRACT

The Cayman Trench (or Trough) is located in the Western Caribbean Sea between Jamaica and the Cayman Islands. The site is renowned for geologic complexity; it is both a transform fault zone and a 'pull-apart' basin which produces many geological features. Within the trench lies a spreading zone, at a depth of between 4000 and 5000 m, bordering the North American and Caribbean Plates. Bathymetric data were gathered using Kongsberg EM302 multibeam sonar aboard the NOAA Ship *Okeanos Explorer* in 2011, and processed using CARIS HIPS and SIPS 7.1 to illustrate bathymetry of the Cayman Trench region. These data show the longitudinal profile of the Cayman Trench as well as the trench's rise, to the south. A bathymetric 3-D map of the Cayman Trench provides information that hydrogeologists and geophysicists can use; the detailed bathymetry identifies essential sites to better understand the subsurface geology.

INTRODUCTION

The Cayman Trench, colloquially known as Cayman Trough, is a seismically active submarine depression (Stoddart, 1980). This depression produces startling features along the rise of the trench such as pull-apart basin characteristics, transform fault zones, and most notably, a small spreading ridge located several hundred miles east of Jamaica (Perfit, 1977). The Cayman Trench is referred to as a "zone of convenience," providing a parcel of the seafloor where lithospheric plates can couple, decouple, subduct, and translate. Translation is predominantly in the form of a left-lateral strike-slip fault. Spreading has been recorded at an average of 0.4 cm/yr, with a measured 0.6 cm/yr of subsidence (Perfit and Heezen, 1978).

The Cayman Trench is approximately 1600 km in length and more than 100 km wide, stretching from immediately east of the Gulf of Honduras westward into Central America as the Polochic-Motagua fault zone. A series of rugged, steep north-south trending ridges transect the Trench in most areas (Perfit, 1977). The graben-like nature of the 120 to 180 km wide midsection of the Cayman Trench is bounded on the north by the Cayman Ridge and to the south by the Nicaraguan Ridge. A series of deep basins, referred to as "deeps," include the Oriente, the Bartlett, and Swan fracture zones (Perfit and Heezen, 1978).

There are pull-apart features associated with the seamounts, which hint at extension. A series of graben-like formations comprise this area and were examined more closely to identify geological complexity. This study alleviates some of the properties of these remarkable geologic features.

'North Seamount'

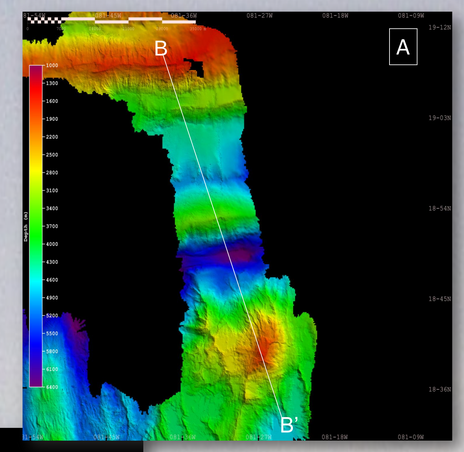
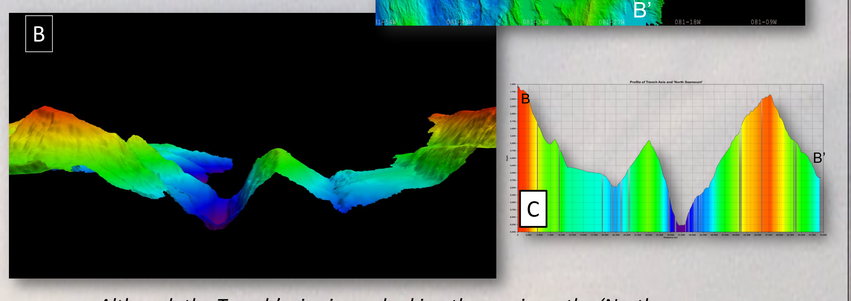


Figure 4.
A) 2-D representation of the axis of Cayman Trench and its accompanying, 'North', seamount.
B) 3-D of the axis of Cayman Trench and 'North' Seamount. VE=2.6x.
C) Depth profile B-B' depicting the changes in bathymetry from the axis of Cayman Trench to 'North' Seamount. Depth range is 1500 to 6500 m.



