Bathymetric Analysis of Axial Seamount's Southeastern Flank, Juan De Fuca Ridge

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BEAMS

ABSTRACT

Multibeam sonar data were acquired aboard the *R/V Thomas G. Thompson* and were processed using CARIS HIPS & SIPS 8.1 software. Axial Seamount is of special interest to researchers due to its active volcanism and recent eruptions, resulting in a dynamic morphology. Axial's southeastern flank exhibits a unique topography that is a direct result of the geological implications and processes associated with extrusive eruptions and seismic activity. Through this study, we found that the southeastern flank is characterized by terraced lava flows. The feature has several layers that extend from the caldera to the base and all vary in depth ranging from ~1450 to 2500 meters. The second area studied was focused on a cluster of small seamounts located at the base of the southeastern flank. The seamounts sit in a linear pattern and all have the same general morphology. These six small seamounts range in depth from ~2400 to 2500 meters. Backscatter analysis showed that the shorter seamounts are primarily composed of hard rock, most likely basalt, and the taller seamounts are composed of more soft substrates, most likely sand, silt, and other sediment deposited to the ocean floor.

BACKGROUND

Axial Seamount is an active undersea volcano located approximately 300 miles off the Oregon coast, on the western edge of the Juan de Fuca Ridge. It is the most seismically and volcanically active area on the Juan de Fuca plate, most recently erupting in April, 2011 (Arnulf et al., 2014). Axial's summit is located ~1300 meters under the surface (West et al., 2001). The most prominent feature on the seamount is its horseshoe-shaped caldera, which shows evidence of past eruptions that emptied the magma chamber and resulted in the volcano collapsing into itself. The seamount also has two prominent rift zones located on its north and south sides (Embley et al., 1998). Low viscosity basaltic lava is extruded during eruptions, covering sections of the caldera in a layer of basalt, some of which cools and builds up along the flanks of the seamount. As a result, the bathymetry of the area is dynamic and has been altered with each past eruption. The southeastern flank exhibits terraced layers of cooled lava flows. This terracing is altered nearly every time Axial erupts, and the base is paved with a new layer of basalt. Small seamounts are present at the base of Axial on the southeastern side and contribute to the dynamic and unique morphology of the area. This study was conducted to observe and analyze the bathymetry of this southeastern flank of Axial.

DATA ACQUISITION

- Data were acquired aboard the *R/V Thomas G. Thompson* (University of Washington) in 2008 using a Kongsberg EM300 multi-beam sonar system, and an EM302 in 2014.
- The data were processed, cleaned, and analyzed using CARIS HIPS & SIPS 8.1.
- Analysis was performed on a CUBE BASE surface with a resolution of 4 meters.
- Profiles were created along two separate areas of study and were analyzed.

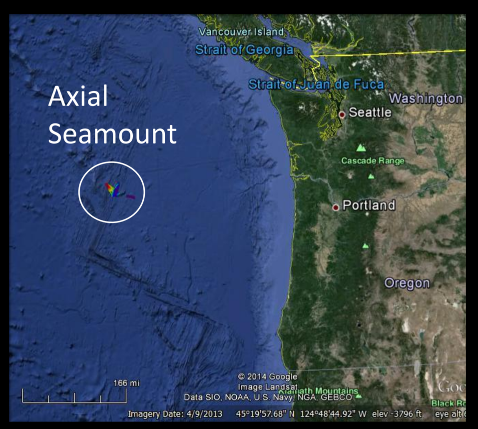


FIG. 1: Google Earth image displaying the map created using CARIS HIPS & SIPS draped over the location of Axial.

