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Measurement of seismic velocity of crustal rocks under high confining pressure and pore pressure

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Introduction

Water of the earth interior is mainly supplied at the subduction zone and has important role on seismic activity and volcanism in island arc. It is guessed that slow slip events and tremors occurring at this region are related to water. Based on the seismic tomography at Kanto district, high Poisson's ratio area (˜0.337) was observed and suggested weak seismic coupling (Kamiya and Kobayashi., 2000). Similar high Poisson's ratio is detected at Tonankai and Sikoku district, exceeding 0.3. Those regions correspond to the plate boundary generating slow slip events or tremors (Kodaira et al., 2004 ; Shelly et al., 2006). Because relatively young oceanic plates are subducting in districts from Kanto to Shikoku, antigorite which Poisson's ratio is ˜0.29 may exist stably in those areas. In this case, the observed high Poisson's ratio requires excess pore fluids in addition to the serpentinized mantle. In order to clarify geometry and the abundance of water, we investigate seismic velocity of crustal rocks under high confining pressure and pore fluid pressure.

Experimental methods

For the measurement of seismic velocity, we used the hydraulic pressure vessel in Hiroshima University, in which seismic wave velocity was calculated by using pulse echo method. Samples are gabbro (from Belfast) and granite (from Inada) and were prepared into a cylindrical shape, which diameter and length is 20 and 5-10 mm. We measured seismic velocity under dry and wet conditions, in the later case, distilled water is supplied into the sample with pore pressure up to 50 MPa.

Results and discussion

Under dry experiments, seismic velocities of gabbro and granite were measured up to confining pressure as high as 200MPa. Calculated seismic velocities of gabbro in each confining pressure (100, 140, and 180MPa) were Vp = 6.88, 6.94, 6.83 km/s, Vs = 3.85, 3.91, 3.79 km/s, and velocities of granite were ranging Vp = 4.94-6.09 km/s and Vs = 2.89-3.36 km/s under confining pressure of 200 MPa. These values are lower than Christensen (1996)'s experiments, but Vs of gabbro are similar to those values. From the measurement of both compression and decompression process, it is confirmed that velocity variation has the reproducibility and there is an effect depending on cracks or pores closed by high confining pressure.

Under wet experiments, granite was measured at confining pressure of 60 MPa with pore pressure of 50 MPa (effecting pressure of 10 MPa). At confining pressure of 60 MPa before raising pore pressure, velocities were Vp = 5.17-5.60 km/s and Vs = 2.84-4.36 km/s. After pore pressure increased to 50MPa, velocities were slightly changed to Vp = 5.02-5.18 km/s, Vs = 2.13-3.64 km/s. However, signal from the sample reflection is very weak and therefore these values have large uncertainty at this moment. It is likely that this pulse weakening is related to the wave splitting, overlapping with background noises, and the reflectivity between the sample and the spacer of sample assembly. We try to fix these issues and hope to present the effect of pore pressure on seismic velocity in the coming JPGU meeting.

Keywords: seismic velocity, crustal rock, Poisson's ratio, geofluid, pore pressure, subduction zone