Bathymetric analysis of the northwestern Channel Islands Slope

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NOAA Ship *Okeanos Explorer*

Abstract

The Channel Islands are a series of land masses situated between the Patton Escarpment and the coast of southern California. Five of the eight islands make up the Channel Islands National Park which spans fewer than 400 square miles. All of the islands are considered to be located in a region known as the California Borderlands. This broader area is a continental slope that is separated from the continental shelf by the islands. The Borderlands area is known to be seismically active, with numerous offshore faults, as well as basins and ridges that trend in a northwest-southeast direction. The islands themselves contain varying topographic and geologic features including steep mountains and marine terraces, and several are prone to landslides, as well as coastal erosion. Bathymetric data were obtained in 2011 from the NOAA Ship *Okeanos Explorer* with a Kongsberg EM302 multibeam echosounder, and processed using CARIS HIPS and SIPS 7.1 software. This bathymetric investigation focused on the northwest geographic region of the Channel Islands in order to provide a more accurate characterization of specific features present. BASE surface generation (depth range of 200 to 2000 m) revealed the presence of old and young features, as well as slumping and material transport pathways.

Background

The Continental Borderlands region of southern California consists of a variety of physiographic features; among which are basins, canyons, and continental slopes (Homa and Normark, 2009). The latter refers to one portion of the overall continental margin of the Borderlands located seaward of the continental shelf (Kennish, 2001). The Channel Islands slopes are of bathymetric interest due to the variability observed in their characteristics. This portion of the continental margin plays a significant role in sediment movement and transportation from the mainland to the deep ocean floor (Field, 1980).

Methods

- Data were collected on the NOAA Ship *Okeanos Explorer* during March of 2011 (cruise EX1101). A Kongsberg EM 302 multibeam sonar was used, as was the SIS acquisition system.
- Data processing was conducted using CARIS HIPS and SIPS 7.1 software.
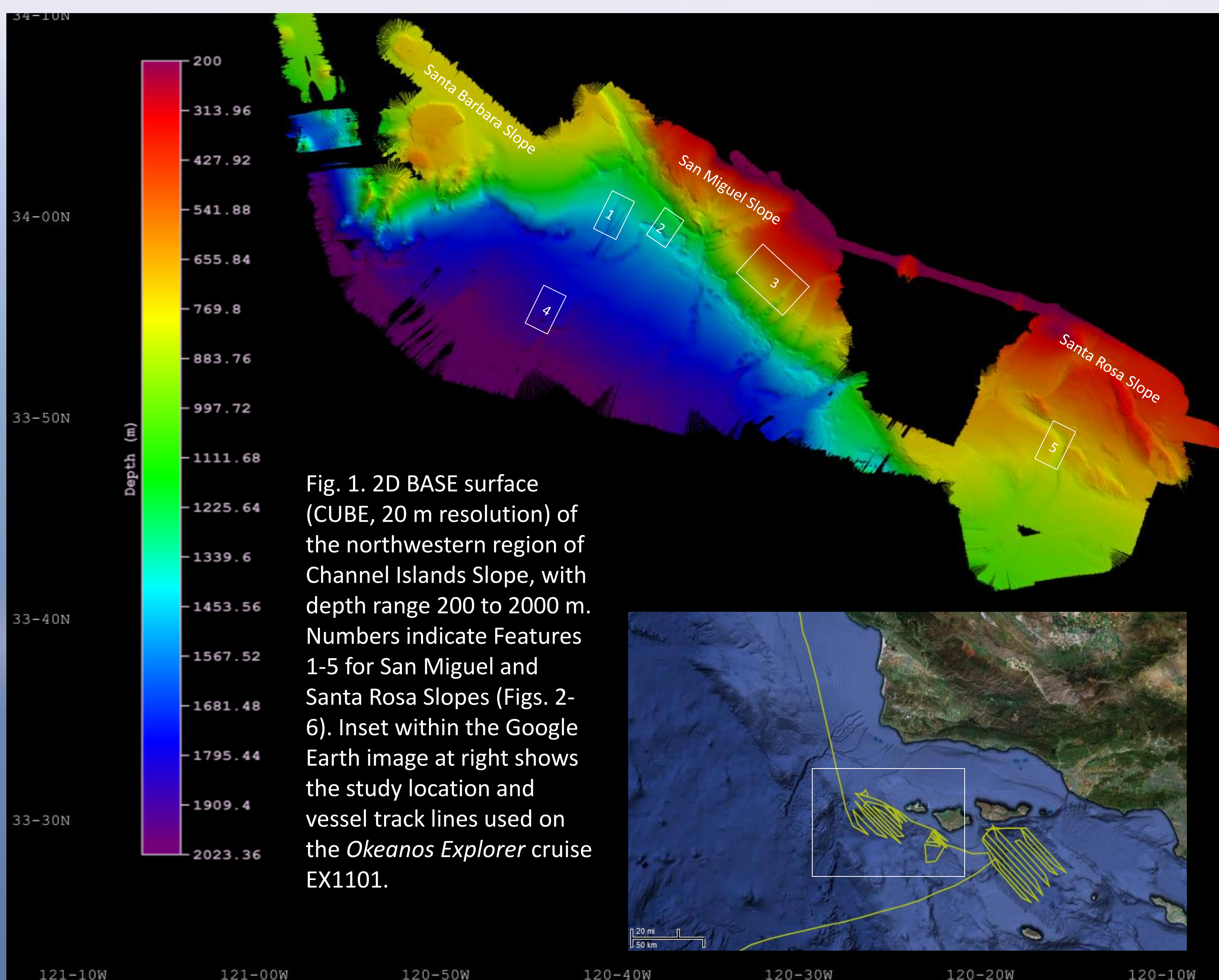- A CUBE BASE surface was generated at a 20 meter resolution.