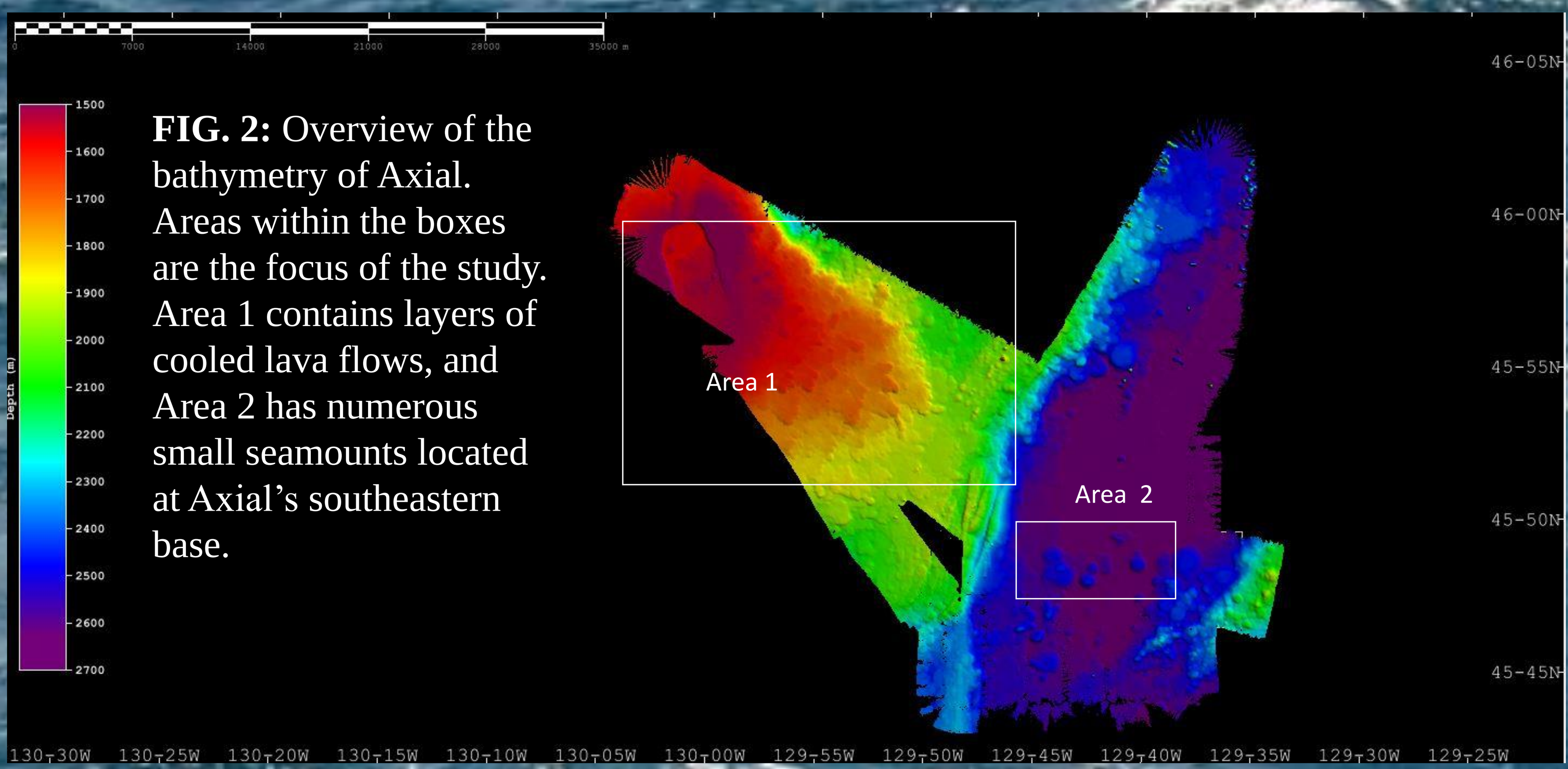


FIG. 2: Overview of the bathymetry of Axial. Areas within the boxes are the focus of the study. Area 1 contains layers of cooled lava flows, and Area 2 has numerous small seamounts located at Axial's southeastern base.

