Inclination Analysis of Seamounts West of the Sangihe Islands and Correlation Analysis of Backscatter Intensity and Roughness

Graham Schertz and Dr. Leslie Sautter

Dept. of Geology and Environmental Geosciences, College of Charleston

ABSTRACT

A bathymetric survey in June – August of 2010 was conducted on the east side of the Celebes Sea in the Western Pacific. The study area is located west of the Sangihe Islands, a volcanic arc. The survey was conducted by NOAA scientists, aboard the NOAA Ship *Okeanos Explorer* using a Kongsberg EM302 multibeam echo sounder. Post-processing of bathymetric data were completed using CARIS HIPS & SIPS 9.1 to create 2D and 3D bathymetric and backscatter intensity surfaces. The purpose of this study is to characterize the area's geomorphology that is resultant of tectonic activity. The Sangihe Islands range from an elevation of 1320 meters, to seafloor depths of nearly 6 km. These islands are also situated very closely to the connecting intersection of the Eurasian, Philippine, Pacific, and the Australian Plates. Heavy tectonic activity that formed the volcanic island arc also formed interesting bathymetry in the surrounding area.

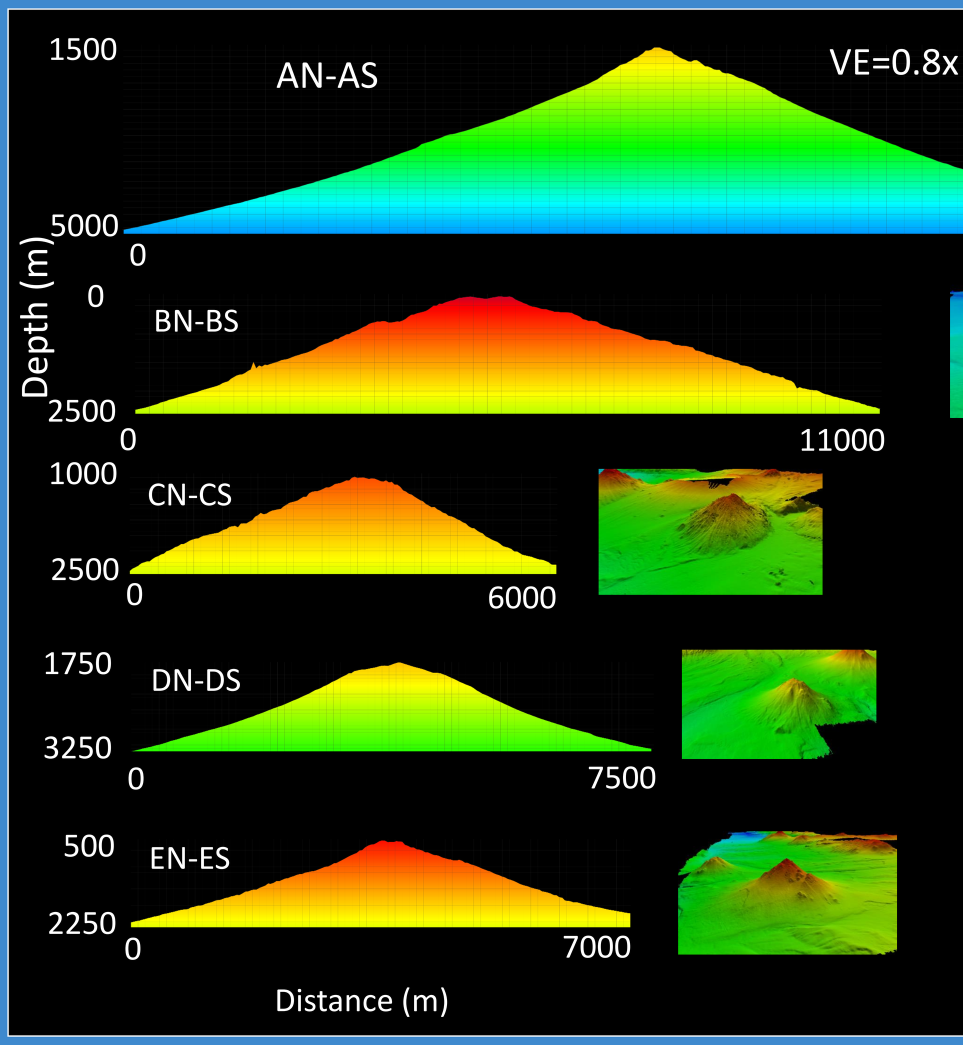


Figure 3: North to South profiles of Seamounts A – E. 3D images of each seamount with a 1.6 VE . Images from 40m resolution CUBE surface.

