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Physical properties of sediments in reference sites and Frontal prism off Costa Rica: IODP Expedition 344

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Comparing physical properties in reference and frontal prism sites is key to understand dewatering and lithification processes in subduction zone. Furthermore, it can be evidence for identifying the location of decollement and the underthrusting materials into seismogenic depth. In this study, we examined the physical properties of sediments in reference sites and frontal prism site both from on-board data and from laboratory experiments for velocity and porosity measurements with variation of effective pressure. Finally, we converted on-board porosity to fluid pressure using laboratory experimental data for reference sites and frontal prism site.

We focused on reference sites, U1381 and U1414, and frontal prism site, U1412 in the Integrate Ocean Drilling Program Expedition 344 off Costarica. Laboratory experiments for velocity and porosity measurements were conducted with variation of effective pressure. We kept 1MPa of pore pressure and changed confining pressure stepwise to control effective pressure. We calculated in-situ effective pressure using sample depth, bulk density and assumption of hydrostatic pressure of pore pressure. We obtained velocity and porosity data by 5 steps up to the in-situ effective pressure and 5 steps more up to 10 times of the in-situ effective pressure. Porosity change during experiments was calculated using volume change in pore water volume. We assumed on-board porosity under atmospheric pressure condition. 4 samples from sites U1381 and U1414 were measured so far.

Porosity ranges from about 77% to about 53% during experiments. P-wave velocity ranges from about 1.4 to 1.6 km/s. Velocity-porosity relationships from on-board data and from laboratory experiments are comparable nicely and also represents a good agreement with global empirical model. Because both laboratory data and on-board data shows a similar trend in the velocity-porosity relationship except for data from U1381 Unit II, the physical properties of sediment except for sediments from U1381 Unit II is similar in velocity-porosity-effective pressure relationships. Therefore, the porosity-effective pressure can be applied on most of sediments, implying that we can convert the porosity to effective pressure using laboratory results. We estimated fluid pressure from on-board porosity with depth using porosity-effective pressure relationship obtained from laboratory experiments.

For U1381 Unit I, hydrostatic fluid pressure was estimated although the error was large. Because U1381 is located in reference site, the hydrostatic pressure is expected in U1381. On the other hand, for U1414, lower fluid pressure than hydrostatic pressure was estimated in ˜10m intervals in the upper part of Unit II. Hydrostatic pressure was estimated in other interval in U1414. Therefore, fluid pressure was recovered to hydrostatic pressure below the over-consolidated layer. In the over-consolidated layer, porosity decreases quickly with constant grain density, which is comparable with the over-consolidation state. Below the over-consolidated layer, porosity increases with decrease of grain density, although the hydrostatic pressure is estimated. In the interval with increase of porosity, because sediments possibly have different physical property, further laboratory experiments on the sediments are needed. Finally, for U1412, over-consolidated sediments were estimated, which may be due to quick dehydration by frontal accretion.

Keywords: IODP, subduction zone, physical property of sediment, elastic wave velocity, pore pressure