Geomorphology of Submarine Canyons and Related Slope Features along the Eastern New England Continental Margin, USA

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Abstract

Multibeam sonar data of submarine canyons and slump features was analyzed along a 390 km segment of the Eastern New England continental margin. Submarine canyons are erosional features located on continental margins that transport sediments from shelf regions to the deep ocean. Major slumping along the margin can alter seafloor morphology and has the ability to generate dangerous tsunamis. In the study area, eight incised canyons and numerous slope canyons were identified, from Veach Canyon to Munson Canyon. Incised canyons were classified based on canyon length, relief, sinuosity, and general morphology. In between incised canyons, the study area displays a transition between areas of dominant slump features to areas dominated by slope canyons. All incised canyons narrowed in width as depth increased. However, Hydrographer and Lydiana canyons had the highest degrees of sinuosity and canyon width increased before ultimately narrowing as depth increased.

Methods

Kongsberg EM302 multi-beam sonar data collected by the NOAA Ship Okeanos Explorer was downloaded from NOAA National Geophysical Data Center for cruises EX1204, EX1206, EX1301, EX1304, EX1305 and 1. 

- Data were post-processed in CARIS HIPS 8.1 and 10 m resolution CUBE BASE surfaces were generated.
- CARIS 8.1 distance and profile tools were used to provide quantitative analyses.

Introduction

Classifying continental margins around the globe is an important task, as tsunamis can be generated by displacement which occurs during slope failures. The submarine canyons along the eastern New England Margin (Figure 1) were surveyed by the NOAA Ship Okeanos Explorer during 2012 and 2013. The study area stretches from Veach Canyon to Munson Canyon, on the east coast of the U.S. continental margin. The New England Continental Margin is a passive margin characterized by this shelf, slope, and rise physiographic provinces (Laughton et al., 1978). Passive margins evolve through continental rifting, seafloor spreading, and post rift evolution. The New England Margin was glacially influenced, which increased the amount of sediment deposited on the continental margin (Twichell et al., 2009). Submarine canyons form from sediment flow and turbidity currents, which allow for sediment transport from the continent to the deep sea (Brothers et al., 2013). Two types of canyons in the study area have been classified: incised canyons and slope canyons. Incised canyons are significantly longer and begin on the inner to mid-continental shelf, continuing to the continental slope and rise, whereas slope canyons originate on the continental slope, and may continue onto the rise. Larger incised canyons allow for greater sediment transport than smaller slope canyons. Slumps are features formed by mass flows of sediment and are more commonly associated with slope canyons (Brothers et al., 2012). Large scale slumping events can generate tsunamis due to mass displacement (Driscoll et al., 2000).

Results

- The study area consists of 8 incised canyons and 74 slope canyons.
- Hydrographer and Munson Canyons are the longest, each with cumulative distances >5 km (Figure 4).
- The width of Powell Canyon, and Munson Canyon have the smallest degrees of sinuosity (Table 1).
- Powell Canyon and Munson Canyon display dramatically higher vertical relief between the 400 m and 800 m isobaths, but generally all canyons show a similar vertical relief in the deeper isobaths (Figure 5).
- There is a general increase in the wall width as depth increases (Figure 4).
- Munson Canyon has the greatest depth (864 m), whereas Veach Canyon is shallowest (513 m) (Table 3).
- Major slumping is observed west of Veach canyon and on the east side of Munson Canyon, with slope canyons dominating interbenthic.

Discussion & Conclusion

There are eight incised canyons and seventy-four slope canyons on the eastern New England Margin (Figure 2). The incised canyons have average slopes near to or exceeding 4°, defined as a deep gradient, likely influenced by an underlying steep continental slope (Pratson, 2001). Widths of the mid to distal canyons increase with depth, correlating to the increase in canyon gradient (Figure 4 and Figure 6). Hydrographer Canyon and Lydiana Canyon have the highest degrees of sinuosity (Table 3), and do not display continuous narrowing with depth, unlike the other canyons (Table 3 and Figure 6). This fluctuation in canyon width may be caused by sinuosity. All canyons in the study area display a similar vertical relief beginning at the 1200 m isobath, where canyon begin to flatten out on the continental rise likely due to the depth and slope (Figure 5). Powell Canyon and Munson Canyon display a very steep vertical relief in the 400 to m 800 m isobath portions of the canyon, perhaps due to certain characteristics in this location not explored in this study, such as substrate hardness.

The area between Veach Canyon and Oceanographer Canyon shows a transition in canyon morphology, changing from an area of dominant slump features to an area dominated with slope canyons (Figure 7 and Figure 8). This transition in submarine canyon geomorphology likely correlates to the degree of substrate hardness increasing from west to east. Oceanographer Canyon is interpreted as having the hardest substrate of the canyons, based on backscatter data interpreted by Norvell and Sautter (2013). Slumping observed near Munson Canyon likely indicates a reduction of substrate moving eastward on the margin, similar to the transition observed adjacent to Veach Canyon. Further research must be conducted to verify interpretations on slumping and substrate hardness.

References cited


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Figure 1. Image of the New England Margin highlighting study area with boxes 1 & 2 shown in the composite BASE surface (Fig. 2). Pink lines indicate western study area of the margin discussed by Rollings & Tyson.

Figure 2. Composite CUBE BASE surface of study area with labeled incised canyons.

Figure 3 (above). CUBE BASE surface of Gilbert Canyon. Profiles of each canyon (Fig. 4) were made by measuring along-ax of the canyon (X to X'). Cross-sections of each canyon were produced by measuring across the axis starting and ending at the isobath depths of 400m (A-A'), 800m (B-B') 1200m (C-C'), 1600m (D-D'), and 2000m (E-E').

Figure 4 (above). Profiles were generated along the axis of each incised canyon in the study area. Cumulative distances of canyon length and fluctuations between Walzer Canyon and Munson Canyon (14 km) and Munson Canyon (52 km) Canyons (Table 1). Figure 6 (right). Cross-sections of the incised canyons were measured at specific points along the sides of each canyon from west to east at 400m (A-A'), 800m (B-B') 1200m (C-C'), 1600m (D-D'), and 2000m (E-E'), listed in Tables 2 and 3. Vertical exaggeration varies to emphasize canyon details. All in all two canyons (Hydrographer and Lydiana), canyon width narrows with increasing depth.

Table 1 (above). Quantitative measurements of incised canyons based on the profiles in Figure 4.

Table 2 (left). Depths of the incised canyons at multiple canyon-wall points were measured using the profiles in Figure 5.

Table 3 (left). Cross-section widths and the relief of the incised canyons were measured using the profiles in Figure 5.

Table 4 (left). Cross-section widths and the relief of the incised canyons were measured using the profiles in Figure 5.

Table 5 (left). Cross-section widths and the relief of the incised canyons were measured using the profiles in Figure 5.