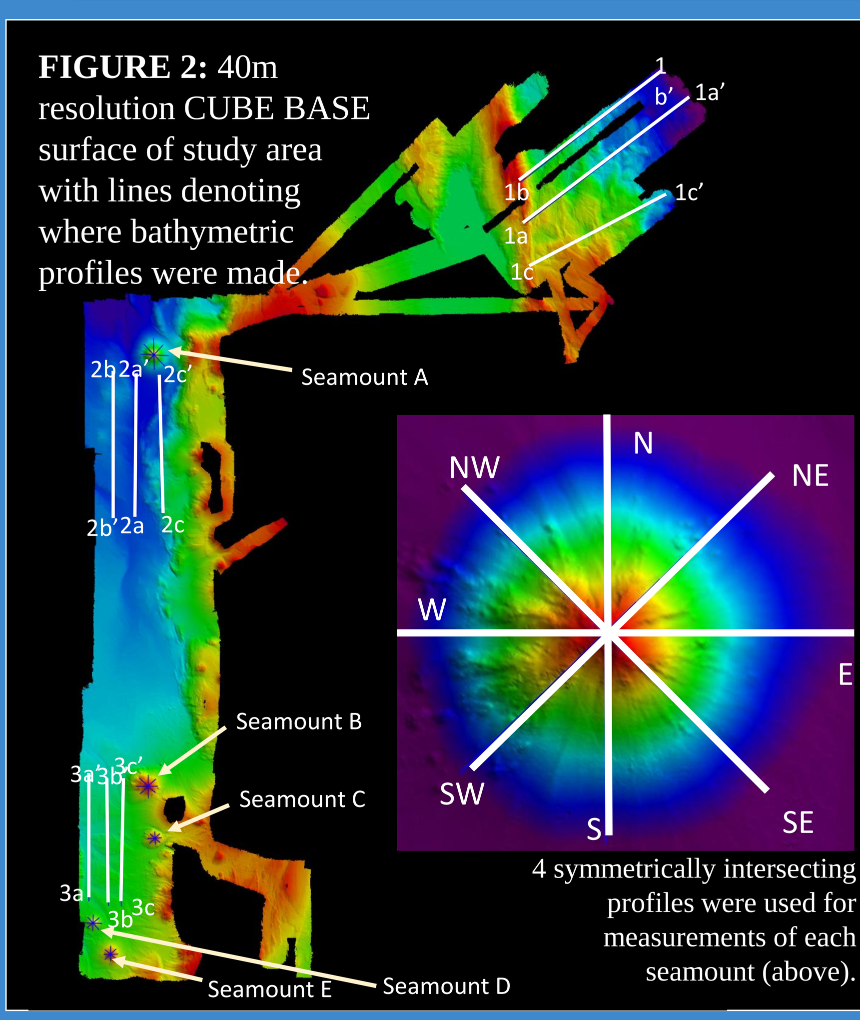


FIGURE 2: 40m resolution CUBE BASE surface of study area with lines denoting where bathymetric profiles were made.

4 symmetrically intersecting profiles were used for measurements of each seamount (above).