Fig. 1. 2D BASE surface (CUBE, 20 m resolution) of the northwestern region of Channel Islands Slope, with depth range 200 to 2000 m. Numbers indicate Features 1-5 for San Miguel and Santa Rosa Slopes (Figs. 2-6). Inset within the Google Earth image at right shows the study location and vessel track lines used on the *Okeanos Explorer* cruise EX1101.
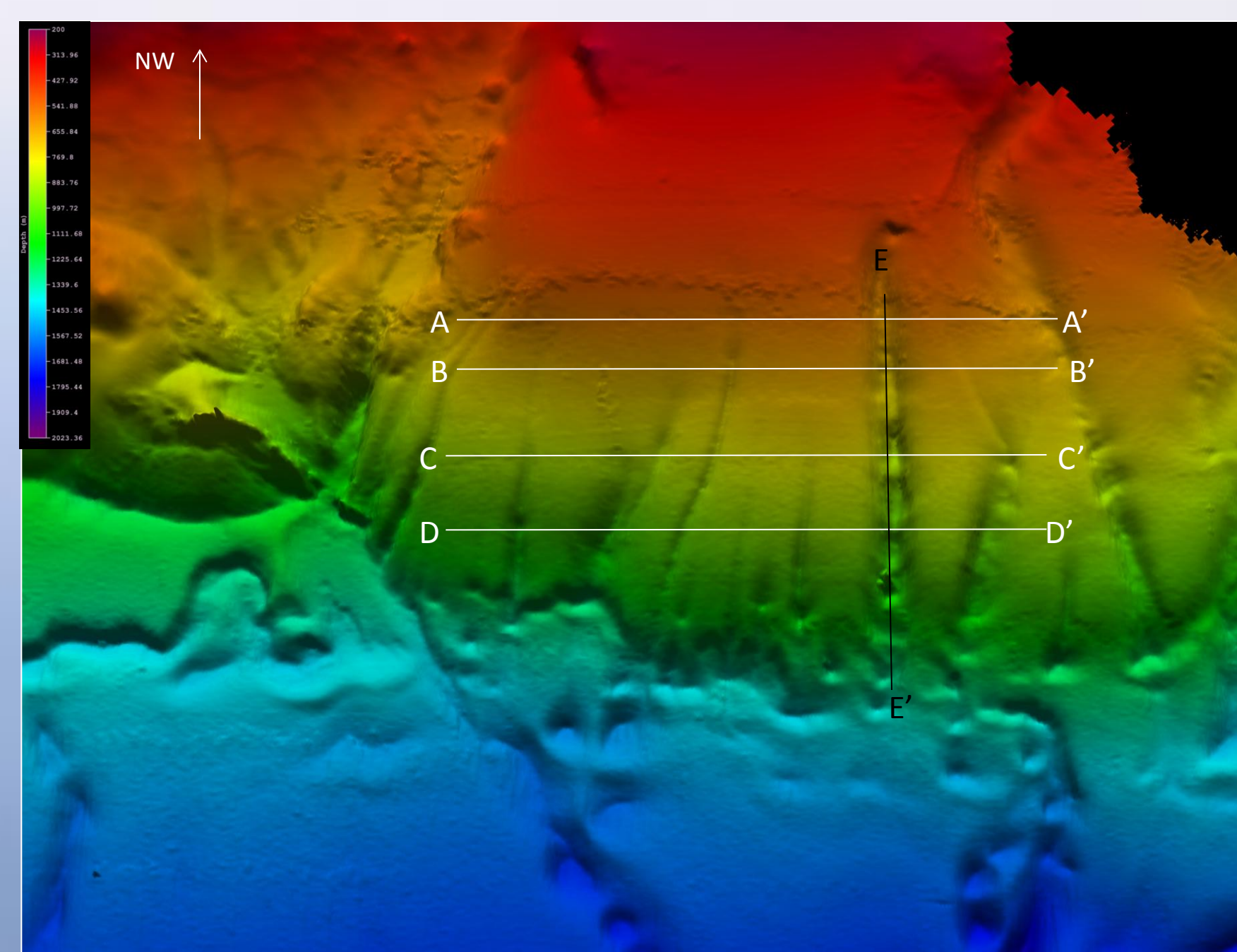
Feature 3 - San Miguel Slope

