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Measurement of the elastic wave velocity of rocks in subduction zones with the gas medium high pressure apparatus

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The velocity structure of the Earth has been illuminated from the seismological observation (Nakajima et al., 2001) in various places and the quantitative measurement of the seismic wave velocity in laboratory (Nishimoto et al., 2005). The seismic wave velocity is higher at the large coseismic slip area of the Mw 9.0 Tohoku-Oki Earthquake in 2011 than surrounding region (Zhao et al., 2011). This indicates that the rupture of the Tohoku-Oki Earthquake was controlled by structural heterogeneities in the megathrust zone. In order to know the relationship between the velocity anomaly and frictional properties of rocks, we need to measure the elastic velocity of various rocks composing of subduction zones.

In this study, we developed a system of elastic (ultrasonic) wave velocity measurement with the gas medium apparatus which has accurate hydrostatic pressure and can control the temperature and the pore pressure. We can also measure elastic properties such as elastic constants and poisson's ratio in the system by the usage of internal strain gages.

The electric wave velocity was measured by pulse transmission technique employing ultrasonic wave (2 MHz frequency). The wave was recorded by oscilloscope which sampling rate is 10^9 sampling/s. The rock sample and two metal jig pasted piezoelectric transducers of 6 mm diameter were placed in the pressure vessel. The height and diameter of rock samples are about 15-40 mm and 20 mm respectively. We calibrated the system with the metal jig and glass samples whose velocity is known. We measured Vp and Vs of the gabbro and granite during pressurization and depressurization to a maximum confining pressure of 200 MPa. The velocity increased drastically with the increase of the confining pressure up to 100 MPa. After the confining pressure exceeded 100 MPa, the velocity showed gradual increase with pressure. Vp and Vs of the rocks were higher during pressurization than those during depressurization at the same confining pressure, because microcracks that closed at high pressure do not completely reopen during depressurization (Birch 1960). We compared the velocity obtained in this study with the theoretical velocity predicted at a given pressure, temperature and rock composition (Hacker and Abers, 2004). At the confining pressure less than 100 MPa, the measured velocities were significantly lower than theoretical velocities. At pressure higher than 100 MPa, they are consistent with the theoretical velocities. Because the theoretical velocities did not include the effect of microcracks, this indicates that the microcracks closed completely at the pressure higher than 100 MPa. In contrast, the velocity measured with the Piston cylinder-type apparatus in previous studies increased by pressurization until about 400 MPa, and this indicates that the microcracks don't close until higher pressure. Thus the measurement with the gas medium apparatus is suited to measure elastic properties of rocks at shallow part of subduction zones. The elastic wave velocity of rocks increases steadily after microcracks close completely with the increasing pressure. So we can estimate the elastic wave velocity at even more than 200 MPa. In the presentation we will introduce measurement of elastic properties of rocks in subduction zones.

Keywords: elastic wave velocity, gas medium high pressure apparatus, microcrack, rocks in subduction zones, seismic tomography, reflection survey