Bathymetric Analysis of Two Type 1 Canyons Located on the West Florida Escarpment

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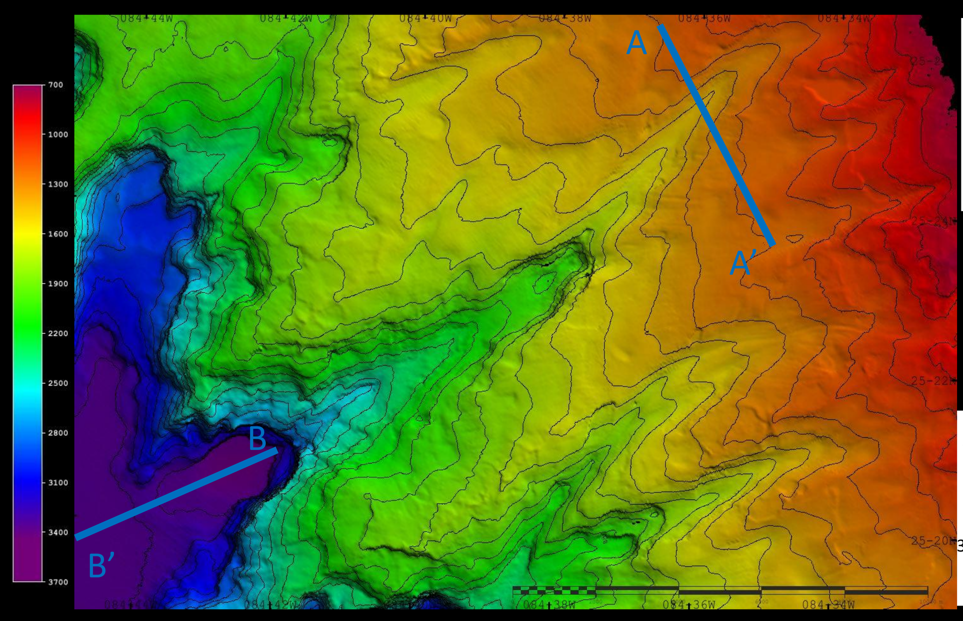
Abstract

Multibeam sonar data for two submarine canyons located off the west coast of Florida were analyzed using CARIS HIPS 8.1 software to determine the bathymetric structure of the two geologic features. Both canyons exhibit the v-shaped profile and slump scarps indicative of a Type 1 canyon. However, these canyons lack the smooth fan-like deposition patterns on the continental rise, characteristic of this canyon type. Both canyons show an unusual feature at their base, characterized by a distinct excavation of the substrate deeper than the adjacent abyssal plain, and significant deposition seaward. These depositional areas are shallower than the abyssal plain, suggesting that these canyons were formed, and continue to be shaped by strong turbidity currents that both carve the canyons and deposit extensive turbidites. The dynamic physical processes that these canyons experience may impact the biodiversity of the surrounding benthic communities.

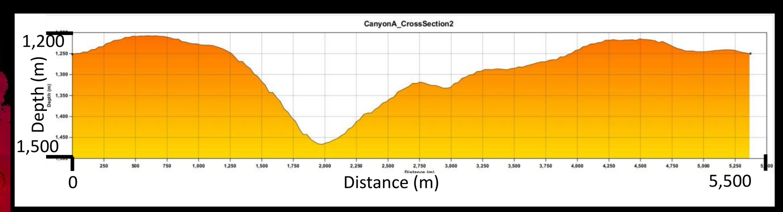
Methods

- Multibeam sonar data were collected from two different surveys in 2011, from aboard the R/V *Falkor* and the NOAA Ship *Okeanos Explorer*.
- A 30 meter resolution CUBE BASE surface was generated using CARIS HIPS and SIPS 8.1
- HIPS measurement, contour and profile tools were utilized to quantify the morphology of submarine canyons within the study site.
- Measurements of canyon depth, width, and slope were used to classify the canyons. Slump, erosion, and deposition sites were used to help determine the forces that created the canyon and what ongoing forces might be affecting the area.

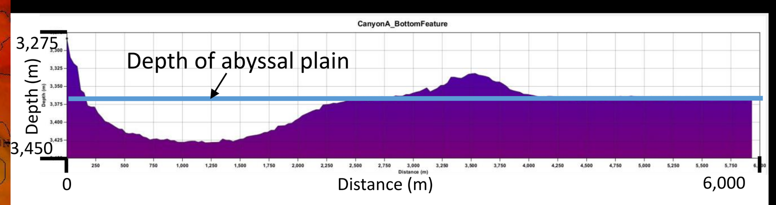
Figure 2: Morphological Analysis of Canyon A .



