ABSTRACT

Seamount Chain Geomorphology West of the Mariana Trench Subduction Zone Using High Resolution Sonar and Seismic Reflection Data for Northern Mariana Trench in the Philippine Sea with red line being the main deep-sea reflector and the spikes representing active faulting tectonics. Inset map of location along the Mariana Trench showing reflection profile location.

METHODS

• Data were collected by NOAA Chief Scientist E. Lobbecker on the NOAA Ship Ocean Explorer using Kongsberg EM302 in May-June, 2016.
• Data were post-processed using CARIS HIPS 9.1 to create both 2D and 3D backscatter, and 3D m CUBE BASE surfaces as well as cross-section profiles of specific features (Fig. 4).
• Three slopes were profiled and their general seafloor roughness was calculated by dividing the total 3D surface expression distance by the total profile distance (Fig. 2, Fig. 6).
• “Steepest slope angles” were determined based on the steepest portion of each slope.
• Based on seismic reflection data, observed thrust escarpments were identified (Fig. 5).
• Four profiles were profiled for qualitative analysis based on backscatter 3D images and compared to profile of a confirmed mud mound and seamount (Fig. 3).

RESULTS

• Slope profiles indicate variable steepness with an echelon thrust escarpments cropping up throughout the study area. Slopes range from 10° to 35° and were found to be associated with exposed surfaces of harder backscatter return (Fig. 2).
• Backscatter intensity returns for the four mounds yielded higher intensities compared with surrounding seafloor (Fig. 3). All exhibited a hard backscatter return intensity of 25 to 13 dB similar to slope backscatter intensity (Fig. 4).
• General seafloor roughness ranged 1.0099 to 1.0217, where values of 1 indicate a smooth surface (Fig. 6). Each “step” on the surface is an escarpment which has experienced displacement, upheaving harder substrate and dislodging the smooth surface.
• Mud mounds were found to be nonconical and based on profile views (Data limitations such as total width of base surface data collected restricted full quantification). (Fig. 3D)
• Comparative morphology of Mounds 1-4 with a nearby mud mound and seamount (Owens and Sautter, 2016) indicates the features in the study are mud mounds (Fig. 3, Fig. 7).

DISCUSSION

Morphology of slope features indicates a bath formed based on observed thrust-escarpments, seismic reflection data, and tectonic fabric expressed as general seafloor roughness on the BASE surface (Fig. 2, Fig. 4). The surficial expression of numerous thrust escarpments, mud mounds, zones of shear deformation, and tension cracks is indicative of subsidence zone faulting mechanics (Fig. 2, Fig. 3). Within these tension cracks (both micro- and macro)-sediments are deposited and are consolidated well enough so that they are still able to maintain the structural integrity of the slopes and cliffs (Ogawa, 1997). The tension cracks on this trench segment are related to open tensile failures from the SE-NW dominant stress-orientation in the region of this study. The mud mounds on this surface are tectonically derived based on comparative morphology (Fig. 3, Fig. 7). The Pacific Plate is subducting beneath the Philippine Plate at an oblique angle, along with the numerous microplates bounded in the north and south (Ogawa, 1997). The multi-directional stress accumulates and results in an intricate series of micro- and macro-cracks that can be found on the many gentle slopes and steep cliffs of the Marianas (Ogawa, 1997). These features are the result of both compressional and tensional stress mechanics, and show the chaotic distribution of seismic activity here (Fig. 5). Slope profiles and backscatter intensity collected from the Northern, Central, and Southern areas illustrate the hard substrate that is exposed on the various thrust-escarpments (Fig. 4). This hard substrate is highly associated with the steepest gradients of the slopes, along with the upper most portion of the mud mound features (Fig. 3, Fig. 4). The roughness is most prominent on the slopes but can also vary on the mud mound features (Fig. 2, Fig. 6, Fig. 3).

In summary, the data collected from backscatter, slope, and profiles provide evidence that the features here are tectonic in origin, and the seafloor in this segment of the trench is highly susceptible to fault displacement deformation through compression, tension, and subsidence. A more detailed seismic study should be conducted for this region in order to gain a better understanding of the distribution of tectonically derived versus volcanic features in the Marianas and where they may crop up in the future.