Tectonic Features West of Gorda Ridge, Northeast Pacific

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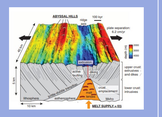
BACKGROUND

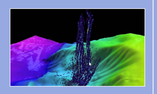
Tectonic features west of Gorda Ridge are located approximately 4,000 km off the coast of Cape Mendocino, California just north of the Mendocino Fracture Zone. In this area, seafloor spreading moves at a rate of 4.0 cm/yr (Mueller, 2008). Axis-parallel ridges (APR), also referred to as abyssal hills are formed where two plates are pulling apart, forming a mid-ocean ridge axis and ridge structures such as those displayed in the study area (Fig. 1)(Olive et al., 2015). The seafloor within the study area ranges in age from 1.5 my on the eastern edge to 4.0 my on its western edge (Mueller, 2008).

The purpose of this study is to further investigate the area west of the Gorda Ridge comparing bathymetry and slope of the two prominent APR sites here referred to as Central and Eastern Sites, and to compare two seamounts located in the study area. The Eastern Site age is 1.5-2.5 my whereas Central Site is older (2.0-2.5 my), as it is farther from the Gorda Ridge axis (Mueller, 2008). The larger and smaller seamounts have been dated at 2.5 to 3.0 and 3.0 to 3.5 my, respectively, and both were formed on surrounding seafloor that is 3.5-4.0 my (Mueller, 2008). A preliminary study of the larger seamount identified methane seeps (Henderson and Bohan, 2014).

The purpose of this study is to use depth profiles and backscatter to characterize differences in geomorphology and substrate among the three sites.



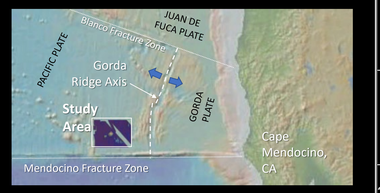
Axis-parallel ridges (Olive et al, 2015)

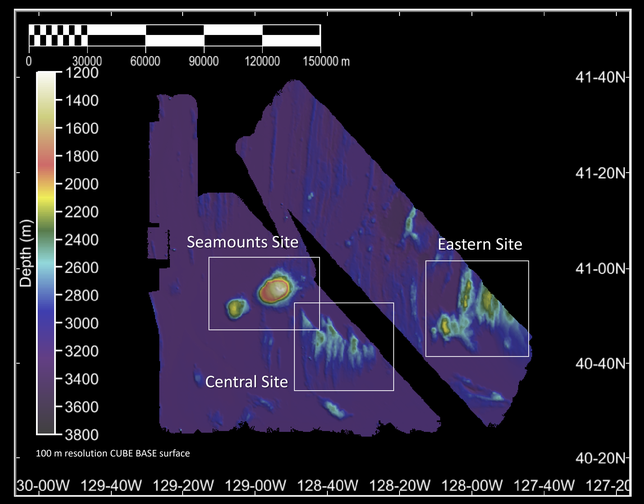


Methane seeps at the larger seamount (Henderson and Bohan, 2014)

Figure 1. Study Area and Sites

Tectonic features west of Gorda Ridge are found directly north of the Mendocino Fracture Zone. The study area includes two sites (Eastern and Western Sites) with axis-parallel ridges, and two prominent seamounts at the Seamounts Site. These features range in depth from 1200 (on the larger seamount's crest) to 2800 m on surrounding flat seabed.





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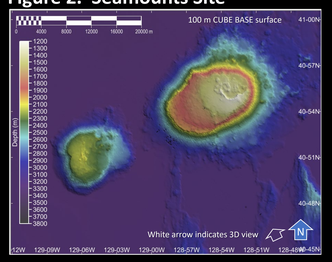
BEAMS

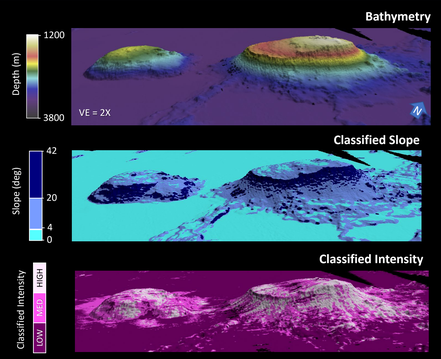
NOAA Ship *Okeanos Explorer*

METHODS

- The NOAA Ship *Okeanos Explorer* collected raw multibeam data during the expedition West Coast Mapping (EX2208) in October/November 2022.
- 2D and 3D bathymetry, slope, aspect, and backscatter surfaces were created using CARIS HIPS and SIPS 11.4 at 100 m resolution.
- Profiles were made of various sites to compare quantitative data of distance, slope, and vertical relief.
- Backscatter was used to determine substrate characteristics.