Panel A: Canyon A With 100m contour lines



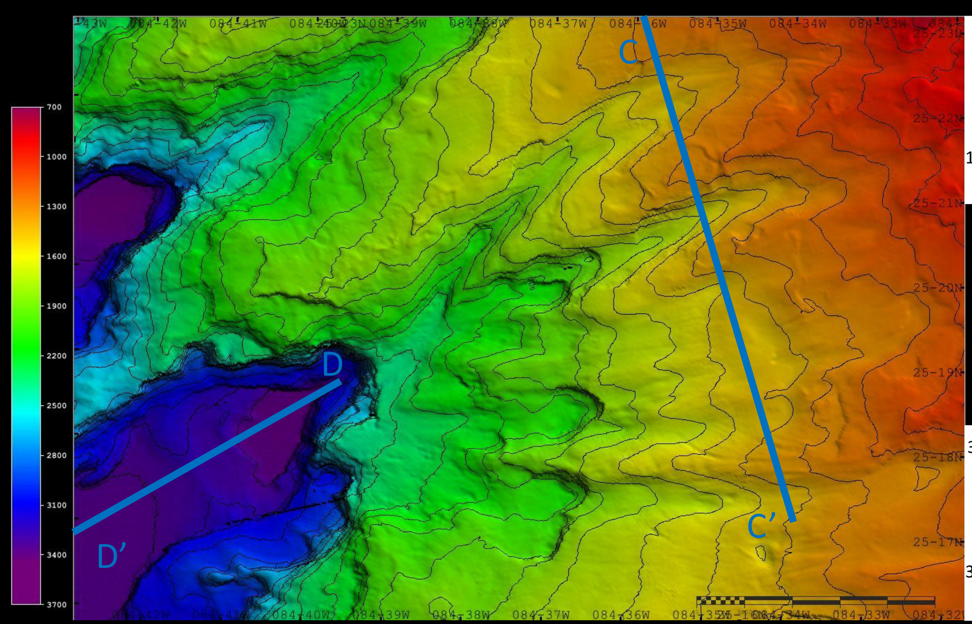
Panel B: Profile A - A'



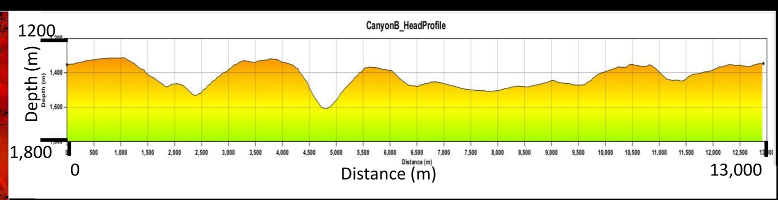
Panel C: Profile B - B'

Panel A shows a 2-D bathymetric image of Canyon A with depth contours and profile locations. Panel B shows a profile slice of the canyon head. Panel C shows the erosional/depositional profile observed at the bottom of the canyon relative to the abyssal plain depth.

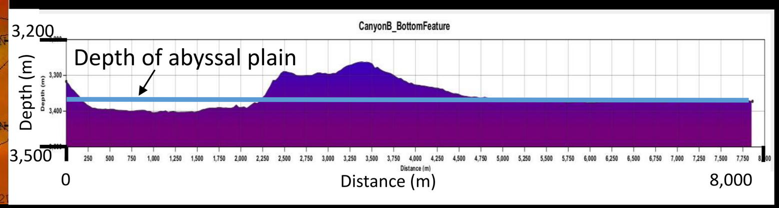
Figure 3: Morphological Analysis of Canyon B .