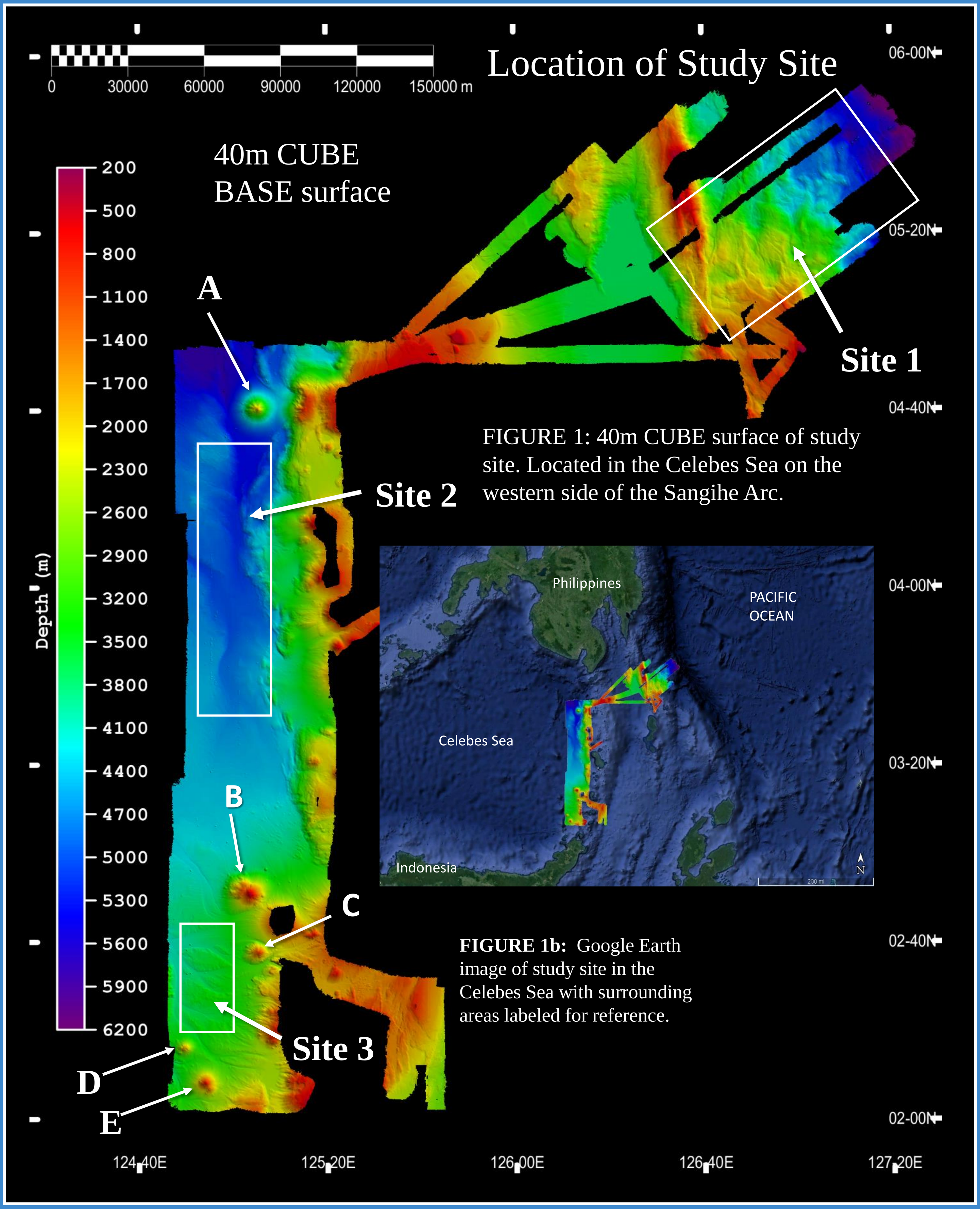


FIGURE 1: 40m CUBE surface of study site. Located in the Celebes Sea on the western side of the Sangihe Arc.

FIGURE 1b: Google Earth image of study site in the Celebes Sea with surrounding areas labeled for reference.