Figure 2. Seamounts Site



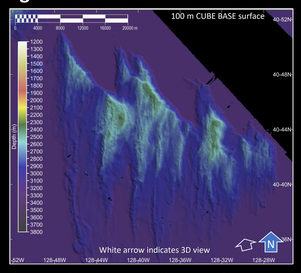


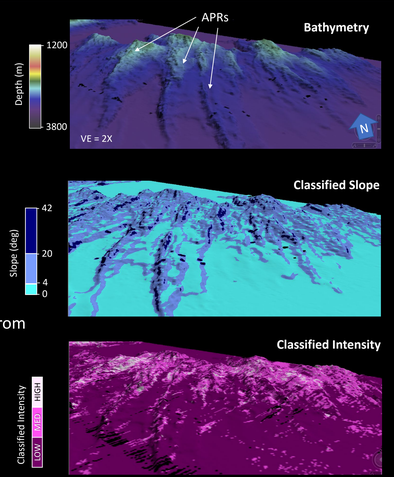
Seamounts Site includes two prominent seamounts, with flank slopes ranging 20 to 40º. The seamounts are steepest (40º) around the rim. Depth ranges are 1250 to 3250 m. The age of the surrounding seafloor is 3.5 – 4 my (Mueller 2008).

The seamounts are flat topped (guyots), indicating weathering and erosion. Guyots form as a result of volcanoes that have grown at/above sea level being weathered and eroded as they become inactive and shrink. Eventually they are completely submerged with flat tops.

Low intensity areas are found in low slope areas of the seabed surrounding the seamounts. High intensity areas, are found on seamount flanks, suggesting rock exposure which is likely to be basalt.

Figure 3. Central Site: Axis-Parallel Ridges



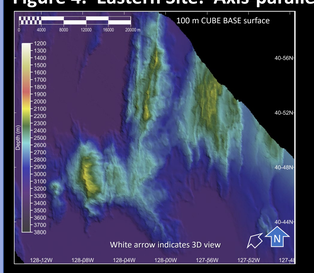


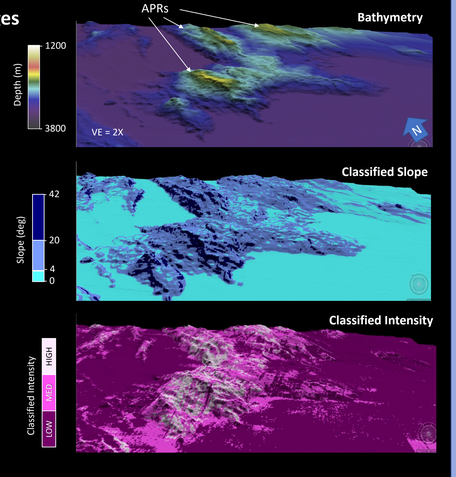
Central Site has prominent axis-parallel ridge (APR) features with a north-south orientation. Depths range from 3200 to 2400 m.
The north ends of the ridges appear faulted with northeast-facing scarps.

Slope is greatest (55 º) on the west side of ridge peaks. The surrounding seabed is < 4º.

Highest backscatter intensities are found at higher slopes, indicating possible rock exposure. Low intensities are found on the flat areas surrounding the APRs, suggesting unconsolidated sediment.

Figure 4. Eastern Site: Axis-parallel ridges



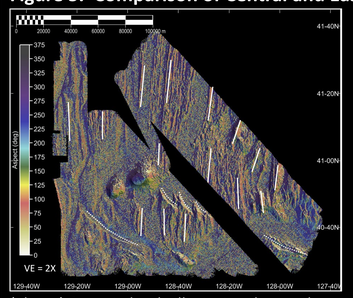


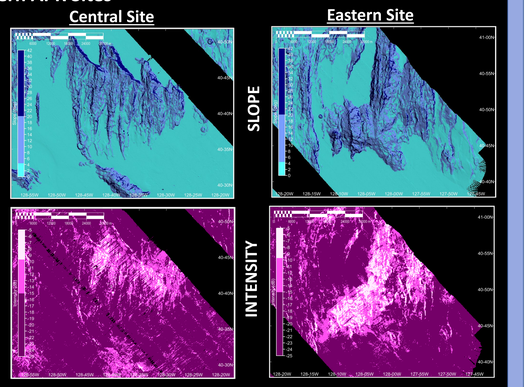
Eastern Site also has APR features, several of which have a north-south oriented, as in the Central Site. The APR in the southwest has a different orientation and is not as steep. Depth at this site ranges 2200 to 3100 m.

