BATHYMETRIC ANALYSIS OF SUBMARINE CANYONS TO ASSESS MORPHOLOGICAL VARIATIONS AND THEIR POSSIBLE ORIGINS

ALLEN, Emily, BLACK, Karen, SAUTTER, Leslie

Dept. of Geology and Environmental Geosciences, College of Charleston

ABSTRACT

Multibeam sonar data were collected by the U.S. Geological Survey (Marine Branch, Woods Hole) aboard the NOAA Ship RONALD BROWN along the continental slope from Cape Hatteras to Nova Scotia in May, 2009. ELAC SeaBeam 2112 was used to collect data; CARIS HIPS 7.0 was used for sonar data processing. Continental slope morphology was examined, revealing dramatic submarine canyons, scarps, and slumps. Submarine canyons are historically formed by underwater landslides. The area studied is located south of the Connecticut coast. High resolution mapping and profile analysis of McMaster Canyon, Hydrographer's Canyon, and Veatch Canyon was used to qualitatively evaluate morphological differences and hypothesize their origin. Similar depths were examined to compare and contrast gradients along transects perpendicular to the canyons.

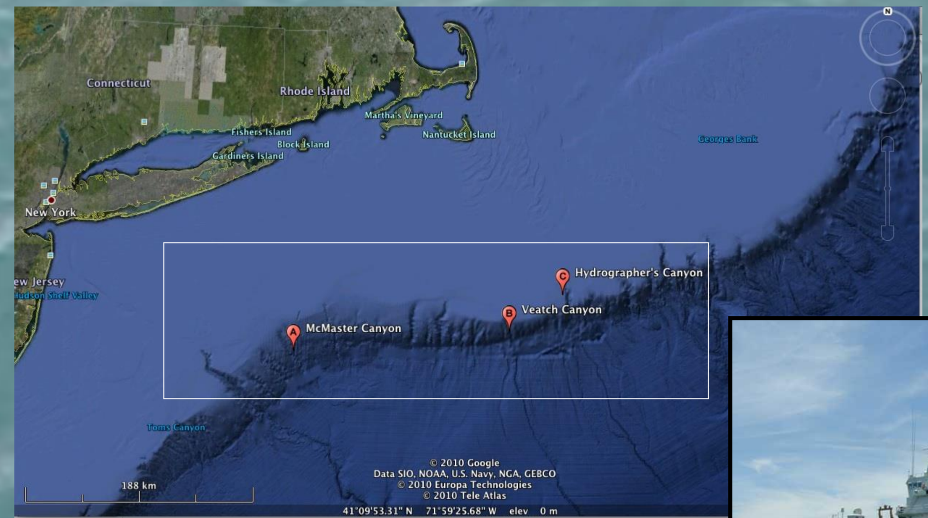


Figure 1. Map of the continental shelf, A: McMaster Canyon, B: Veatch Canyon, C: Hydrographer's Canyon.

Figure 2. NOAA Ship RONALD BROWN from NOAA's Earth System Research Laboratory's photo gallery (online source)

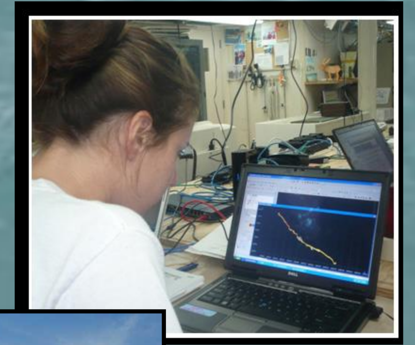


Figure 3. Processing data on board the Ron Brown.

Figure 5. The hardware and sonar used for data acquisition.

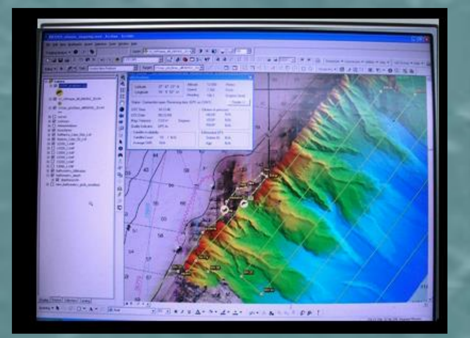


Figure 4. Image of a Geographic Information System (GIS) simultaneous assessment of older charts and surveys.