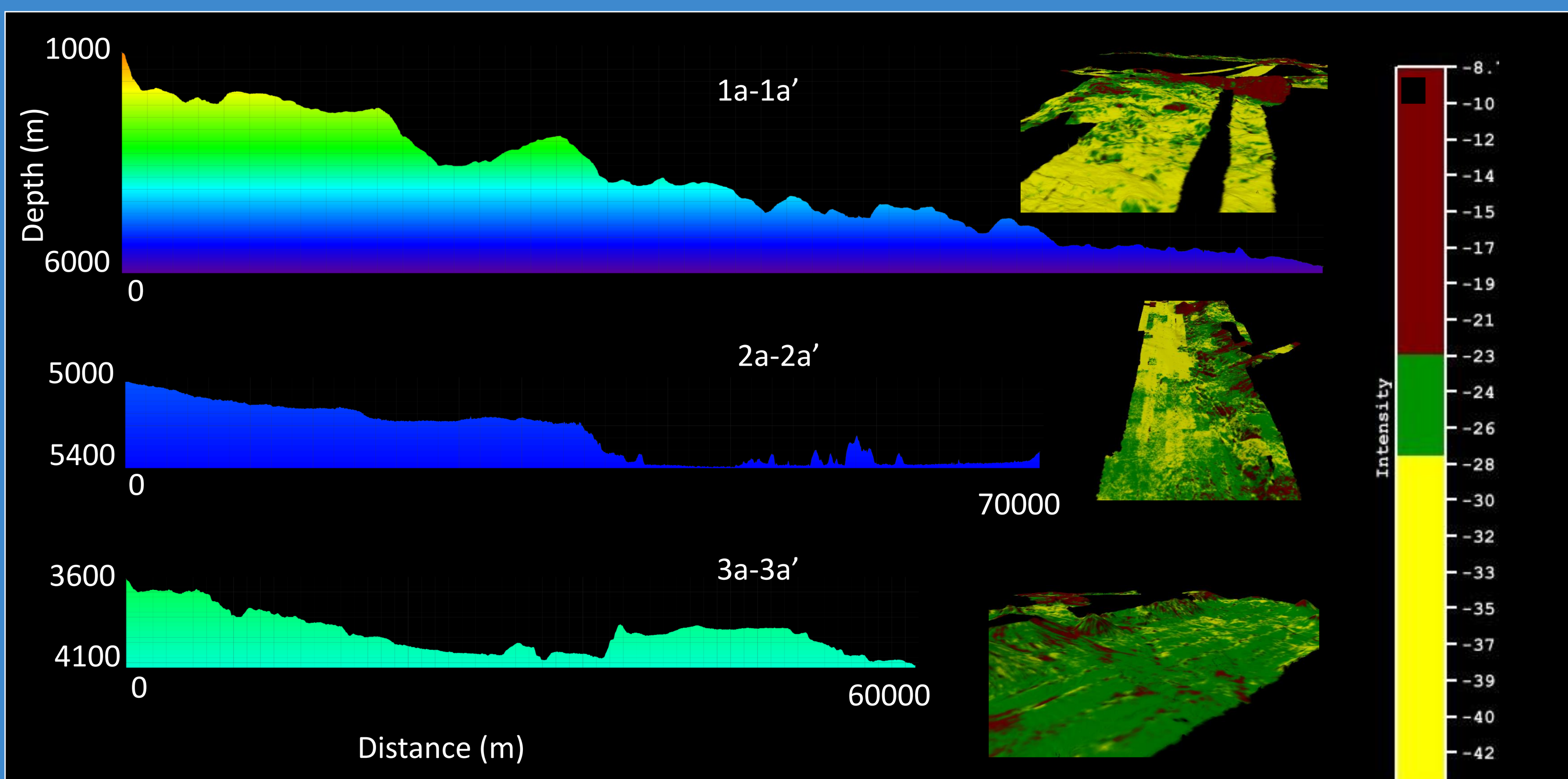
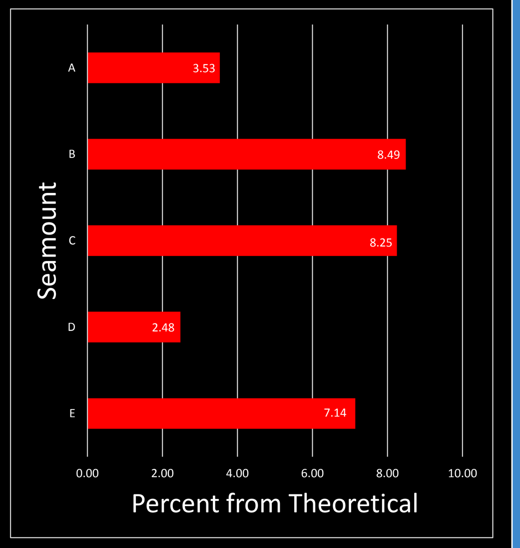


Figure 4: Profiles of Sites 1, 2, and 3. Site 1 with .7 VE and Sites 2, and 3 with 2.8 VE. 40m resolution CUBE surface. 3D images of backscatter intensity draped on 40m 3D bathy surface of 1.6 VE.

TABLE 1: Comparison of an average of the actual slope of each seamount versus the theoretical slope of each seamount given the average height and average width.