Fig. 4. 3D view (above) of San Miguel Slope, Feature 3 (VE= 3.3x), showing locations of Profiles A –E (below). This portion of the slope contained several shallowly-incised canyons.
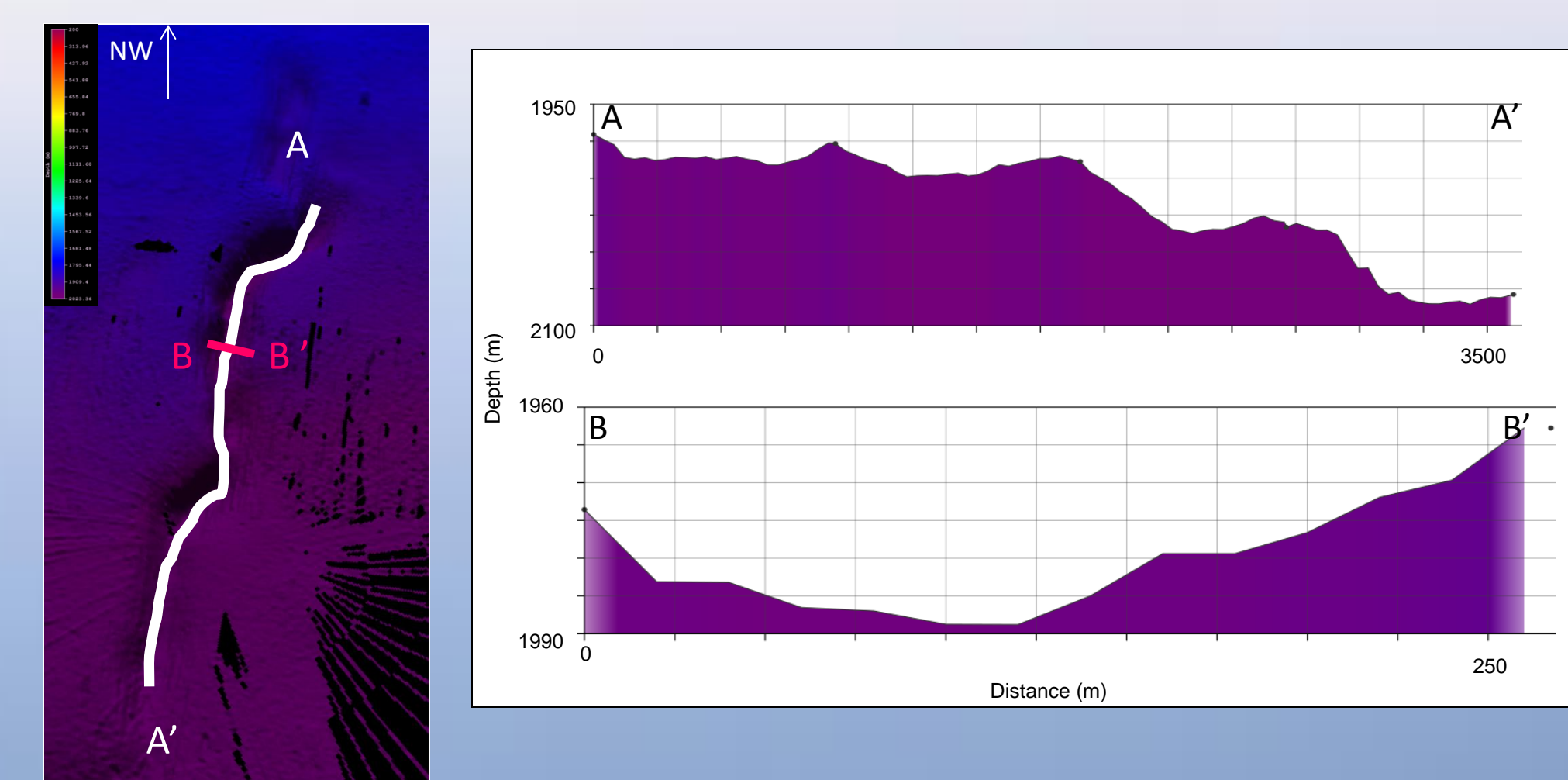