Panel A: Canyon B with 100m contour lines



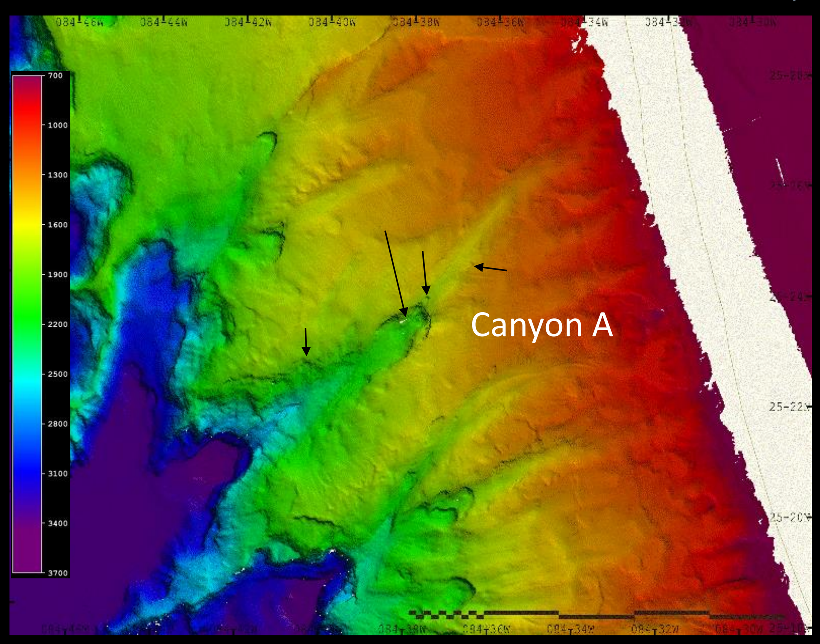
Panel B: Profile C - C'

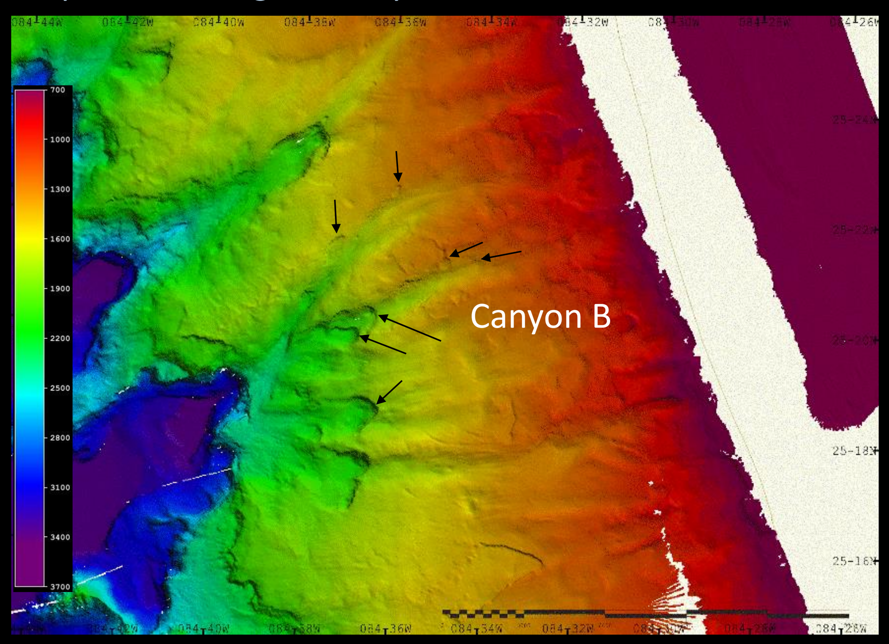


Panel C: Profile D - D'

Panel A shows a 2-D bathymetric image of Canyon B with contours and profile locations. Panel B shows a profile slice of the canyon head. Panel C shows the erosional/depositional profile observed at the bottom of the canyon relative to the abyssal plain

Figure 4: Evidence of slumping events associated with Canyons A and B. The arrows indicate some of the slump scars present along the canyons.





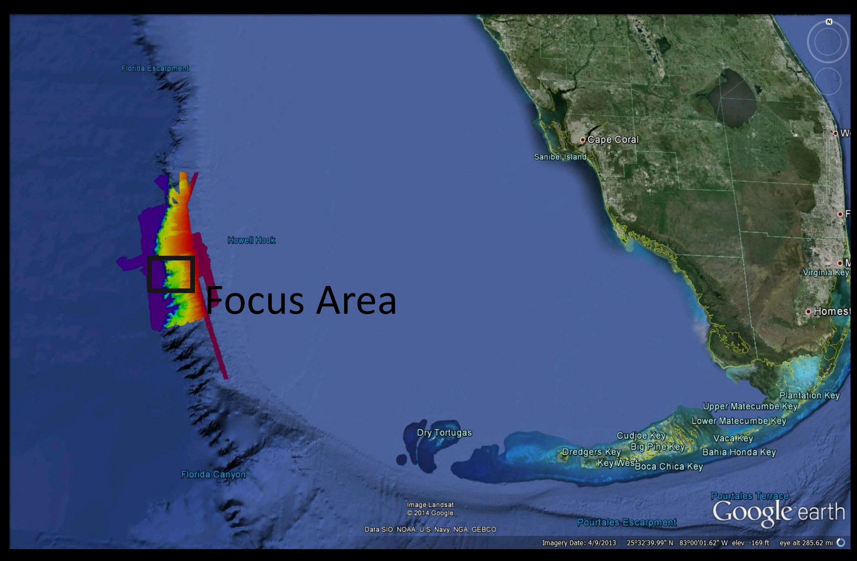


Figure 1A: Location of BASE Surface along the west coast of Florida in an area known as the West Florida Escarpment