Similar to Central Site, slope is steepest (35º) on the west side of APR crests.

Backscatter intensity demonstrates high rock exposure within the site.

Figure 5. Comparison of Central and Eastern APR Sites





(above) Aspect clearly illustrates the north-south trend of most APR features (solid white lines). Faulting which truncated the north ends of several APR features is also evident (dashed white lines).
(above, right) At Central Site, slopes are greatest near the flank top where faulting has occurred, whereas Eastern Site's slopes are greatest around the west side of the ridge peaks.
Larger extent of high backscatter intensity suggests a much higher potential of rock exposure at Eastern Site. More rock is exposed due to the younger seafloor, as expected considering this site is closer to the Gorda Ridge.

(right) Steepest slopes are found on the west side of both sites, demonstrating they originated from the same side of the Gorda Ridge axis.

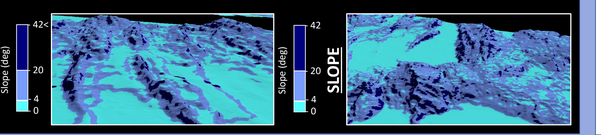
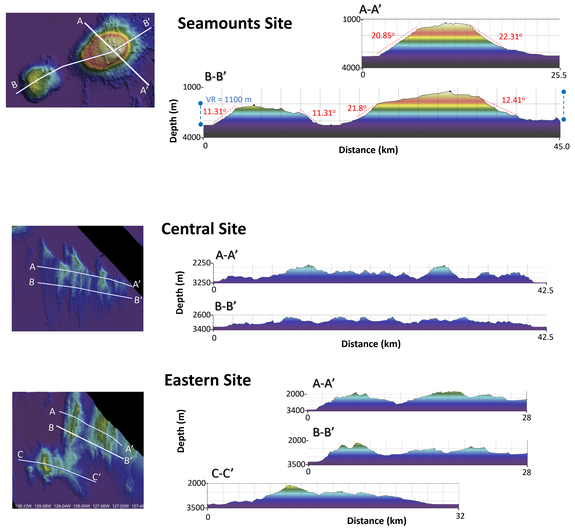


Figure 6. Comparative profiles

VE=2X, all profiles are shown at the same scale.



The larger seamount has flank slopes ranging 20 to 23º, whereas the smaller seamount's flanks are less steep (11 to 22 º). The larger seamount's VR is 1500 m compared to 1100 m of the smaller seamount.

Central Site has lower relief APRs than Eastern Site, which may be due to weathering and erosion that has occurred over a greater time span.

Slopes at Central Site range up to 55 º, whereas Eastern Site slopes range up to 35 º.

DISCUSSION

Geomorphologically, the study area is relatively flat, with numerous prominent features including seamounts and axis-parallel ridges (APRs) that define the area. The seamounts appear to be guyots, whereas the APR Sites show features such as elongate crests, truncated faulting, and steeper slopes.

Seamounts Site

The larger seamount has approximately 800 m greater vertical relief than the smaller and has a width that is 13,750 m longer, or nearly two times as wide. Classified backscatter intensities suggest significant rock exposure at both sites, with more sediment accumulation on the smaller seamount. The larger seamount shows rock exposure closest to the flank's rim, with sediment buildup on the flank bases as well as on the relatively flat top. These seamounts did not originate on the ridge axis, but were formed approximately 1 my after the seafloor moved away from the Gorda Ridge axis.

Central and Eastern Sites

Central Site's greatest slopes are up to 20º steeper than the steepest slope of Eastern Site, and the ridge features have slightly lower vertical relief. Both APR sites have faulting from extension during seafloor spreading, with faults that likely face eastward. Only the Central Site has truncated fault features at the north ends. Central Site has steeper APR slopes than those of Eastern Site APR, yet slopes are greatest on the west flanks of ridge crests.

This study helps better characterize the seabed west of the Gorda Ridge, helping researchers and scientists know which features are most prominent in this site.

ACKNOWLEDGEMENTS

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