BACKGROUND

The Northeast Atlantic continental slope is currently characterized by surface sediments of hemipelagic silt and clay overlying lithified Tertiary strata. Fine grain turbidites and hemipelagic sediments accumulate on the continental slope and parts of the continental rise, creating a dynamic environment. This region's bathymetry was produced by erosion during the late Tertiary. Sedimentation rates along the base of the slope in this area changed dramatically during the middle to late Pleistocene and Holocene as a result of the network of submarine canyons (US Geological Survey).

Development of a canyon is dependent on the removal of buried and consolidated sediment as well as less compacted material that may accumulate on the slope. The canyons of the Northeast Atlantic (Figure 1) are developed through landslide processes – such as turbidites originating at the shelf break – that converge into pre-existing older troughs mid- to lower-slope. Older canyons become buried by sediments in their upper slope regions, but the lower slope trough has a thinner veneer of sediment infill. As a result, a new adjacent canyon can converge into the pre-existing canyon at the lower slope trough. This process of development results in canyons of various shapes, sizes, and meandering flow paths (Pratson et al., 1996).

METHODS

1) Multibeam sonar data were acquired using SeaBeam-2112 aboard the NOAA Ship RONALD H. BROWN. Backscatter data was also acquired in conjunction with other bathymetric data using a Bathy2010 chirp echo sounder.
2) Profiles of sound speed as a function of depth were used to calibrate sound proliferation for the multibeam sonar data.
3) Bathymetric data were cleaned, validated, and integrated using CARIS HIPS 7.0.
4) The new data were qualitatively examined to postulate the origin of various canyon's morphology.

CONCLUSIONS

The three transect profiles taken reveal a much wider canyon channel in Veatch Canyon than Hydrographer's Canyon, which would imply erosion over a wider region. McMaster Canyon is characterized by two canyon channels along transect B-B' that differ in width but follow the same general trend in shape.

All canyons have some degree of meander, however it appears to be most dramatic in the upslope portion of Hydrographer's. Based on the transect profiles taken, each canyon has strong variance in degree of canyon wall slope. Each canyon also exhibits varied channel shape within cross sectional view.

The varied morphologies of the examined canyons suggest different erosional histories during their formation. A combination of many factors would result in such canyon diversity. Factors that influence the diversity of canyons include: the size, number and frequency of debris flows and slides, hemipelagic sedimentation on canyon slopes and in between canyon regions, resistance of underlying stratigraphy to erosion and other transitory effects.

Based on this discussion, a more in depth study of each individual canyon would need to be performed to assess their origin which may vary from canyon to canyon.