Feature 4 - San Miguel Slope

Fig. 5. 3D view (left) of San Miguel Slope, Feature 4 (VE= 5.0x), showing locations of Profiles A and B (right). Feature resembled a pathway of material transport.
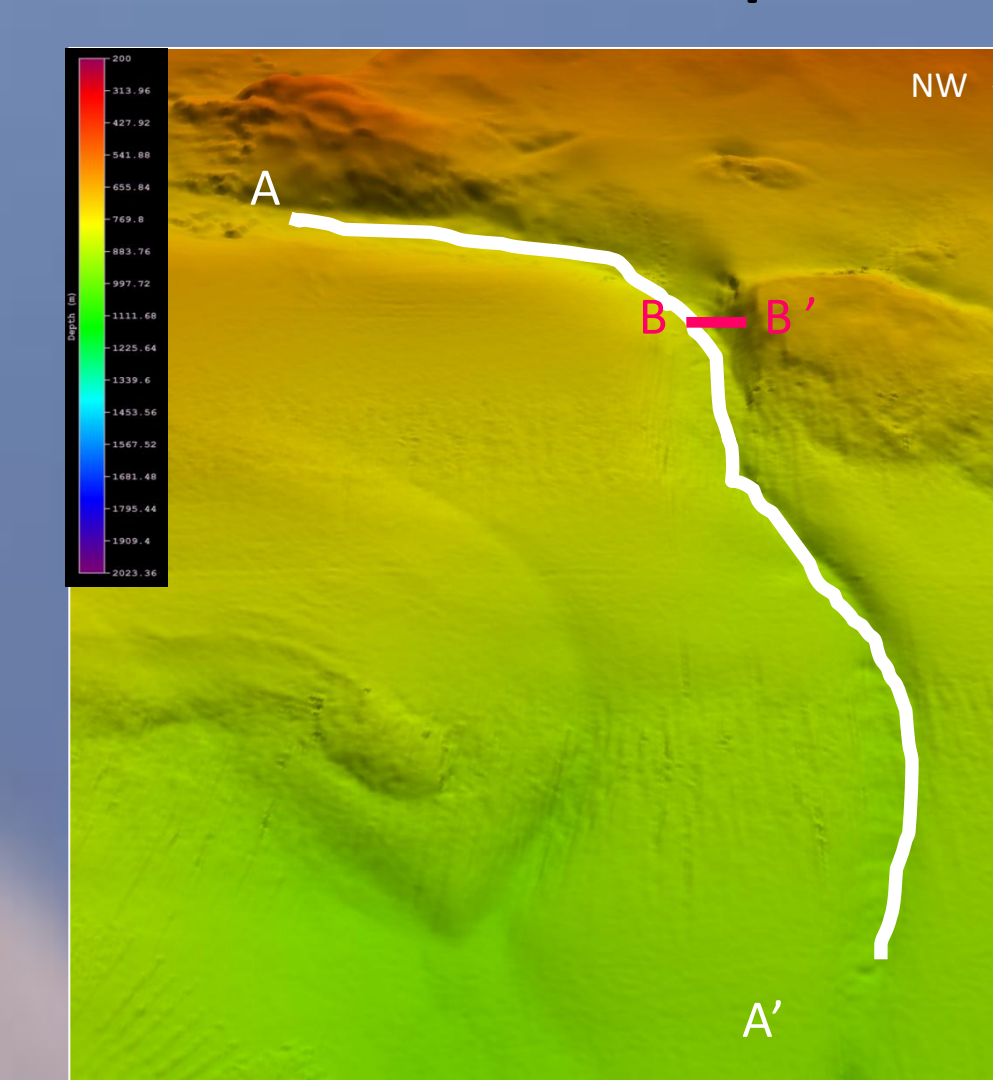
Feature 5 - Santa Rosa Slope

