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Measurements of elastic wave velocity of Aji granite on triaxial compression fracture test

ZAIMA, Kanta[1*] ; KATAYAMA, Ikuo[1]

[1]Department of Earth and Planetary Systems Science, Hiroshima university

Elastic wave velocity is one of the important physical properties to understand underground mechanics. Especially, in geothermal generation, it has an important part to play in estimating geothermal fluid reservoir. In addition, it is imperative in estimating artificial geothermal reservoir which is formed by hydraulic fracturing. Elastic wave velocity varies in different situations, for example, porosity, shape of crack, distribution of crack, with or without fluid and so on. Many experimental results have been reported until now, for example, velocity change against confining pressure (Nur and Simmons, 1969), velocity change in fracture process (Bonner, 1974). At laboratory, examining these change lead to interpreting underground mechanics which means that estimating geothermal reservoir or artificial one. This study is intended to examine the velocity change in fracture process existing pore pressure and lead to interpreting artificial reservoir in hydraulic fracturing. In this graduation work, we improved the system of measurement of elastic wave velocity using inter-vessel deformation fluid-flow apparatus at Hiroshima University and examined change of elastic wave velocity of dry rock in fracture process.

We used Aji granite which is formed into cylindrical shape as a specimen and tried three measurement systems. First method is pulse reflection method which place piezoelectric device on the top of specimen. Second method is transmission method ($\sigma 1$ direction) which place piezoelectric device on the top and bottom of specimen. Third method is transmission method ($\sigma 3$ direction) which place piezoelectric device on the lateral face of specimen directly. We measured elastic wave velocity under the confining pressure 10 to 200MPa using these methods. In all methods, we could find increase of elastic wave velocity due to compaction through increasing confining pressure. However, in pulse reflection method and transmission method ($\sigma 1$ direction), we could'nt calculate the velocity under low confining pressure in which porosity is high and in long specimen because of attenuation of pulse. So these two methods are not well-suited on the purpose of measurement in fracturing process which use specimen of 40mm long. On the other hand, in transmission method ($\sigma 3$ direction), although we cannot reuse piezoelectric device because it is attached directly, it is possible to minimalize the pulse attenuation.

From the results mentioned above, We used the transmission method ($\sigma 3$ direction) and measured elastic wave velocity of Aji granite in fracture process. This experiment is conducted under confining pressure 20MPa and displacement rate 0.01mm/min using loading system by servo control of inter-vessel deformation fluid-flow apparatus. Specimen is Aji granite which is prepared into a cylindrical shape, which diameter and lengths is 20mm and 40mm, and also which is processed to attach the piezoelectric device.

Increasing of elastic wave velocity was observed until about one-fifth of fracture stress, and then over one-third of it increasing shifted to decreasing. Firstly, increasing of the velocity means closure of micro-cracks in existence. Then gradually, the changes of the velocity start to decrease due to formation of new cracks in the specimen. This effect of formation of crack is more strengthen and the velocity decreases rapidly. Therefore it is possible to explain this decreasing of the velocity by dilatancy effect. Increasing of Vs is affected strongly by closure of cracks extended to $\sigma 3$ direction because direction of vibration of S-wave is normal to maximum compressional axis in this experiment.

Keywords: elastic wave velocity, geothermal fluid reservoir, hydraulic fracturing, dilatancy