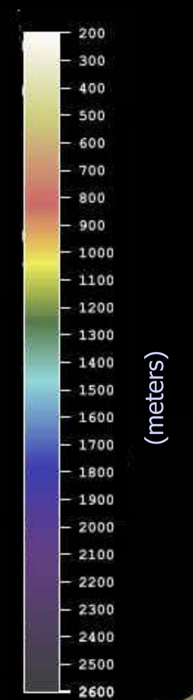
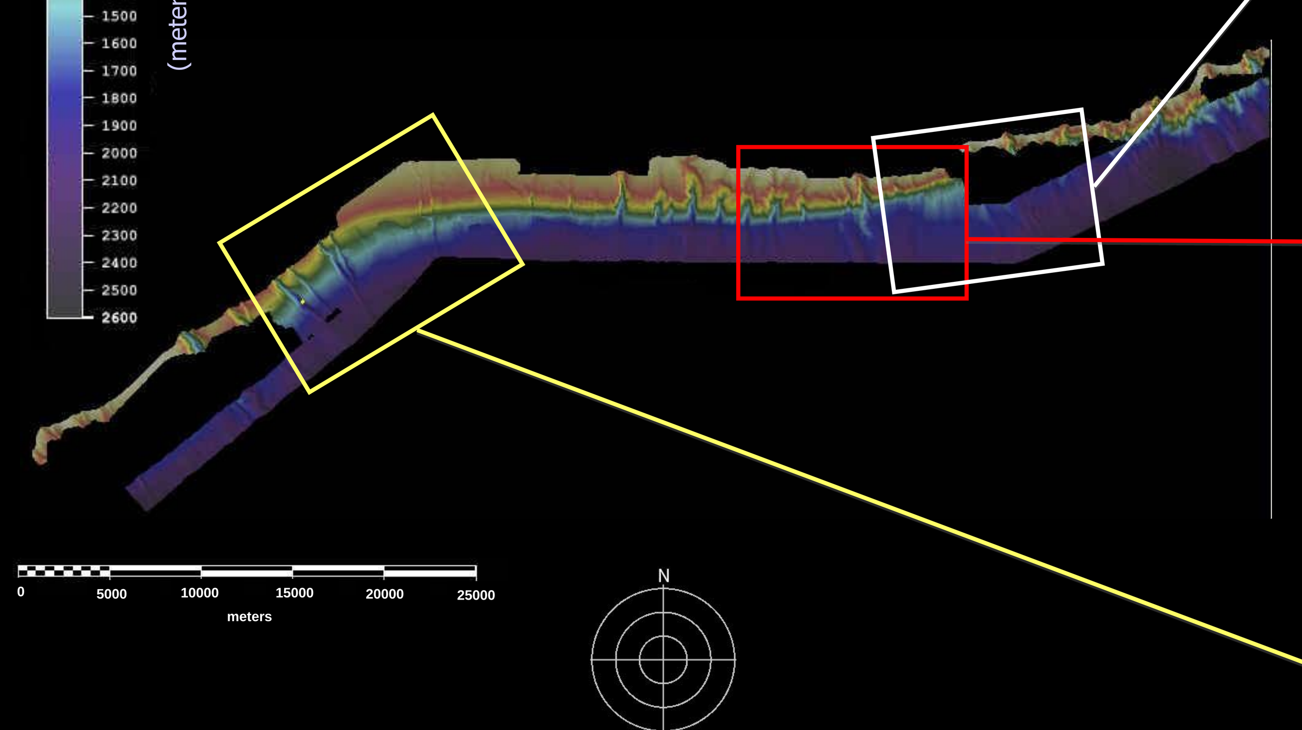
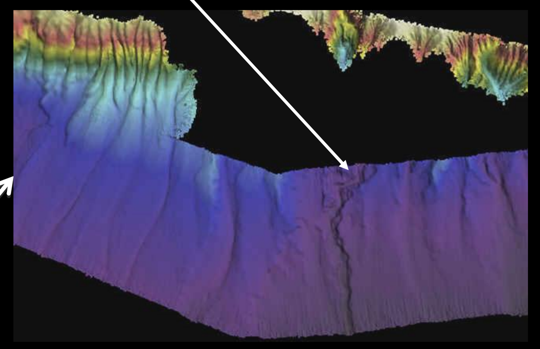
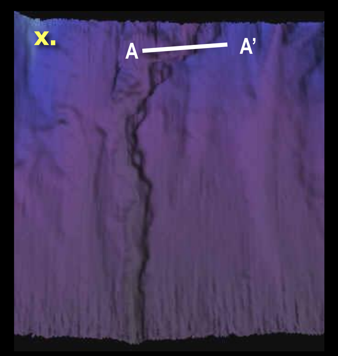


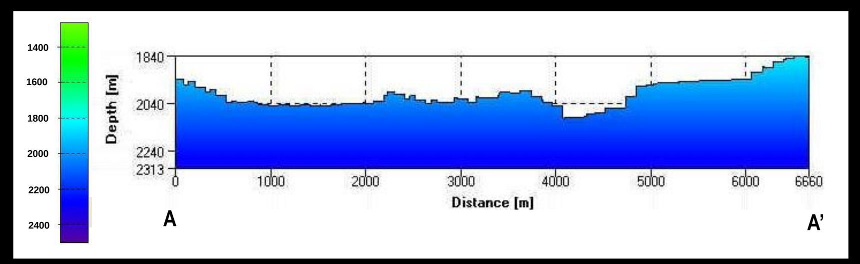
Figure 6. Edited bathymetric data with identified canyons used in case study analysis. The area of the continental shelf that was cleaned and validated for this study is defined by the following coordinates: 38°50' N to 40°20' N, 67°33' W to 72°44' W.

