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Physical property and Microstructure across the Seismic reflectors in the Upper plate of the Costa Rica Subduction zone

HAMAHASHI, Mari[1*] ; SCREATON, Elizabeth[2] ; TANIKAWA, Wataru[3] ; HASHIMOTO, Yoshitaka[4] ; MARTIN, Kylara[5] ; SAITO, Saneatsu[3] ; KIMURA, Gaku[1]

[1]The University of Tokyo, [2]University of Florida, [3]Japan Agency for Marine-Earth Science and Technology, [4]Kochi University, [5]U.S. Naval Research Laboratory

Costa Rica subduction zone offshore Osa peninsula is known as an erosive margin characterized by active seismicity, subduction of the Cocos Ridge, active fluid seeps, and mud volcanoes. To understand the geologic processes of this margin, Integrated Ocean Drilling Program (IODP) Expedition 334 and 344 have drilled into the overriding Caribbean plate and the subducting Cocos plate offshore Osa in 2011 and 2012. Velocity structures acquired from previous seismic reflection surveys indicate that the upper plate is composed of a few hundred meters to ˜2 km thick slope sediments overlying consolidated high velocity material (˜3.5-4.3 km/s), bounded by distinct seismic reflectors (von Huene et al., 2000). The nature of the seismic reflectors and the lithology of the consolidated material beneath the slope sediments had been unknown and were considered to be the uplifted basement or old accreted material (e.g. Vannucchi et al., 2013) before Expedition 344 drilled deeper into the middle slope. The unconformity between the slope sediments (Unit 1) and consolidated materials (Unit 2 and 3) were penetrated at Site 1380, across zones that correlate with seismic reflectors. Unit 2 and 3 consists of lithified, low porosity sediments compared to Unit 1, but the age gap between Unit 1 and 2 is very small (<˜0.49 m.y.), indicating rapid sedimentation rate (NN18 zone, ˜600 m/m.y.) despite the unconformity (Harris et al., 2013). The process for the formation of the unconformity and the physical property transitions are yet to be clarified. In our study, to understand the tectonic and depositional history and the processes of subduction erosion occurring at the Costa Rica subduction zone, we evaluate the depositional, tectonic, and geochemical factors that account for the consolidation nature and the formation of the seismic reflectors in the upper plate, by conducting microstructural observations, particle size analysis, X-ray fluorescence analysis, X-ray diffraction analysis, and resistivity measurements using the samples from Site 1380.

The microstructures of the samples observed through the microscope tend to develop dense and cohesive textures in the low porosity sediments of Unit 2 and 3, and particle size changes across several unconformities. Particle size decrease with depth in Unit 2 and finer sediments form well-sorted structures that may account for the porosity decrease. The cross correlation between measured particle size and shipboard porosity show negative correlation especially at Unit 2, indicating that larger sized particles form smaller or fewer pores which may be due to finer particles filling pores between larger particles. The microstructures of the sediments occasionally exhibit foliated fabrics that are partially distributed. From the X-ray fluorescence and X-ray diffraction measurements, Al, K, Ti tend to concentrate in the higher porosity sediments of Unit 1, whereas Si, Ca, P, Mg, Na, and Mn concentrate in the lower porosity sediments of Unit 2 and 3, which are consistent with the transition in mineral composition marked by the increase in analcime and chlorite and the decrease in clay abundance in Unit 2 and 3. The crossplots between porosity and element concentration show negative correlations in Mg, Na, and Mn with porosity, suggesting that the minerals rich in these elements may relate with the consolidation and/or form the pore-filling materials or cements in Unit 2 and 3.

The depositional effect of grain size sorting, the tectonic effect of formation of foliated fabrics, and the geochemical effect of mineral precipitation and/or cementation are indicated to be the factors that characterize the unconformity, consolidation state and the seismic reflectors. In our presentation, we further investigate each effect to constrain the geologic processes occurring across the unconformity and seismic reflectors that form the upper plate structure of the Costa Rica subduction zone.

Keywords: Costa Rica subduction zone, seismic reflector, IODP, Costa Rica Seismogenesis Project, physical property, microstructure