Although the Trench's rise is gradual in other regions, the 'North Seamount' seems anomalous as it reaches nearly the same height as the Ridge to the North.

'Western Seamounts'

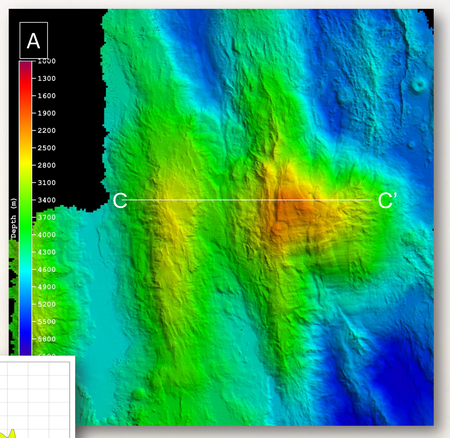
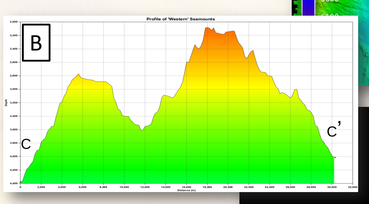
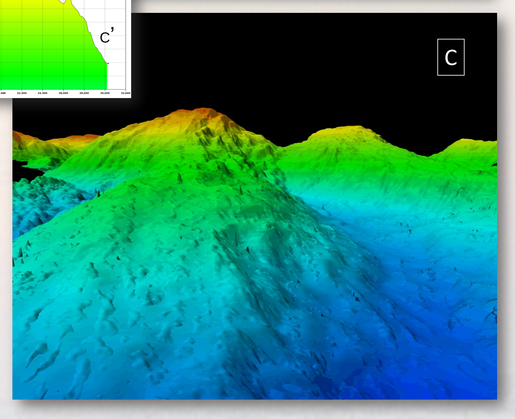


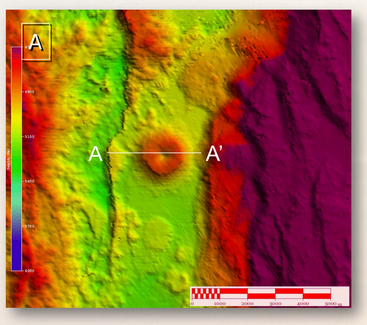
Figure 5.
A) 2-D representation of the 'Western' Seamounts.
B) Depth profile C-C' (shown in A) of the 'Western' Seamounts. Depth range is 2000 to 4400 m.
C) 3-D representation of the 'Western' Seamounts, viewed looking from the North. VE=2.4x.





These features are perpendicularly oriented N-S to the Trench's axis, which hint at extension. There are magmatics underneath, topping the seamounts between 2100 and 2800 m.

'Central Seamount'



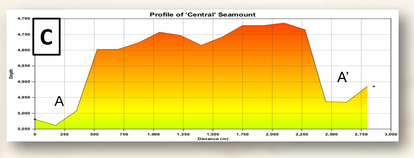
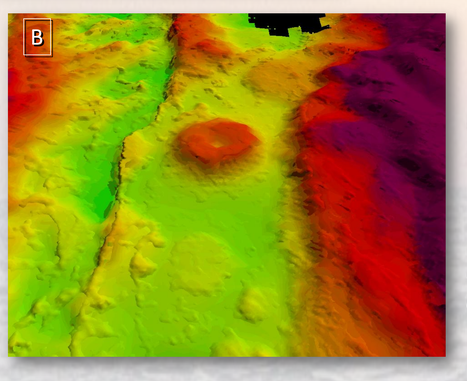


Figure 3.
(Note the depth scale change used to emphasize the feature.)