Fig. 6. 3D view (above) of San Rosa Slope, Feature 5 (VE= 3.5x), showing locations of Profiles A and B (below). The channel-like feature is located in a canyon in which material is transported from higher to lower depths.

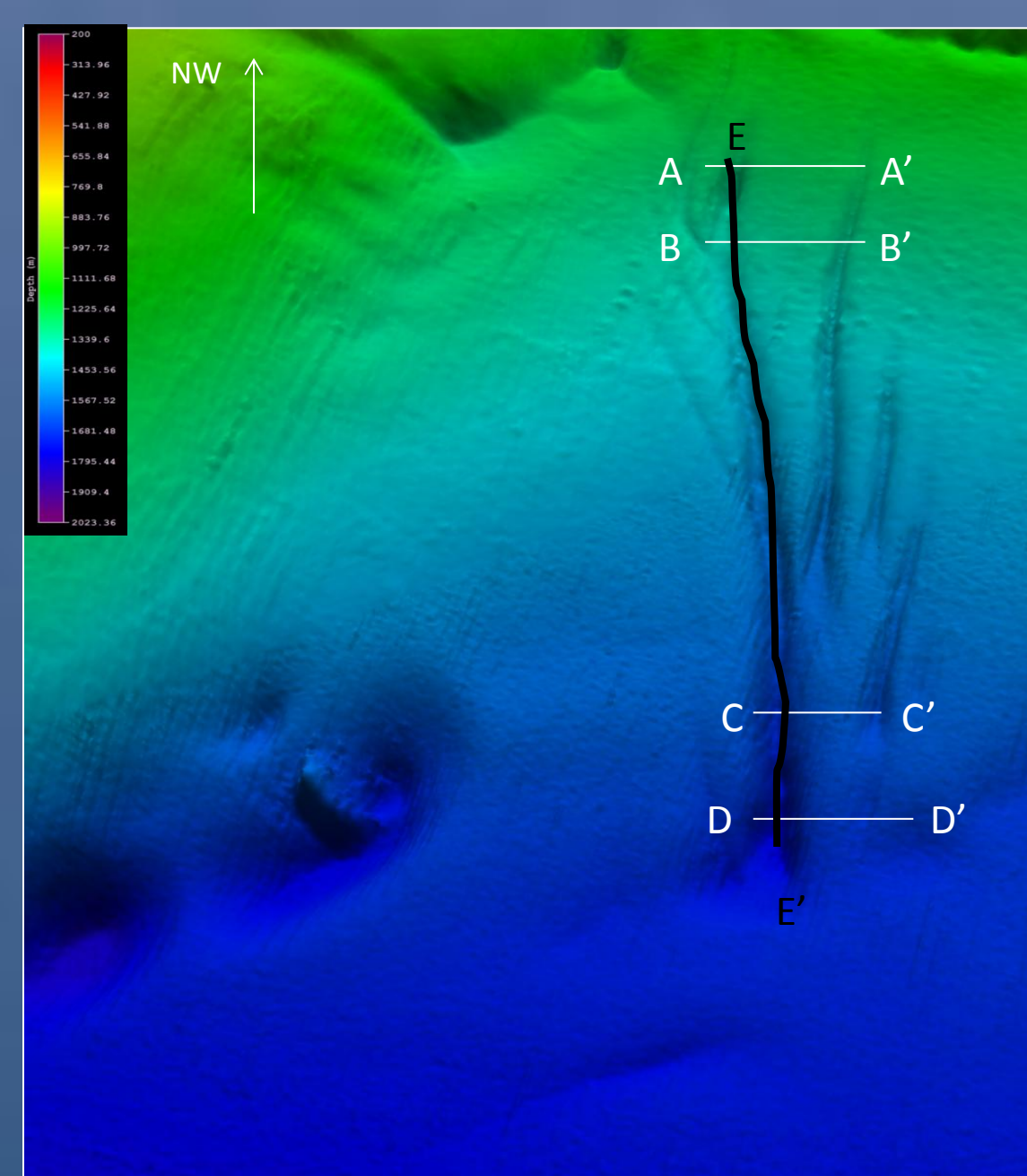### Feature 1 – San Miguel Slope

Fig. 2. 3D view (above) of San Miguel Slope, Feature 1 (VE= 3.7x), showing locations of Profiles A –E (below). Area was characterized by the appearance of linear, sloping features over a depth range of approximately 1340 m to 1400 m.