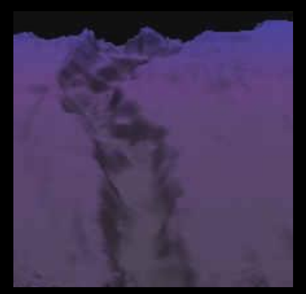


Hydrographer's Canyon



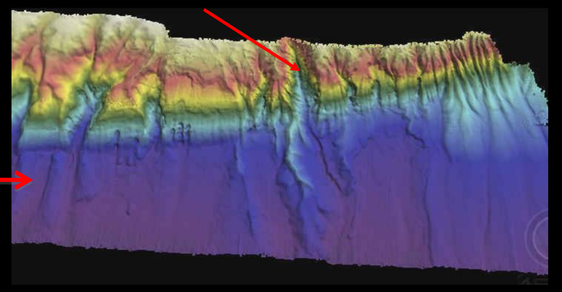


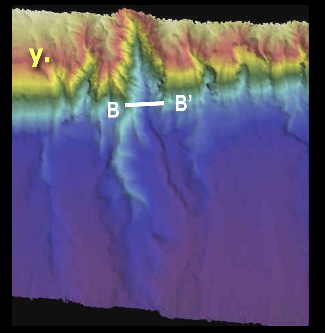


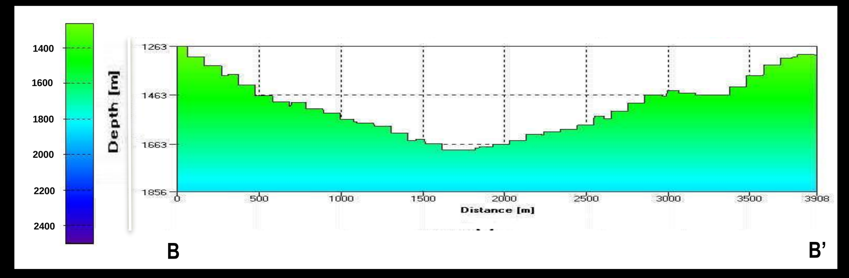


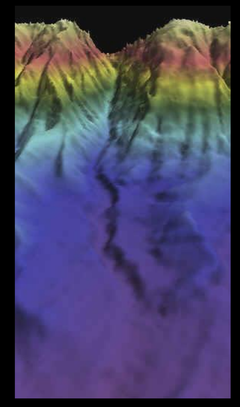
In the lower portion of this single channel canyon, the bathymetry of the slope is relatively unvaried compared to the profiles and images of other canyons. The canyon meanders throughout the section examined, although there is a strong bend upslope of the canyon as seen in image x.
Transect A-A' reveals a narrow canyon channel with a cliff or sudden and dramatic change in bathymetry on the western wall. The eastern wall slopes gently upwards. Regions to the west and east of the channel exhibit broad plateaus that eventually slope upward on the outer portions of the transect.

