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Distribution of physical properties and pore pressure of sediments off Costa Rica: IODP Expedition 344

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Evolution of physical properties in subduction zone is a key to understand lithification processes, location of decollement, and stress distribution. In this study, we examined the physical properties of sediments using on-board data and laboratory experimental data on sediments obtained off Costa Rica margin to understand the distribution of acoustic properties.

Target sites are in the Integrate Ocean Drilling Program (IODP) Expedition 344 off Costa Rica, including reference sites (U1381 and U1414), frontal prism site (U1412), mid-slope site (U1380) and upper-slope site (U1413). In this study 4 samples from reference sites are from Unit I in shallower Unit. Only one sample in U1381 is located in Unit II below the Unit I. Another samples is from UnitII.

Laboratory experiments for velocity and porosity measurements were conducted with variation of effective pressure.

In U1381, porosity, P-wave velocity, and S-wave velocity were represented about 50-72%, 1.4-1.7m/s and 0.75-0.85 m/s, respectively, during the experiments. From the value, Vp/Vs, bulk modulus and shear modulus were calculated to be 1.85-2.02, 1.8-2.6GPa and 0.8-1.0GPa, respectively. A sample in U1381 was from Unit II, which has relatively low bulk density, indicates 80-66% of porosity, 1.5-1.6 m/s of Vp, 0.85-0.9 m/s of Vs, were obtained, and 1.74-1.78 of Vp/Vs, 1.7-2.0GPa of bulk modulus, and 1.0-1.1GPa of shear modulus correspond to obtained Vp and Vs.

In Unit 1414, similarly described above, porosity, P-wave velocity, and S-wave velocity ranges, 55-73%, 1.5-1.7km/s, and 0.85-0.95 km/s, respectively. Vp/Vs, bulk modulus and shear modulus were computed to be 1.85-2.02, 1.8-2.6GPa and 0.8-1.0GPa, respectively.

Finally, Unit 1412, porosity, P-wave velocity, and S-wave velocity covers, 73-76%, 1.51 -1.56km/s, and 0.75-0.77 km/s, respectively. Vp/Vs, bulk modulus and shear modulus were obtained as 2.0, 0.91-0.95GPa, and 2.4-2.7GPa, respectively.

Vp-porosity relationships from on-board data and from laboratory experiments are comparable nicely and also represents a good agreement with global empirical model, although Site U1381 Unit II has relatively high velocity. This comparable trend in Vp-porosity relationship suggests that the physical properties of sediments except for U1381 Unit II can be similar.

In Vs-porosity relationship, Vs increases with depth increment in each site although the difference in porosity is very small around 0.7 in the obtained state. The sample from U1412 has relatively high both in Vp and Vs even the sample depth is shallow around 14 mbsf.

In terms of bulk and shear moduli, samples from reference sites represent a constant bulk modulus with wider variation of shear modulus. U1381 Unit II shows relativly low bulk modulus in middle value in the variation of shear modulus due to low bulk density and relatively high Vs. A sample from U1412 shows relatively high bulk modulus and low shear modulus.

For sediments in Unit I of reference sites, the trend of constant bulk modulus with variation in shear modulus is similar to that reported from off Osa Peninsula, Costa Rica (ODP Leg 170) (Gettemy and Tobin, 2003). It might be a common evolution in reference site with depth. The samples from U1412 is located at frontal prism even in shallow portion. The sediments should be affected by shear deformation, which may make Vp and Vs increased. Therefore, the bulk modulus is relatively high among the samples. The sample in U1381 Unit II has low bulk modulus due to higher porosity in deeper portion. The higher porosity is kept by skeletons of nanofossils which act as a cement in the sediment. The change in physical properties from Unit I to Unit II is large at the boundary. The effect of the change in physical properties on fluid pressure at the unit boundary should be examined in the near feature.

Keywords: Drilling, IODP, Costa Rica, Expedition 344, Physical properties