Seamount	Actual Θ of inclination (degrees)	Theoretical Θ of Inclination (degrees)	% from theoretical (%)
A	20.87	20.82	3.53
B	18.56	18.52	8.49
C	20.27	20.11	8.25
D	19.93	19.90	2.48
E	22.00	21.82	7.14



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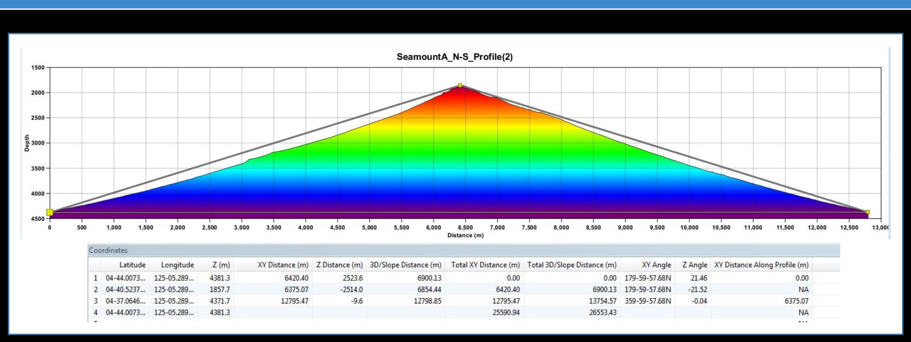
Graham Schertz
schertzge@g.cofc.edu

BACKGROUND

The study area, located due west of the Sangihe Islands, Indonesia (figure 1) paralleling the oldest active subduction zone in the Indo-Philippine region, the Sangihe subduction zone. This study area is constantly undergoing tectonic activity from the subduction of the Molucca Sea Microplate under the Eurasian Plate and has been for the past 25 million years (Di Leo et al., 2012). Formed within the Sangihe Benioff Zone, andesitic volcanoes rise from the seafloor, creating the Sangihe Arc and the surrounding seamounts (Hamilton, 1979). The purpose of this study is to classify seamounts based on their angle of inclination and to compare the roughness of three sites within the study region (Fig. 1).



METHODS

- Collected by NOAA scientists aboard the NOAA Ship *Okeanos Explorer* in 2010.
- Kongsberg EM302 collected bathymetric and backscatter data.
- CARIS HIPS & SIPS 9.1 used to generate 40m CUBE BASE surfaces.
- Seamounts: z measurements, XY distances, avg. slope
- $\theta\ of\ inclination = \tan^{-1}\frac{height\ of\ seamount}{half\ base\ width\ of\ seamount}$
- $\%\ from\ theoretical = \frac{|theoretical\ \theta - avg.\ actual\ \theta|}{theoretical\ \theta} * 100\%$
- % from theoretical taken from average or error of each profile
- $Roughness = (\frac{3D\ slope\ distance}{XY\ distance} - 1) * 10{,}000$

