Permeability structures of the Ashigara Group and the epicentral area of Chi-Chi Earthquake in central Taiwan

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To know the fluid flow in sedimentary basins is of importance for understanding growth process of accretionary prism, earthquake mechanism, toxic water disposal and so on. To know the fluid migration system in some focal areas, we are demanded to investigate permeability structure at depth and porosity distribution. As we are possible to measure the in-situ physical parameter from drilling at subsurface, this has much limited to the depth and place to drilling for economical and technical reasons. Our goal is to know the permeability structure in wide areas from the laboratory experiment using surface samples.

In the first step, we estimated the permeability structure at depth of the Ashigara sedimentary basin in Japan. Then we applied the result to evaluate the permeability structure at Taiwan western foothill. Both basins are composed of younger sedimentary rocks (mainly neogene). They are located at the subduction plate boundary. And they are strongly tectonically deformed and almost all formations are cropped up successively. Since the 1999 Chi-Chi earthquake in Taiwan, west-central part of Taiwan, where the earthquake occurred, has been paid much attention. An underground structure has been estimated in detail from a seismic reflection profile. Pore pressure or some properties have been measured from borehole. The focal depth was determined to 8.0 km, which is the depth that we can recreate in our laboratory. We also investigated the influence of the fault for the permeability structure at the focal area.

At first, we have attempted to estimate permeability structures in the Ashigara basin by measuring permeability of surface samples in laboratory taking into account the effects of burial and uplifting/erosion history. We regarded burial and subsequent uplifting and erosion as a pressure cycling process. In view of our pressure cycling tests, sample collected at a surface outcrop showed a permeability (or porosity) vs. depth curve starting from lower permeability then joining the normal burial curve at about the maximum burial depth. Thus, the normal burial curve can be estimated by using samples with different burial depths (samples from different stratigraphic horizons). Above the maximum burial depth, the permeability depends highly on the history of the sample.

We constructed porosity-depth curves for the Ashigara group from the permeability test. Samples were collected from several stratigraphic horizons, and porosity on the vertical axis was estimated from measured permeability using the relationship by Chilingar et al. (1963). Results are similar to logging data from oil fields except at low effective pressures where porosity are affected by previous history of samples. At a greater depth, porosity from samples with deeper burial depths (older samples) clearly exhibits smaller porosity than those from shallower burial depths (younger samples). This difference is probably due to the effects of time dependent compaction, chemical cementation and tectonic deformation. Such a trend was not recognized for mudstone from Ashigara group.

Now we tried to estimate permeability structure at depth of the western foothill. We took several samples of various formations from the middle tertiary in the eastern part to quaternary in the western part around the Chelungpu fault, which was active during the Chi-Chi earthquake.

At the low effective pressure all the samples of Taiwan showed higher permeability value from 10-14 m2 to 10-15 m2 . At the higher effective pressure, permeability showed different value as the different kind of rock. At a effective pressure of 100 MPa, permeability of sandstone, fault gouge and shale showed 10-15 m2 ~ 10-17 m2, 10-18 m2 , 10-19 m2 respectively.

Sandstone showed different pressure sensitivity of permeability (as determined by the slope of the curve). It is remarkable that some sandstone did not decrease permeability at higher effective pressures.