Measurements of elastic wave velocity of Aji granite during triaxial compression tests under pore pressure

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Elastic wave velocity is one of important physical properties to investigate structure in the Earth's interior. Because of a markedly change in elastic wave velocity at the presence of fluid, the geothermal fluid reservoir is frequently detected through seismic tomography. Previous laboratory experiments have carried to investigate effect of confining pressure (e.g. Nur and Simmons, 1969), axial stress during deformation (e.g. Gupta, 1973; Bonner, 1974; Lockner et al, 1977; Yukutake,1989; Ayling et al. 1995), fluid saturation (e.g. Nur and Simmons, 1969). However, there are few studies examining elastic wave velocity change on fracture process under pore pressure. In this study, we examined change of elastic wave velocity, amplitude and wave period during triaxial compression tests under pore pressure as a fundamental research on estimating of artificial geothermal reservoir on hot dry rock system.

We used Aji granite with a cylindrical shape, 40 mm long and 20 mm in diameter. For triaxial compression tests, we used intra-vessel deformation and fluid flow apparatus at Hiroshima University and deformed sample at 0.01 mm/min displacement rate. On dry condition, confining pressure was 20 MPa, and on wet condition, we used water as a pore fluid and confining pressure was 20MPa and pore pressure was 10 MPa. We kept pore pressure constant using syringe pump and calculated approximate porosity from volume change of fluid at syringe pump. We adopted pulse transmission method using electric transducers directly attached on the sample, and elastic wave velocity (Vp, Vs), amplitude and wave period from waveforms were recorded by oscilloscope.

We observed a systematic change of elastic wave velocity possibly due to closure, growth and formation of cracks during triaxial deformation. While elastic wave velocity was increased due to closure of preexisting cracks at the primary stage of deformation, it decreased markedly at the late stage of deformation. Vp/Vs tends to increase in association with development of deformation on wet condition while it decreases on dry condition. These data are consistent with theoretical model by O'Connell and Budiansky (1974), in which fluid filled cracks increase Vp/Vs but open (dry) cracks have an opposite influence. Based on the model of O'Connell and Budiansky (1974), crack density is suppressed during deformation under wet experiments. During triaxial deformation amplitude was attenuated and wave period became long as a consequence of increasing cracks in the specimens. Attenuation of P wave is relatively small on wet condition because of less scattering of elastic wave at crack surfaces with water. On the other hand, amplitude of S wave vibrated perpendicular to compressional axis tends to increase at initial of deformation, because S wave is sensitive to closure of horizontal cracks. Our experimental results show a correlation between porosity and elastic wave velocity, and we could use this relation to infer extent of fluid reservoir through seismic wave velocity.

Keywords: elastic wave velocity, triaxial deformation, crack density, pore pressure