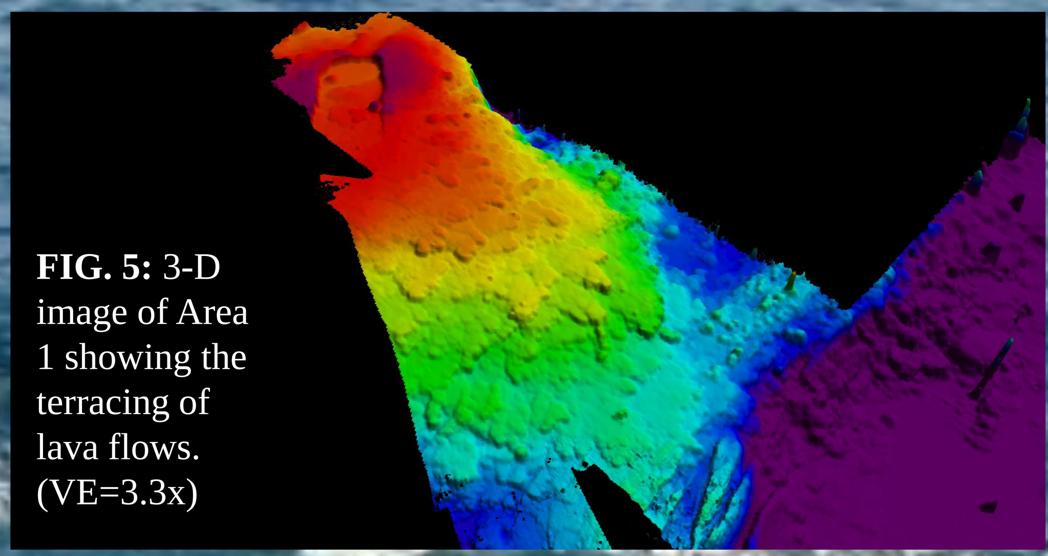


FIG. 5: 3-D image of Area 1 showing the terracing of lava flows. (VE=3.3x)

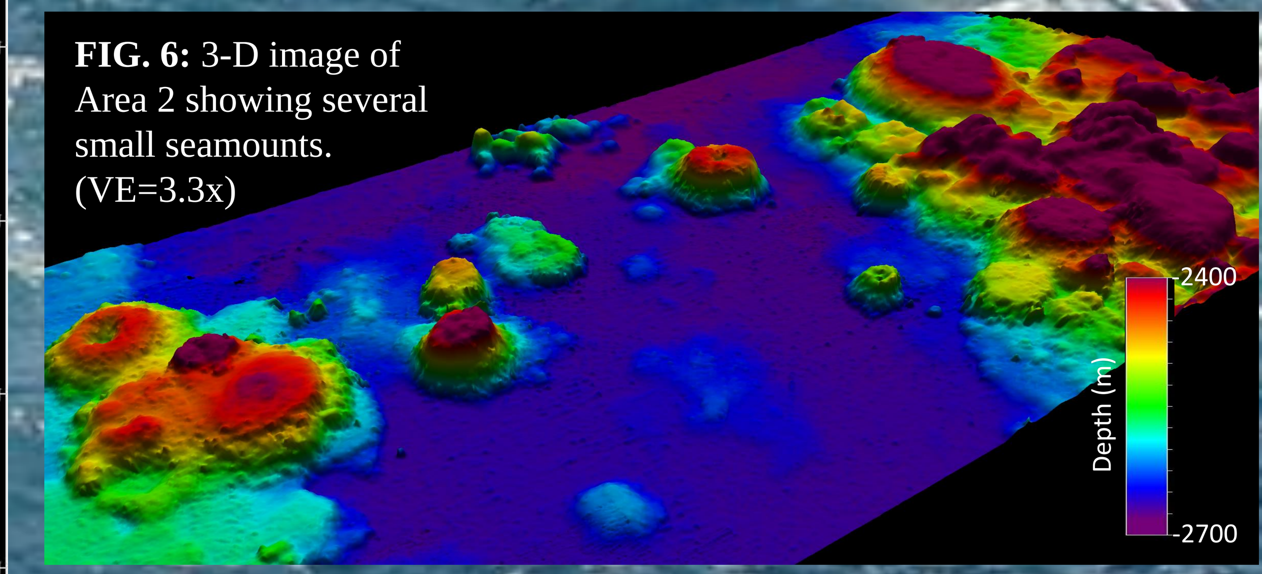
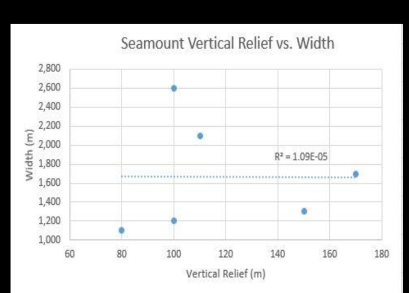


