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Stress estimate in seismogenic region

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The state of stress provides us insights into understanding the mechanisms of generation and propagation of large earthquakes. Several methods have been proposed to estimate stress state at depths: In-situ stress measurements, core stress measurements and stress estimates from earthquake focal mechanism analysis. It is possible to estimate stress state at seismogenic depths (deeper than 10 km) by earthquake focal mechanism analysis. However, it is still necessary to estimate absolute value of stress at great depths, because earthquake focal mechanism analysis provides us only stress ratios and orientation. In-situ measurements and core stress measurements have advantages and disadvantages. Hydraulic fracturing stress measurements will be difficult to be performed at great depths due to breakouts and has fundamental problem regarding maximum stress. Core stress measurements need to have physical basis on the assumption on the stress estimates. To overcome the problem that we do no have a method, with which we can estimate stress values and orientation, we need to combine all the possible methods and compare the results to establish realistic and reliable methods to estimate stress at great seismogenic region.

We will review the results at three site: 1) Stress measurements at the region with very shallow earthquakes and and 2) Stress measurements after the 1999 Chi-Chi earthquake (Taiwan).

In the western Nagano region, central Japan, the Naganoken-Seibu earthquake (M 6.8) occurred in 1984. Because of the shallow hypocenter earthquake (2 km), it is one of the best areas in Japan to study earthquake source process through borehole observations in the close vicinity of the earthquake sources. We drilled an 800 m deep borehole which almost reaches the earthquake focal region. We compare the hydraulic fracturing and core results. The measured stress field is consistent with that expected

from the focal mechanism of the main shock, and the stress direction is in the ambient angle for the right lateral movement of the fault system.

The anelastic strain recovery (ASR) measurements were carried out on the cores taken from the depths close to a fault zone in the Hole-A of Taiwan Chelungpu-fault Drilling Project (TCDP). Four fault zones were encountered between 1100m and 1300m of depth during drilling. Beneath the shallowest fault zone at the depth of 1111m, two cores, at about 1m and 11m away from the gouge, respectively, were used for the ASR measurements. For all the directions of both the samples, the expansional anelastic strains were obtained. By using these strain data, a three-dimensional analysis of the principal orientations of in-situ stresses was conducted. The orientations of the minor principal stress at the two depths were roughly the same for each other and approximately equal to west-east orientation with a small plunge. That is, this orientation of the minor principal stress approximately coincides with orientation of the slip displacement of Chelungpu-fault during the Chichi earthquake. The magnitudes of the three principal stresses can be estimated when rock density data is obtained. We will also compare the in-situ stress measurements , which will be schedule in the Hole B.

We will also discuss the strategy of stress estimates in future seismogenic zone drilling, for example Nankai subduction zone.