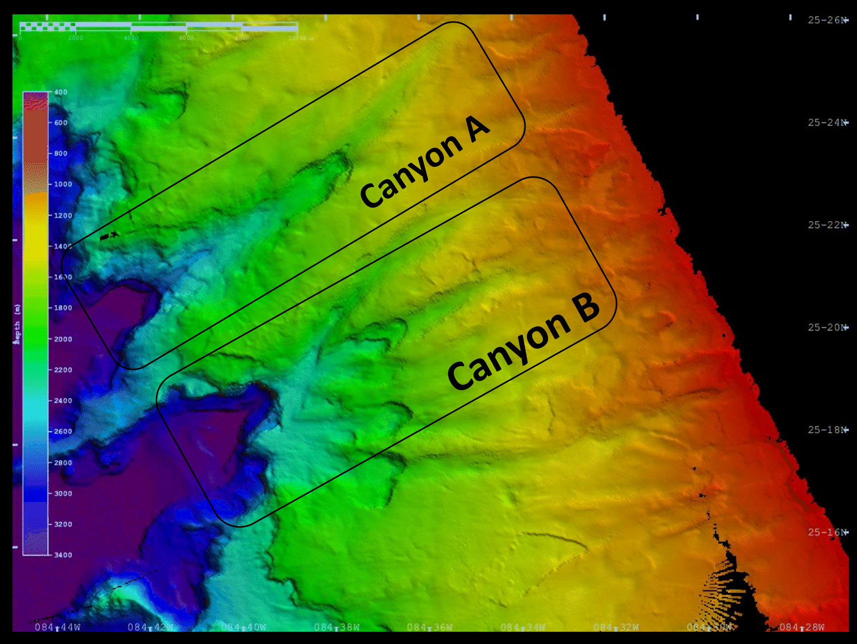


Figure 1B: 30m CUBE BASE surface of focus area, with canyon depths ranging from 400 to 3450m.

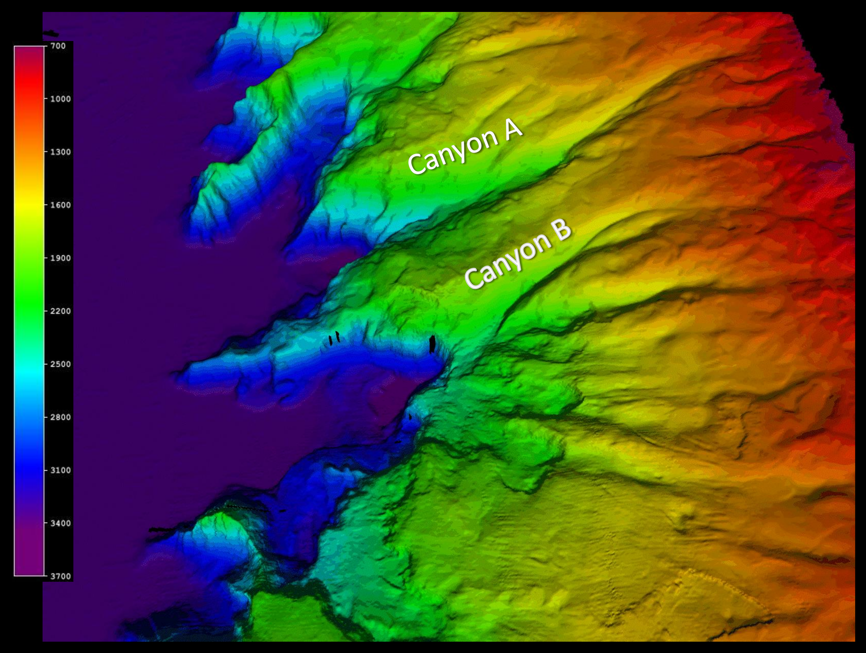


Figure 1 C: 3D image of the two canyons (VE= 2x).