Veatch Canyon



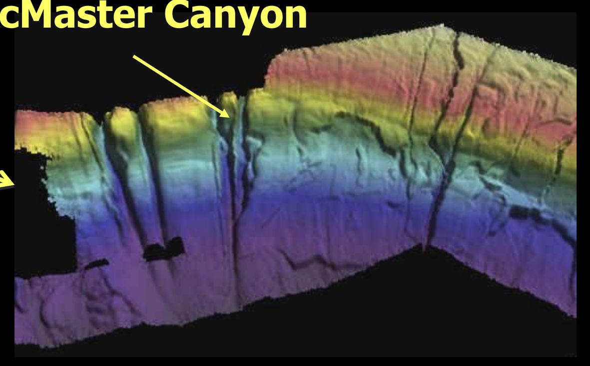


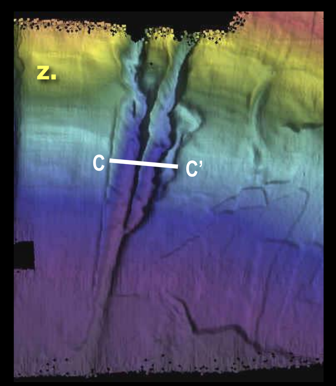


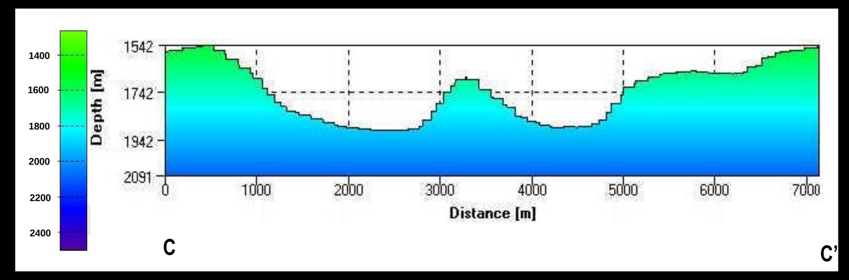


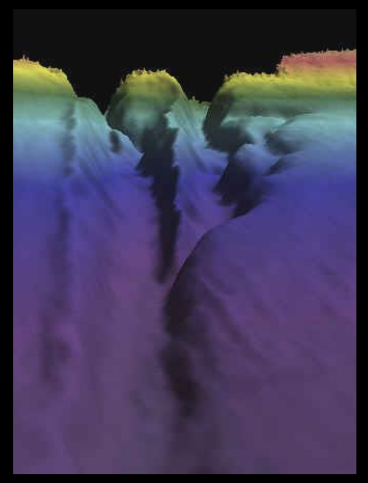
The lower part of the slope gently meanders; it appears to change over a broader area as seen in image y. Throughout the canyon bathymetry is variable. On the upslope, depth varies significantly in image y.
The B-B' transect reveals a broad, wide channel. The two sides converge in a V-shape in the bottom of the channel. The degree of slope appears somewhat symmetrical except for a plateau region on the east wall.

McMaster Canyon









As seen in image z, McMaster Canyon is comprised of two parallel canyons separated by a narrowing ridge that eventually converge downslope into a single channel. Both channels exhibit some degree of meandering. However, the west channel appears to be more linear.
Transect C-C' crosses a roughly midslope region of the canyon before the two channels converge. The west channel is wider than the east channel. Both channels exhibit more gently sloping walls on the west side than the east, with the west channel sloping more gently and resulting in a flatter bottom than that of the east channel.

