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Relationship between compressional-wave velocity and porosity of sediments along subduction plate interface

YAMAGUCHI, Mika[1*], Yoshitaka Hashimoto[1]

[1]Kochi University

Evolution of physical properties of sediments along subduction interface has an effect on wedge strength, wedge geometry, dewatering and dehydration processes, and seismic behavior. Sediments have initially more than 70% of porosity prior to subduction. Through underthrusting and accretion, porosity of sediments decreases by compaction and cementation to be lithified sediments. The purpose of this study is to understand evolution of physical properties from a state before subduction to a state within a wedge using a relationship between compressional-wave velocity and porosity.

In this study, we obtained new data for sediments from a reference site in IODP NanTroSEIZE, Expedition 333, sites in Expeditions 315 and 316. In addition to that, we have complied velocity-porosity relationships obtained by previous studies from NanTroSEIZE (off Kumano) (Hashimoto et al., 2010, 2011, Raimbourg et al., 2011), ODP Leg 190 (off Shikoku) (Hoffman and Tobin, 2004) and ODP Leg 170 (off Costa Rica) (Gettemy and Tobin, 2003).

Locations of sites are as following: For off Kumano, Site C0011 in Expedition 333 is in reference site (prior to subduction), Site C0006 is located at toe of accretionary prism, C0004 is located on a Megasplay fault, Site C0001 is located at landward of C0004 and ocean-ward of Kumano basin, and C0002 is located in the Kumano basin above the seismogenic zone. For off Shikoku, Site 1173 and Site 1174 are located in reference sites, off Muroto and Off Ashizuri, respectively. For off Costa Rica, Site 1039 is located 1.5km of ocean-ward of deformation front (reference site), Site 1043 and Site 1040 are located in 0.6km and 1.7km landward from deformation front, respectively.

Velocity measurement procedure in this study to obtain new data is as following: In the velocity measurements, two pumps (Teledyne ISCO 1000D syringe pump) were used to control pore fluid pressure and confining pressure. The pore pressure of 1000kPa was kept under drained conditions. Confining (effective) pressure was increased stepwise in the measurements. Velocity measurements were conducted under isotropic pressure conditions. Confining pressure was pressurized in tens seconds and kept for more than 8 hours for next step to obtain equilibrium conditions between effective pressure and sediments strain. About 8 steps were conducted for each sample. A in situ effective pressure was approximated for each sample from the accumulation of the bulk density of sediments and hydrostatic pore fluid pressures at the depth of recovery. The maximum effective pressure for each test was up to about 2.5 times of in situ effective pressure. Lead zirconate titanate (PZT) shear wave transducers (500kHz) were used in a source-receiver pair to measure wave speed. PZT in a shear orientation generates a weak compressional mode in addition to its primary shear mode.

Porosity and P-wave velocity ranges about 27 ? 65% and 1.5 ? 2.6 km/s in this study. The P-wave velocity from Raimbourg (2011) is relatively about 1.0 km/s higher at corresponding porosity comparing with that from Hoffuman and Tobin (2004) and Hashimoto et al., (2011).

Sediments were classified into two, simply compacted sediments (reference site and slope sediments) and wedge sediments. Different trend in Vp-porosity relationships were observed for the classified sediments. For compacted sediments, Vp-porosity relationships are along the global empirical relationships (Erickson and Jarrard 1988) and within the area between normal and highly compaction curves. On the other hand, some of Vp-porosity relationships for wedge sediments represent trends with higher velocity at a porosity. Such trend was observed for wedge sediments from Site C0001, C0002 and even from Costa Rica. Those higher Vp trend in Vp-porosity relationship for wedge sediments can be explained by shear strain of sediments and or cementation.

Keywords: compressional-wave velocity, porosity, subduction plate boundary, accretionary complex