Estimation of water content in the crust from resistivity structure - A case study in back-arc area of the TOHOKU district

Makoto Uyeshima[1], Yasuo Ogawa[2]

[1] Earthq. Res. Inst., Univ. Tokyo, [2] TITECH, VFRC

In order to estimate crustal rheology and to synthesize tectonic process such as seismic and volcanic activities beneath the island arc, crustal water content and its connectivity is one of the most important parameters. Owing to significant improvements in instruments, data processing methods and inversion schemes, we are now coming to obtain detailed crustal resistivity structures. On the other hand, dependence of whole rock resistivity versus temperature and water content can be estimated by referring resistivity-temperature dependence for dry rocks and water from laboratory experiments, and by assuming a connection rule of the interstitial water. Then, if we can estimate temperature structure successflly, spatial distribution of crustal water content can be estimated for the connection rule directly from the resistivity cross section. In this presentation, as a case study, we try to estimate spatial distribution of water content from a 2-D resistivity structure beneath back-arc area of the Tohoku district, NE Japan (Ogawa, et al., 2001), and compare the results with a seismic structure (Matsubara et al., 2003).

Temperature structure was first determined from thermal parameters such as surface heat flow, thermal conductivity and crustal heat generation compiled by Furukawa, 1995 and Tanaka et al., 2000. Based on this temperature structure, we estimated whole rock resistivity versus depth dependences for various water contents, by referring laboratory experiment results compiled by Kariya & Shankland (1983) (for dry rocks) and Nesbitt (1993) (for crustal fluids). Here, we assumed that upper and lower crust is respectively granitic and gabbroic, and we estimated whole rock resistivities for Hashin & Strikman (1962)'s perfectly connected(HSc) and isolated(HSi) models. For the HSi model, whole rock resistivity takes almost the same value as that of dry rocks unless water content becomes more than 10 %, and more than 90 % water content is necessary almost throughout the crust to explain the observationally determined resistivity range: from 0.1 to 10k Ohm.m. On the other hand, for the HSc model, water content range from 0.01% to several % can explain the 2-D resistivity cross section.

Ogawa et al., 2000's 2-D resistivity cross section contains three remarkable low resistivity portions in the upper crust beneath three tectonic faults in the area (Kita-Yuri thrust fault, Senya fault and Kitakami Lowland West Boundary fault). Depths of these low resistivity portions range 10-20 km and resistivity is as low as 1-10 Ohm.m. In order to explain this low resistivity, interstitial water should be connected and its content is estimated as 0.5-5 %. Microearthquake foci are distributed in the resistive portion and just above the boundary between conductive and resistive portions. Water in the conductive portion may trigger the microearthquake activity. This estimation is not inconsistent with the water content estimation only from tomographic results for P and S seismic wave velocity perturbations (Matsubara et al., 2003) and theoretical study by Takei, 2002. But joint analysis using both electric and seismic information will reveal more detailed features of the interstitial water and enhance persuasiveness of the estimation.