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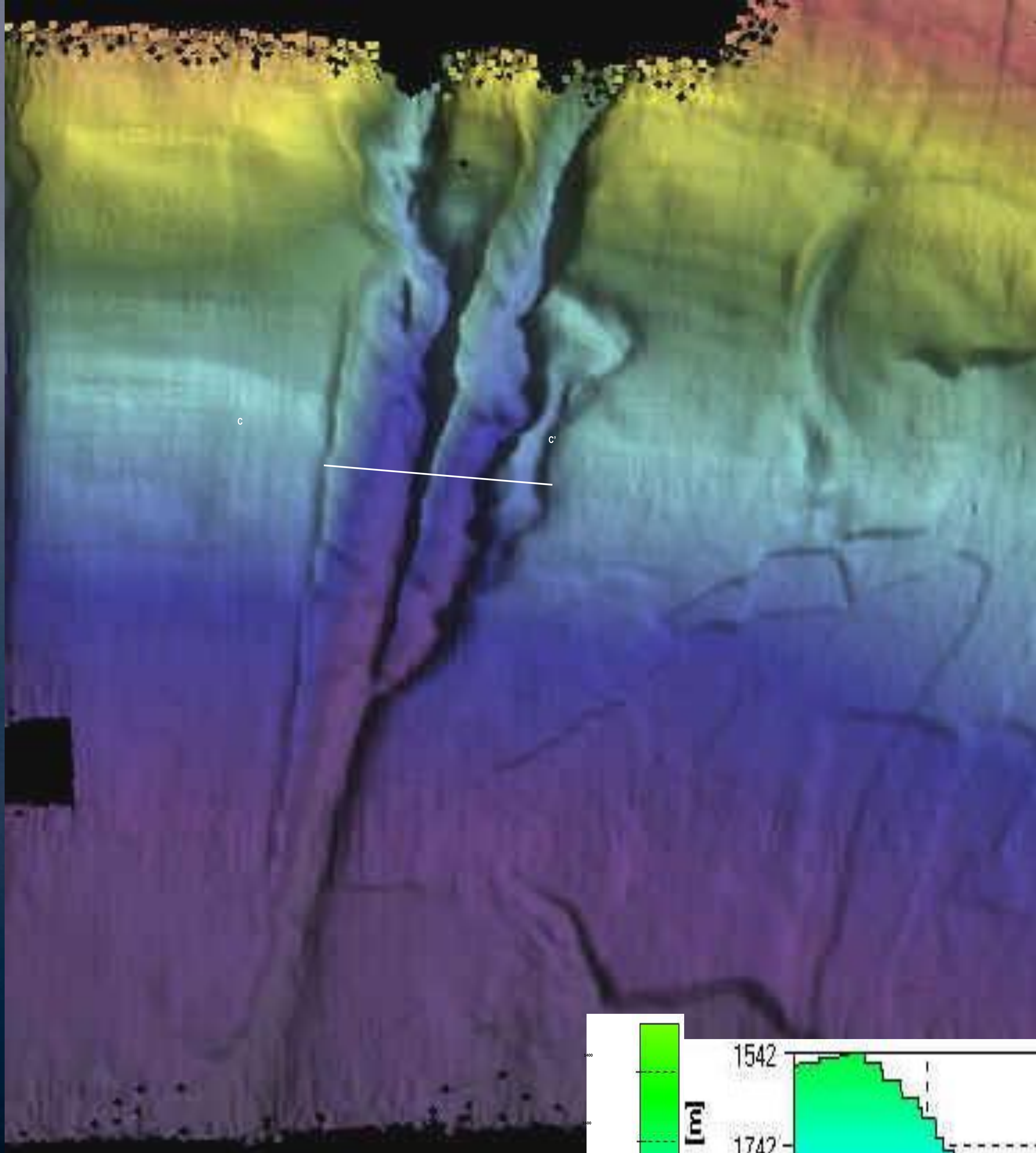
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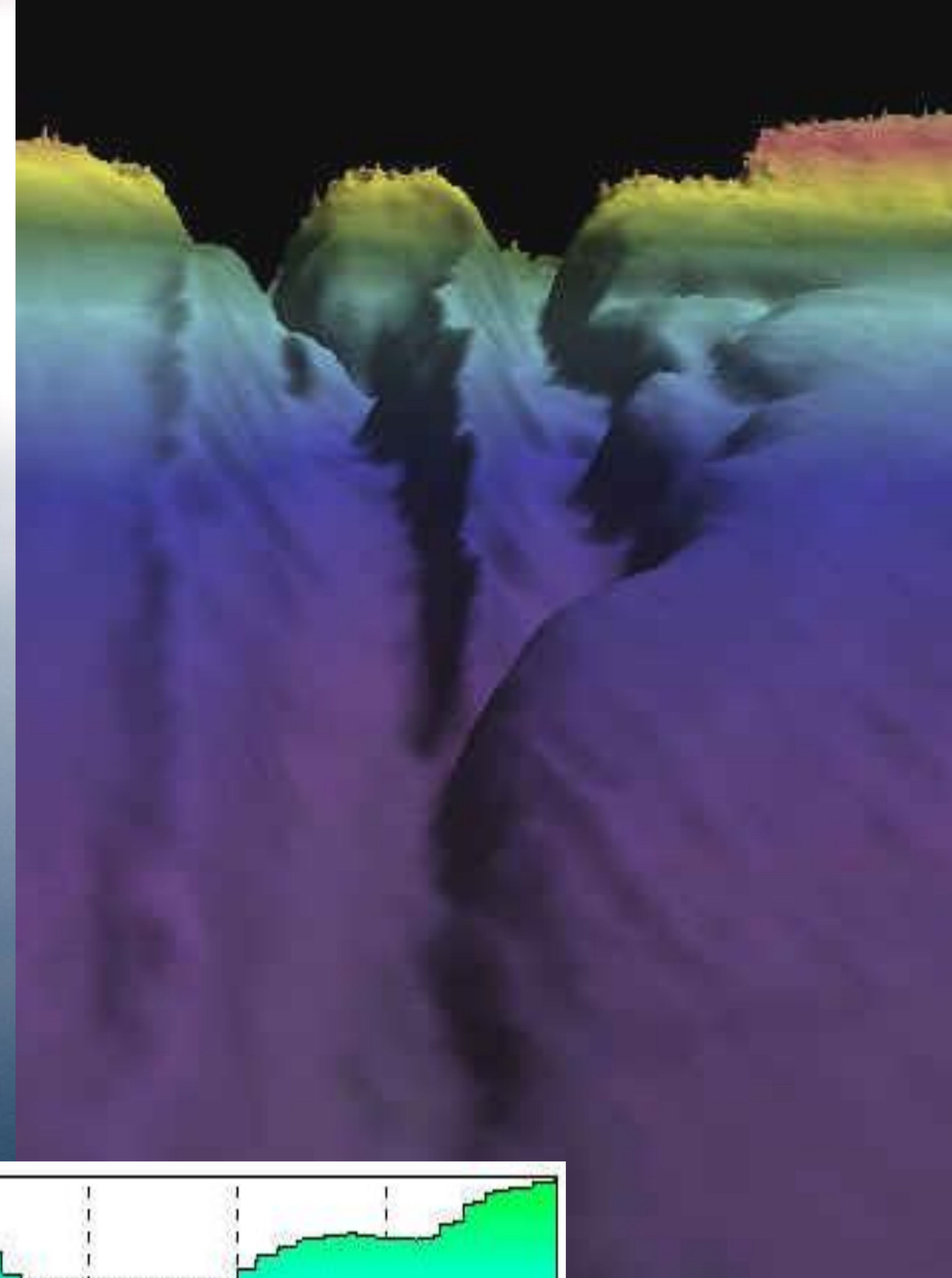

