Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

SSS32-P03 Room:Poster Time:May 1 18:15-19:30

Evolution of fluid transport property by diagenesis in basaltic rocks from the Shimanto belt, Southern Shikoku

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Large slip displacement was observed at shallow portion of the plate boundary fault during 2011 Tohoku earthquake, and this slip has contributed to cause large tsunami. The large displacement was probably caused by dynamic fault weakening at shallow boundary fault, or reduction of fault strength at middle to deeper portion by pore pressure generation. Pore pressure can be generated by chemical dehydration, fluid influx from deeper crust or pore volume reduction associate with permeability reduction at a large subduction plate boundary. In this study, we investigate the change of fluid transport property for basalt during diagenesis process at Nankai Subduction zone.

We collected basalt brocks in the Cretaceous Shimanto accretionary complex of Japan from Okitsu-Kozurutsu site and Kure site in Kochi, Japan. Porosity and P-wave velocity of each basalt at atmospheric pressure are 1.4 % and 2.1%, and 6.4 km/s and 5.9km/s, respectively. We found a slight difference of S-wave velocity for basalts. Permeability was measured by using N2 gas as a pore fluid, and calculated by steady state gas flow method. Permeability was measured at room temperature and under confining pressure that were increased from 1 to 160 MPa in steps.

Gas permeability was decreased with an increase of differential pore pressure at a same confining pressure. This pore pressure dependence implies the Klinkenberg effect, therefore we converted gas permeability to water permeability using the Klinkenberg equation. We did not find a variation of permeability at the lowest effective pressure of 1MPa, and permeability shows from 10^{-15} to 10^{-16} m^2. Permeability in all basalts decreased with an increase of effective pressure, and reaches from 10^{-18} to 10^{-21} m^2. Basalt from Kure site shows the lowest permeability of 10^{-21} m^2 at 100 MPa, and permeability of basalt from Okitsu site shows the largest value of 3×10^{-19} m^2. Permeability reduction with an increase of effective pressure in most samples is described by the power law equation where exponent ranges from -2 to -3. The permeability reduction for the highest permeable basalt was expressed by the theoretical relation that is based on the Hertzian contact theory (Gangi, 1978). Fractures are apparently developed in this sample, therefore the reduction in permeability is influenced more by fracture asperity rather than pore structure.

The permeabilities of basalts in this study are smaller than permeability of basalt in fault zone at Okitsu site (Kato et al., 2004), Juan de Fuca and Tonga-Kermadec (Christensenan and Ramananantoandro, 1988). At present, we did not see clear relationship between the permeability and diagenesis. Most of basalt rock shows very low permeability, therefore they have higher potential to generate a pore pressure by dehydration reaction or influx from depth during subduction at Nankai Trough.

Keywords: permeability, fluid pressure, diagenesis, subduction zone, Nankai Trough earthquake, basalt