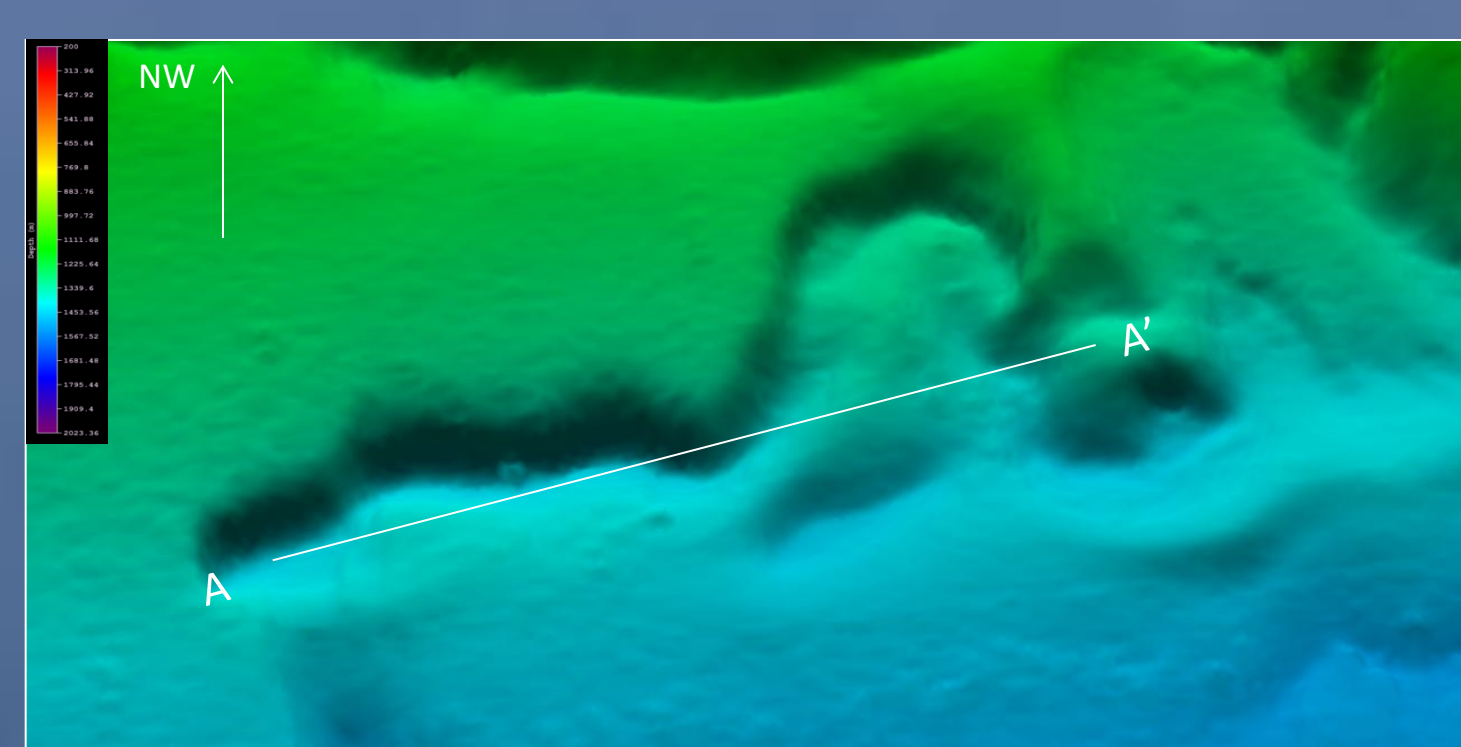