FIG. 6: 3-D image of Area 2 showing several small seamounts. (VE=3.3x)



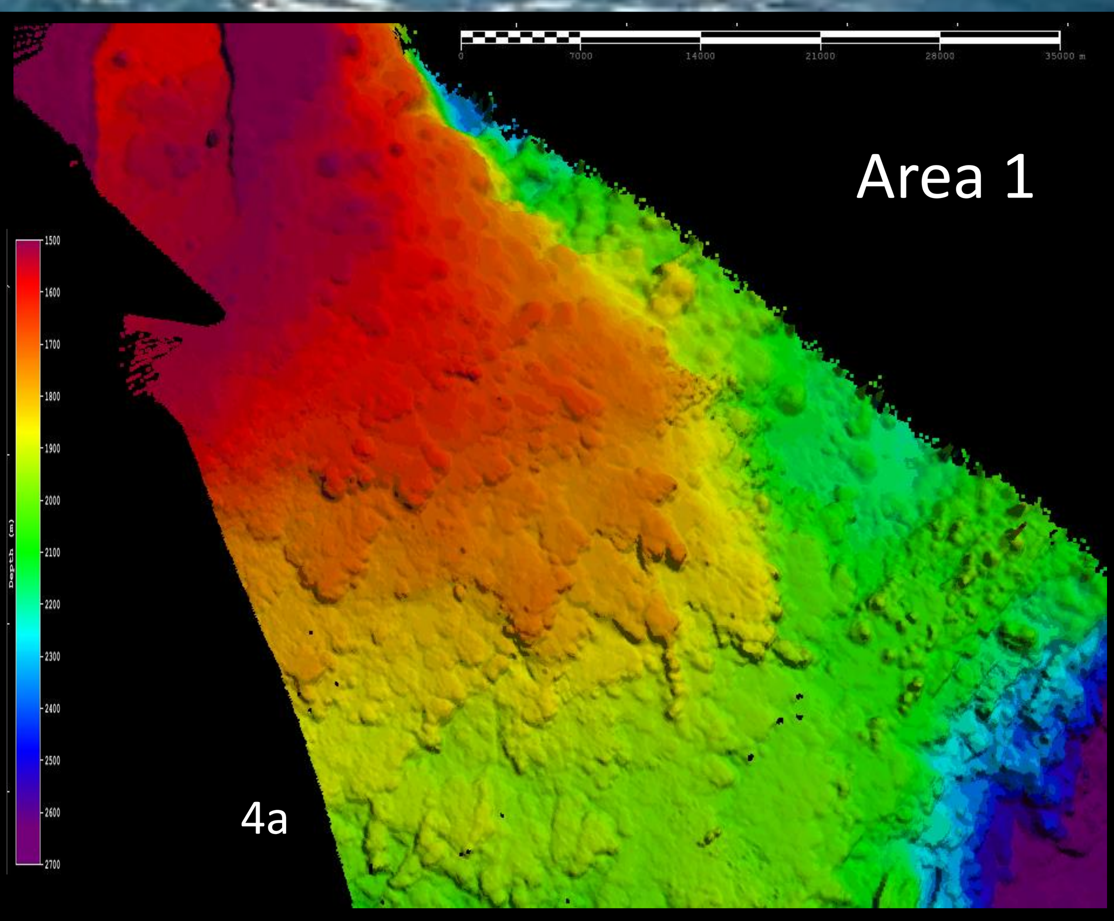
GRAPH 1: Scatter plot of the relationship between vertical relief and width of the small seamounts.