Introduction

The western Florida continental margin is part of the North American continental plate and drops off abruptly to the oceanic crust at the West Florida Escarpment, defining the edge of the Gulf of Mexico oceanic basin (Bird et al., 2004). The continental margin here has been influenced by the Gulf Loop Current for about 12 MY, following the emergence of the Florida panhandle (Buster and Holmes, 2011). This current affects the sedimentation patterns, blocking the progradational deposition of sediments and initiating a pattern of aggradational deposition where the shelf edge was no longer extending seaward and has been maintained at an equilibrium. Formation of the Gulf Loop Current resulted in erosion of soft sediment at the shelf edge.

The major sediment deposits on the shelf are biogenic carbonate ooze from the abundant plankton in the Gulf of Mexico (Buster and Holmes, 2011); in recent years, the acidification of the ocean likely also played a role in intensifying the erosion of the shelf edge leading to the unusually steep shelf edge observed today (Ries et al., 2009). To examine the bathymetry of the shelf edge, several studies have been conducted using multibeam sonar. From these data, two submarine canyons off the West Florida Shelf were examined with the goal to quantify the canyons' morphology, to better understand the physical processes that shaped these canyons and the possible implications on biodiversity in the area. The multibeam data suggests that many of the canyons in the area Type 1 canyons which are associated with significant erosional processes and usually significantly cut into the shelf edge (Jobe et al. 2010).

	Max slope of Canyon Sides	Difference above Abyssal Plain (meters)	Difference below Abyssal Plain (meters)
Canyon A	0.290	34	-62
Canyon B	0.427	109	-32

Table 1: Slope of each canyon, calculated from profiles made at the canyon head, quantifying the morphology of the unusual depositional feature.

Results

- Bathymetry of the main channel of two submarine canyons located in the Gulf of Mexico along the West Florida Escarpment (Fig 1A,) were analyzed using CARIS HIPS 8.1 software. Canyon A, shown in Fig 1.B is a single channel canyon, ranging in depth from ~1200 to 3450 m (Fig. 1C).
- Morphological analysis of Canyon A was done using profile locations A-A' in the head region and B-B' in the basin. This canyon shows a v-shaped topography at its head (Fig. 2B), with a maximum channel slope of 0.29 (Table 1). The depositional pattern at the base of the canyon shows an excavation below the abyssal plain of 62 m and an associated deposition amount 34 m above the abyssal plain (Fig. 2C; Table 1). There is also clear evidence of slump scarps within the canyon, as shown in Fig. 4.
- Canyon B has a more complex slope structure where several submarine canyons feed into one basin (Fig. 1B). Several of the feeder canyons show a v-shaped topography in the head region (Fig 3B), with a maximum channel slope of 0.427 (Table 1). The depositional profile of the Canyon B basin shows a shallower excavation below the abyssal plain (Fig. 3C) of 32 m, and a markedly higher associated deposition, 109 m above the abyssal plain (Table 1). As observed for Canyon A, distinct slump scars are observed within Canyon B, as indicated in Fig. 4.

Discussion

Bathymetric analysis revealed structural similarities between these two canyons. The shape of the contour lines suggests that both canyons are created by fast moving, erosional currents resulting in a canyon with high, steep walls and a narrow basin. This geomorphology is most evident in Canyon A, although a similar structural phenotype, with steep walls and narrow basins, was observed for Canyon B. Further evidence of the origin of the canyons is shown in Figure 4, where several slump scars are visible along the canyon walls and in the channels of both canyons. The canyons' steep sides and evidence of past slumping events is indicative of a Type 1 canyon (Jobe et al., 2010). Type 1 canyons are created and maintained by mass wasting events such as turbidity currents, which are basically underwater landslides. However Type 1 canyons are usually associated with a large depositional structure at their base on the abyssal plain, such as a submarine fan (Jobe et al., 2010). This common feature is not present in the basin of either canyon, but a deep incision into the abyssal plain followed by a large mound of sediment were observed in the profiles of the bottom features in Figures 2 and 3. This variation from the normal pattern of Type 1 canyons may be due to the unusually steep continental slope present in this location. These canyons show clear evidence of being created and maintained by violent turbidity events.

Based on previous work in this area using backscatter data and ROV ground trothing, there appears to be a significant benthic community present (Rittinghouse et al. 2013). The effects these turbidity events have on the local deep sea communities are unknown. However, it is possible that major turbidity events combined with the slow growth and development of deep sea communities may impact the benthic biodiversity (De Leo, 2012).

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