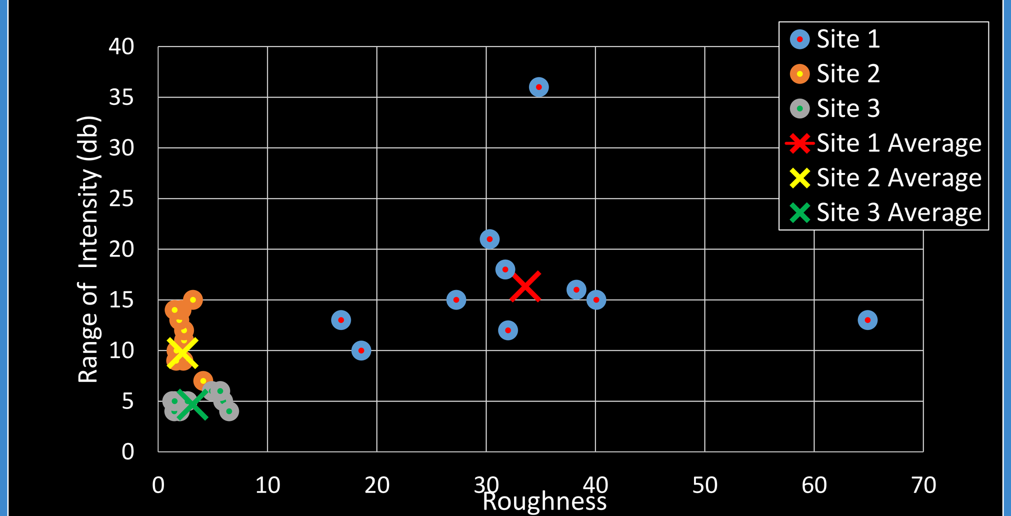
RESULTS

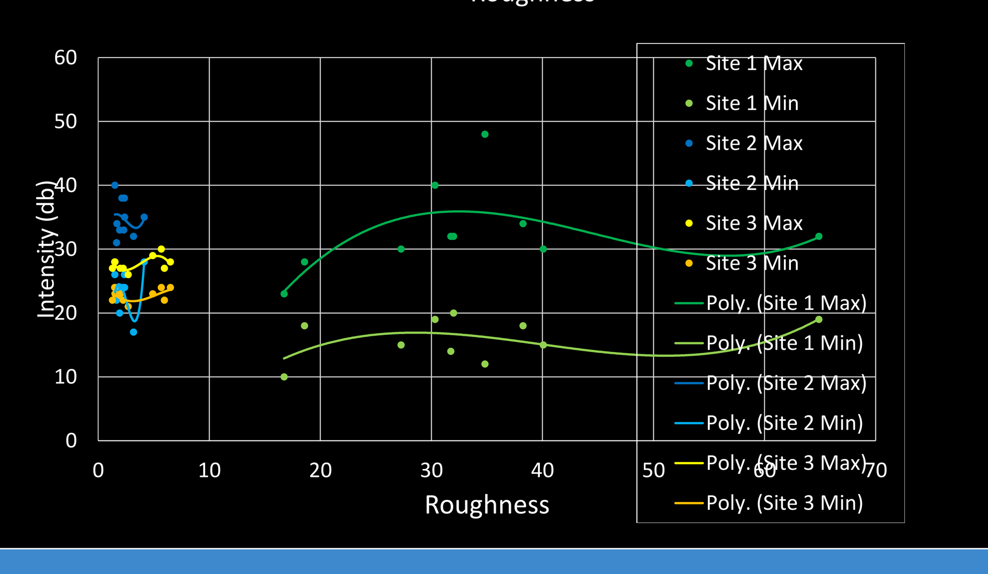
This study area has a diverse seafloor topography and many interesting features.

- Seamounts A, D have a relatively low % from theoretical (= high conicity) indicating that they are exceptionally conical and are a result of non-erupted submarine volcanoes (Table 1).
- Seamounts B, C, and E have a high percent from theoretical (= low conicity) showing that the seamount slope is further from the theoretical slope (Table 1).
- Site 1 has a relatively high roughness with a corresponding high change in backscatter intensity.
- Sites 2 and 3 have a relatively low roughness with a corresponding low change in backscatter intensity.

Table 2: Each site's roughness is compared to range in backscatter intensity across profile lines. Dots represent individual profile datum, and X's represent averages calculated for each site.

	Averages			
Site	Avg. XY Distance (m)	3D Slope Distance (m)	Roughness	Range of Backscatter Intensity (db)
1	82592.17	82861.97	33.58	16.33
2	72991.56	73006.16	2.22	9.75
3	59465.71	59476.67	3.14	4.67





DISCUSSION

Using the methods for determining the average angle of inclination, the seamounts were compared to a perfect cone given the height and average width of each seamount. The near perfect conicity of 2 of the 5 seamounts, <4% from theoretical, located in the study area implies that these submarine volcanoes are relatively young and have not undergone any major eruptions to disfigure the slope surface (Hamilton, 1979). The other 3 seamounts with an error of more than 4% implies that these seamounts have undergone some process to disfigure the slope surface. For future research in studying seamounts, this method of comparing the angle of inclination to a theoretical slope could be used to classify seamounts based on age of the seamount and possibly the tectonic setting.

The preliminary results regarding Sites 1 – 3 suggest that backscatter intensity is a function of surface roughness rather than substrate type. Site 1, taken from 10 profiles selected around the area, showed that a large numerical roughness. Site 1 also had the highest change in backscatter intensity across the profile lengths. Sites 2 and 3 each had a relatively low roughness while simultaneously having a lower change in backscatter intensity. This potential correlation of high roughness to high change in backscatter intensity and low roughness to low change in backscatter intensity led to the hypothesis that backscatter intensity is a function of surface roughness rather than substrate type. Further research can be done to better understand the relationship between surface roughness and backscatter intensity.

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