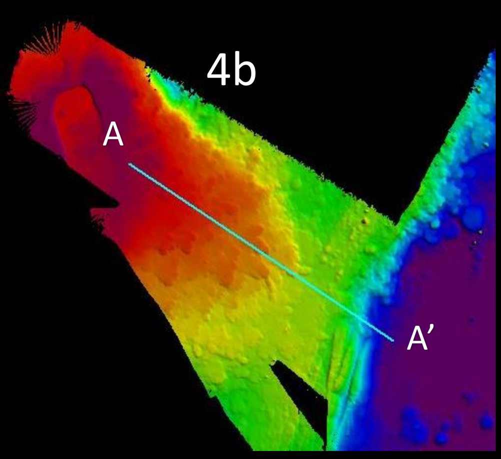
Seamount	Vertical Relief (m)	Width (m)
A	110	2,100
B	100	2,600
C	170	1,700
D	80	1,100
E	100	1,200
F	150	1,300

TABLE 1: Table of the measured vertical reliefs and widths of the small seamounts taken from the profiles created of each.

RESULTS

The 3D map produced exhibits the terraced formation of past lava flows. The terracing appears in a wide, stair step-like morphology. The flows closest to the caldera occur at a depth of 1,560 m and the flows farthest from the caldera are at a depth of 1,935 m. The measured distance from the top of the terrace to the bottom is ~4,000 m. The small seamounts located at the base of Axial are clustered together and have vertical reliefs between ~2,400 and 2,500 m. They all have the same basic morphology and the calderas of several are visible on the map. Backscatter showed that taller seamounts generally are composed of hard substrate, and shorter seamounts are composed of soft substrate.