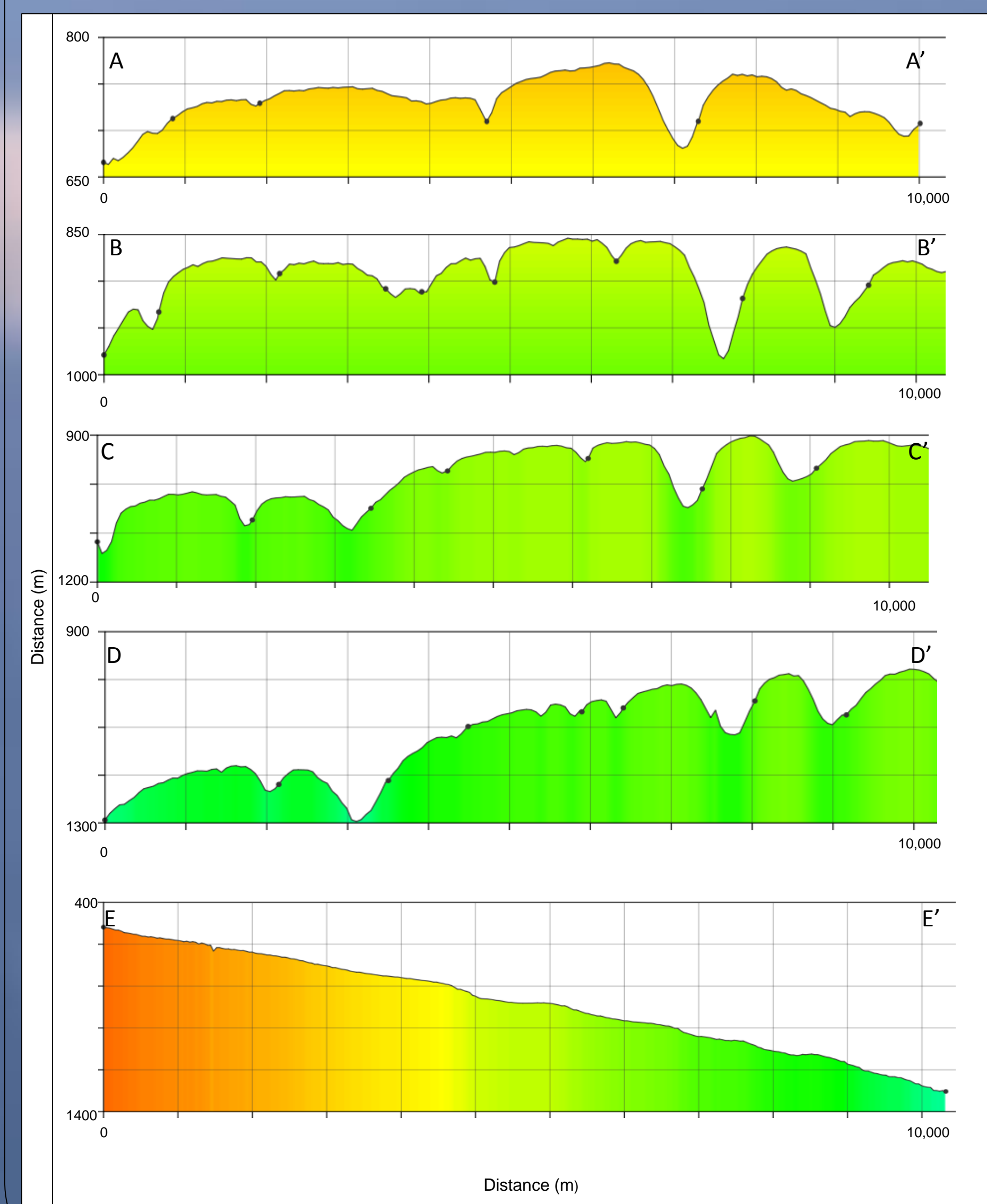### Feature 2 – San Miguel Slope

