SCG57-10 Room:IC Time:May 28 09:00-09:15

Estimation of fluid distribution from seismic velocity and electrical resistivity

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Geophysical mapping of fluids in the crust is critical for understanding crustal dynamics. Pore-fluids play important roles in geodynamic processes including seismic activities. Though a lot of studies have suggested the existence of aqueous fluids in the crust, the fluid distribution has not been quantitatively constrained. Seismic velocity and resistivity should be combined to make a quantitative inference on fluid distribution. It is impossible to infer the amount of fluid only from seismic velocity. Since the lithology of a study region is usually unknown, elastic properties of the rock matrix must be assumed. The fluid amount cannot be inferred only from electrical resistivity, either. The inference of the fluid amount requires the assumption on the fluid resistivity. The fluid amount estimated from resistivity must be identical to that estimated from seismic velocity. The combination of velocity and resistivity can thus constrain the rock matrix and fluid conductivity.

We propose a new method for estimating the amount of fluid from seismic velocity and resistivity. It utilizes an empirical relationship between the normalized resistivity and crack density parameter, which was obtained from measurements of elastic wave velocity and electrical conductivity in a brine-saturated granitic rock under confining pressures (Makimura and Watanabe, Poster session). Resistivity is normalized by the fluid resistivity. If we assume a lithology for the study region, we can estimate the crack density parameter from observed velocity. Using the empirical relation, we can obtain the normalized resistivity. Comparing the normalized resistivity with observed resistivity, we can obtain the fluid resistivity. If the fluid resistivity is an unrealistic value, we must modify the assumed lithology. Both the lithology and fluid resistivity can be constrained through these procedures.

The applicability and limitation of the empirical relation should be studied both experimentally and theoretically. In experimental studies, the relation should be studied in different rock types. A theoretical work on the network of grain boundary cracks will give us a basis of the relation.

Keywords: seismic velocity, resistivity, fluid