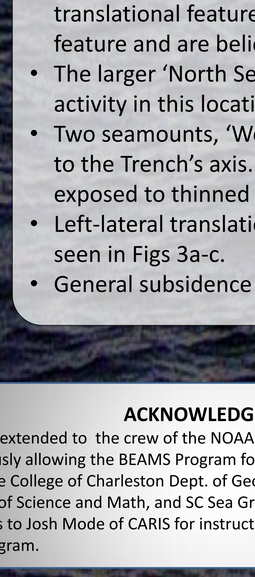


A) 2-D representation of the 'Central Seamount' located south of the Cayman Trench axis.
B) 3-D representation of the 'Central' Seamount. VE=0.76x.
C) Depth profile A-A' across the 'Central' Seamount using CARIS profiler. Depth range is 4700 to 5500 m.

This seamount is located between two ridges, perhaps part of a graben-like structure, which is perpendicular to the Trench axis.

METHODS

- Multibeam data were acquired on the *NOAA Ship OKEANOS EXPLORER*, August 4-16, 2011
- A Kongsberg EM302; hull-mounted transducer, multibeam sonar system was used.
- 35 and 200 m resolution CUBE BASE surfaces were created using CARIS HIPS & SIPS 7.1.
- CARIS BASE Editor 2.0 was used to create a .kmz file for the Google Earth Satellite Image overlay.



NOAA Ship *Okeanos Explorer*

RESULTS AND DISCUSSION

- A small, concentric seamount, the 'Central Seamount' (Figs. 3a-c), was observed to be ~300 m tall and a direct product of the translational features found flanking either side of the seamount. Other smaller seamounts resulted from this translational feature and are believed to be a product of crustal thinning and magmatics in that region.
- The larger 'North Seamount' (Figs. 4a-c) is immediately south of the Cayman Trench's axis and represents increased magmatic activity in this location. The dimensions of this seamount are 2850 m tall by 25,500 m long.
- Two seamounts, 'Western Seamounts' (Figs. 5a-c), are complex in orientation since they are approximately perpendicular (N-S) to the Trench's axis. This may be due to decoupling in the Piccard Basement Rocks which have been prone to 'pull-apart' when exposed to thinned crust and magmatics.
- Left-lateral translation dominates the area and has produced small extensional rifts (Perfit, 1977). Evidence for these rifts can be seen in Figs 3a-c.
- General subsidence is cause by declining isotherms, and causes depressions in the bathymetry (Figs. 6a-c) (Stoddart, 1980).

Additional Features

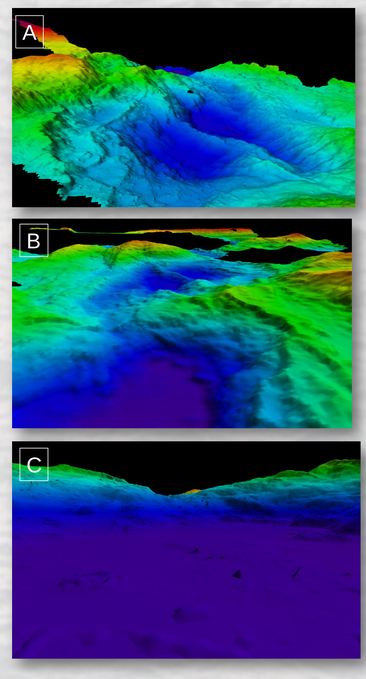


Figure 6.
A) A view from the north looking at the southern reaches of the survey. VE=2.4x.
B) View looking north, still centered on the southern reaches to emphasize features. VE=1.7x.
C) An abyssal feature that is almost at the same depth (~6100 m) as the trench located in the southern reaches. VE=1.7x

This region adds to the geologic complexity of the Cayman Trench. There are distinct ridges that may indicate divergence but most studies suggest graben-formations. Faulting and decoupling may be a factor in producing these features.

ACKNOWLEDGEMENTS

Thanks are extended to the crew of the NOAA Ship *OKEANOS EXPLORER* and NOAA for generously allowing the BEAMS Program for using their data. We would also like to thank the College of Charleston Dept. of Geology and Environmental Geosciences, the School of Science and Math, and SC Sea Grant for travel support. Finally, a special thanks goes to Josh Mode of CARIS for instructing this invaluable technology to the BEAMS Program.

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