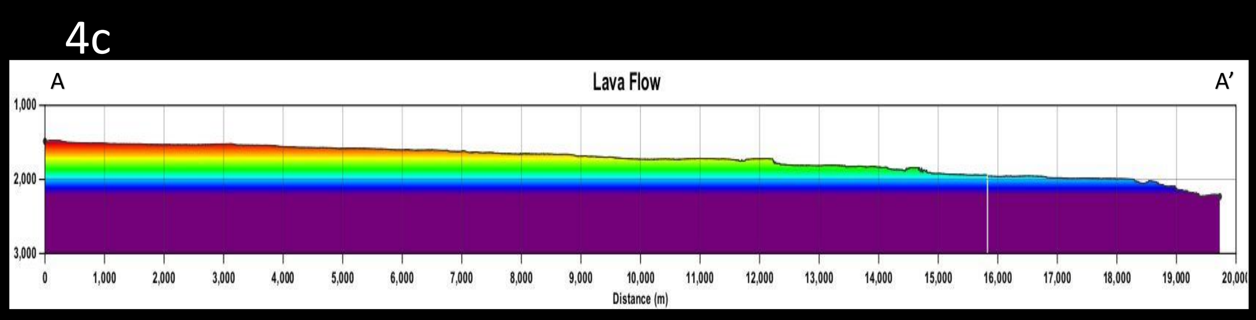
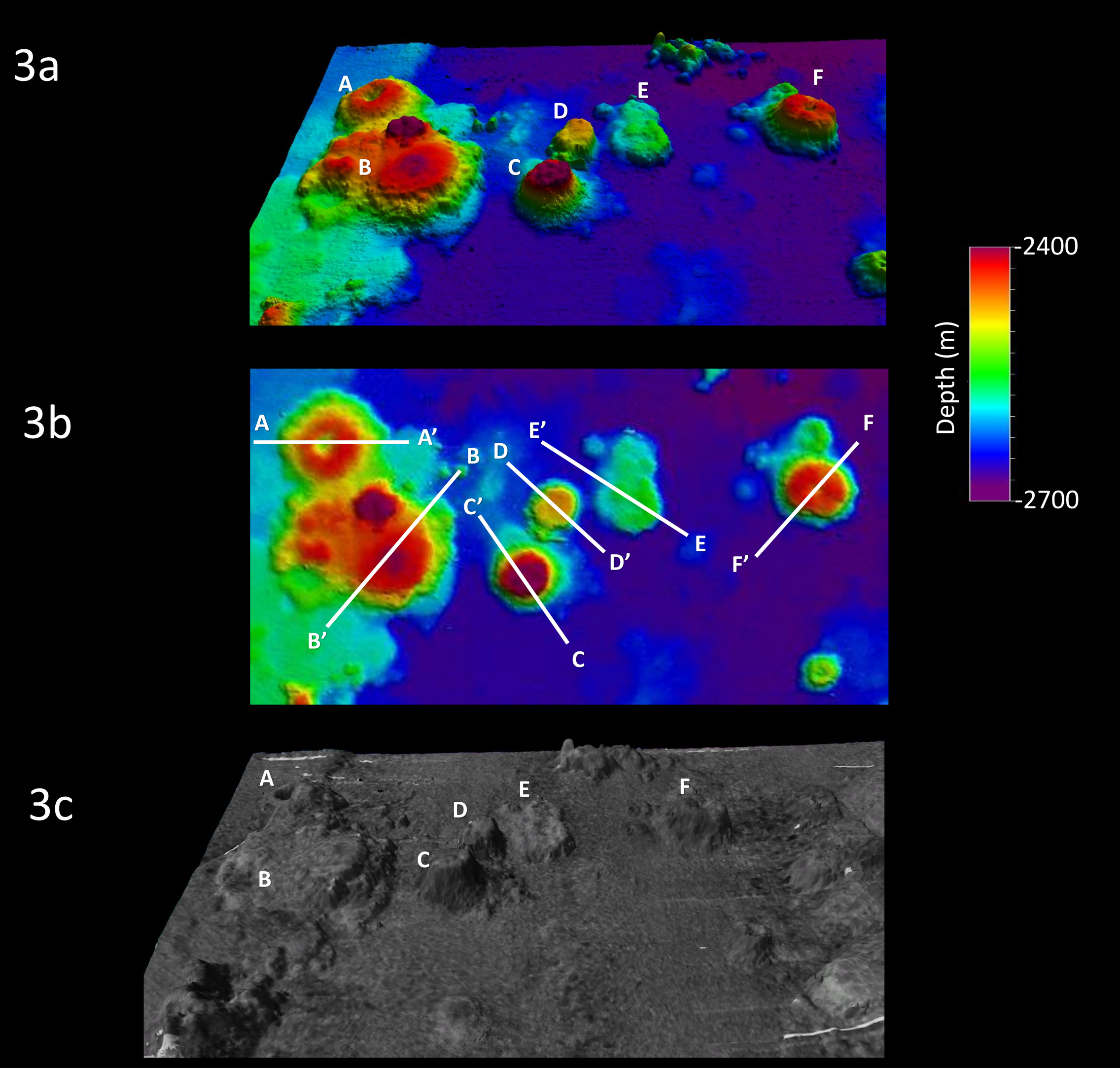


FIG. 4
a) 3-D image of the terraced feature on the southeastern flank of Axial. Layers of past lava flows are exhibited. (VE=3.1x)
b) Overview of profile created along the length of terrace feature.
c) Profile of the past lava flows measuring the length and height of the entire feature. Note the terracing.