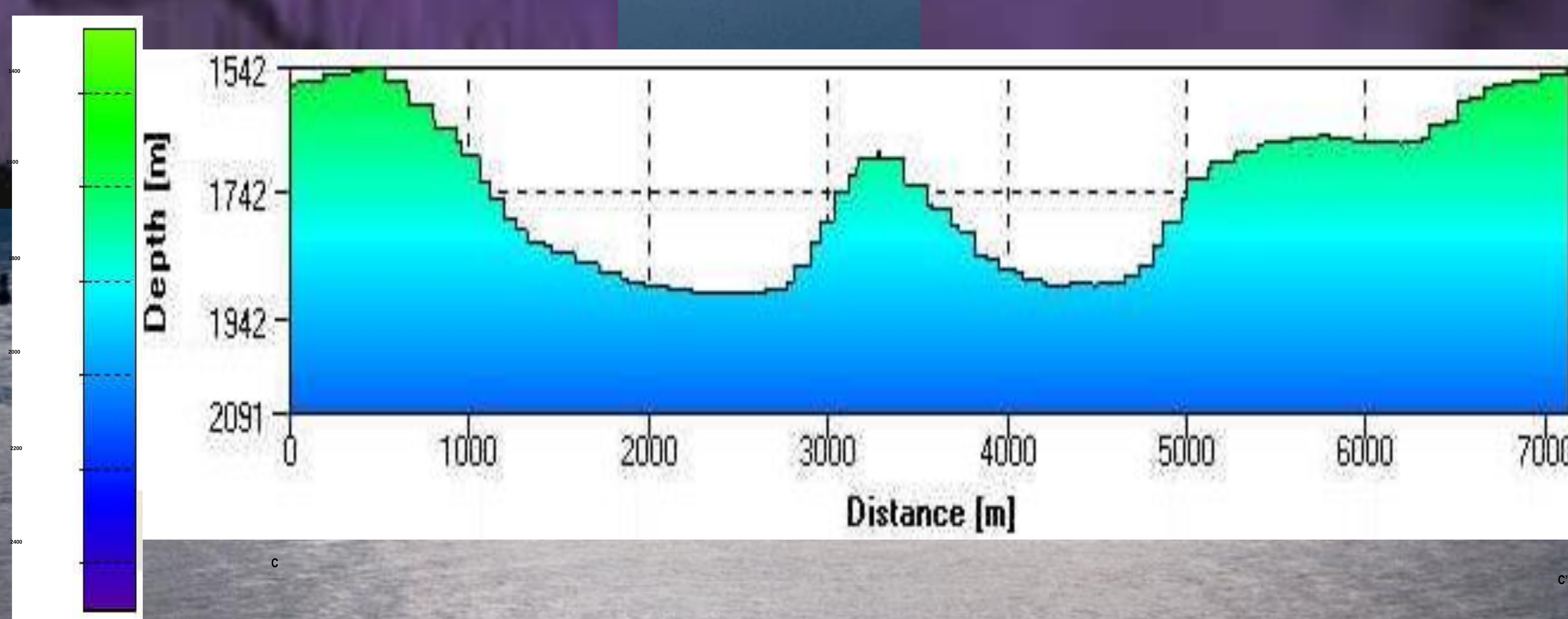
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