Fig. 3. 3D view (above) of Feature 2 on San Miguel Slope (VE= 3.7x), showing location of Profile A (below). Feature 2 shows characteristic slump features.

Results

- The BASE surface was separated into three broad areas designated Santa Barbara Slope, San Miguel Slope, and Santa Rosa Slope, in order to examine specific features unique to each region of the Northwestern Channel Islands slope (Fig. 1). The latter two regions are presented here.
- The San Miguel region was characterized by a broad slope leading to a flat bottom.
- The Santa Rosa Slope contained a submarine canyon. BASE surface generation suggested the presence of a channel within this portion of the slope (Fig. 5).
- Slumping was observed at San Miguel Slope Feature 2 at an approximate depth of 1400 m (Fig. 3).

Digitized Profiles

- Feature 3 on the San Miguel Slope consists of shallow-incised submarine canyons (Fig. 4).
- Feature 1 on San Miguel Slope showed a smoother slope except for a single canyon (Fig. 2).
- Along-axis profiles of San Miguel Slope Feature 1 showed a smooth gradient, however, terracing was visible on Feature 3.
- San Miguel Slope, Feature 4 and Santa Rosa Slope, Feature 5 illustrated that the former consisted of a greater amount of variation in depth changes than the latter.

Discussion

San Miguel Slope (Features 1 and 3)

- Based on the multiple dips or terrace-like steps observed in the horizontal profile (profile E-E'), the submarine canyon of Feature 3 (Fig. 4) appears to have formed as a result of erosion. Due to the absence of numerous dips and a more continuous, smooth transition from higher to lower depth of Feature 1 (Fig. 2), it is most likely younger than Feature 3.
- As a function of time, the erosive processes that have taken place at Feature 3 have not yet occurred on Feature 1. However, Feature 1 terracing (Fig. 2) indicates that smaller scale erosion may be taking place currently.
- The shallow-incised and straight canyons of Feature 3 may be the result of tectonically-induced faulting.

San Miguel Slope (Feature 4) and Santa Rosa Slope (Feature 5)

- Features 4 and 5 are visually similar on a 2-D scale (Fig. 1). It is probable that the consistent slope of Feature 5 is due to more continuous movement of material. Feature 4 is positioned at a greater depth and may experience a reduced amount of material deposit and transport due to the discontinuation of sediment movement.

Conclusion

- The goal of this study was to further characterize a specific region of the Channel Islands slope region. This task was accomplished by highlighting two portions of the slope: San Miguel and Santa Rosa.
- San Miguel slope consisted of a larger depth range as well as a greater amount of features due to its broader area. Similar material transport features were observed in both regions. However, Santa Rosa slope appears to maintain the character of a submarine canyon.
- The variability of features observed on San Miguel and Santa Rosa slopes can be attributed to the region's depth differences and tectonic setting.

References

Field, M.E. and Edwards, B.D., 1980, Slopes of the Southern California Continental Borderland: A regime of mass transport, *Pacific Coast Paleogeography Symposium 4: Quaternary Depositional Environments of the Pacific Coast*, p.169.

Kennish, M.J., 2001, *Practical Handbook of Marine Science* Third Edition, CRC Press LLC, Boca Raton, 896 p.

Lee, H. J. and Normark, W.R., 2009, *Earth Science in the Urban Ocean: The Southern California Continental Borderland*, The Geological Society of America Inc., Boulder, CO, 481 p.