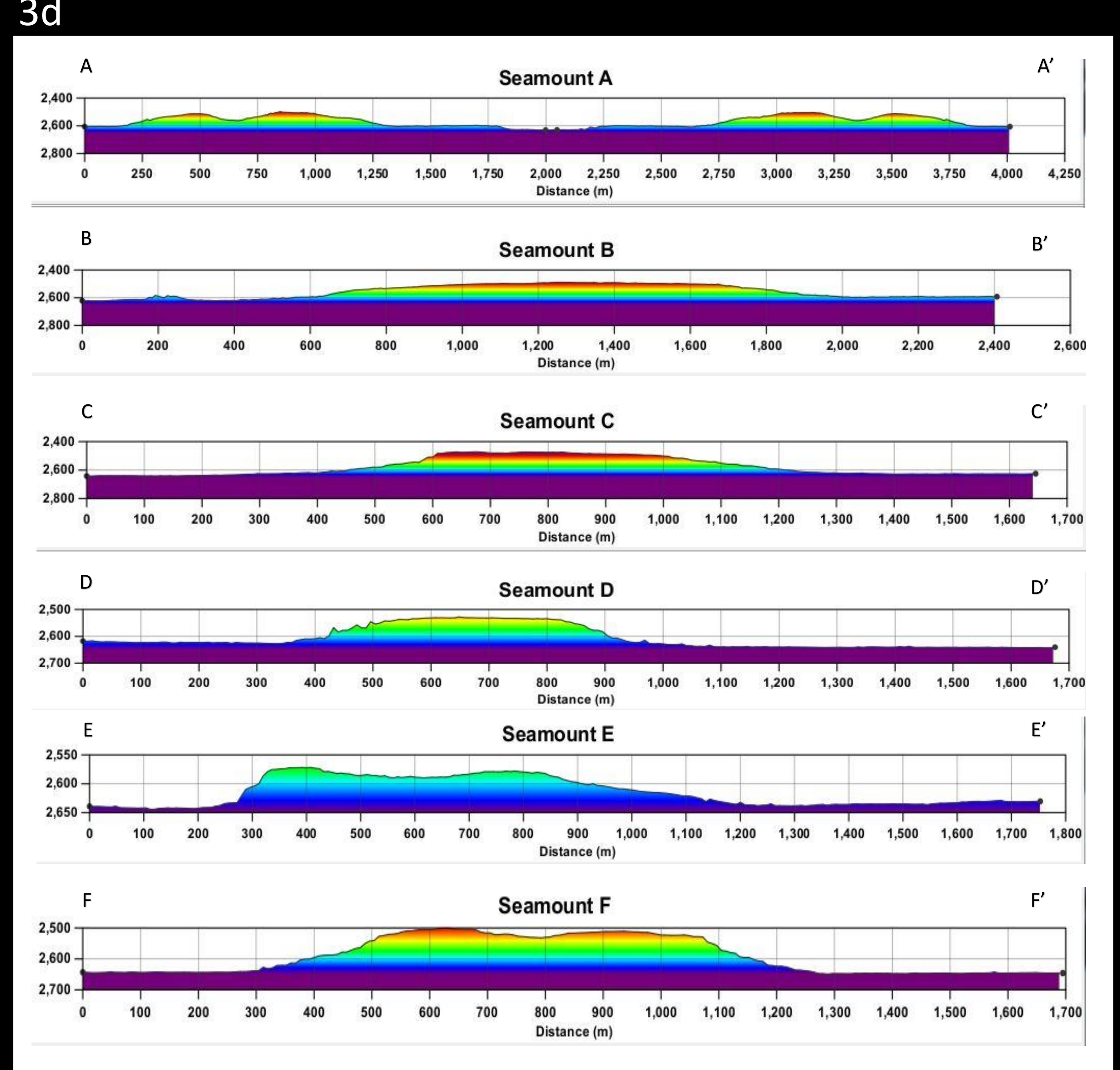


FIG. 3
a) 3-D image of the small seamounts A-F located at the base of Axial. (vertical exaggeration 3.1).
b) Overview of profiles created across the seamounts.
c) Backscatter image draped over 3-D image of the seamounts. Darker color indicates hard substrate, lighter indicates soft substrate.
d) Profiles created, measuring the height and width of each seamount.

DISCUSSION

Axial most recently erupted in April 2011 (Chadwick et al., 2012). A majority of the lava flowed and cooled in the same area along the southeastern flank of the seamount. Based on observations of the generated map, the lava followed this same general trend in past eruptions due to the amount of lava built up along the terrace and the number of layers the terrace exhibits. The oldest lava flows are located at the base, farthest away from the caldera. The most recent flow makes up the top layer of the terrace, closest to the caldera.

The small seamounts that occupy the area at the base of Axial are all very similar in both relief and morphology. The hard rock present on the taller seamounts is most likely basalt, and soft substrate present on the shorter seamounts is most likely silt or other pelagic sediment deposited on the ocean floor. The study was inconclusive as to whether they are seismically or volcanically active.

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