In-situ stress measurement beneath seafloor by Deformation Rate Analysis

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[Introduction]

The measurement of in-situ stresses near the plate boundary is essential to clarify the static interaction between plates as well as the dynamic one. There are two kinds of method for the measurement of in-situ stress. One is the method for measurement at drilling site. the other is the method for measurement from core samples in laboratory. The laboratory method is considered to have the advantage of small cost compared with the in-situ method. We introduce Deformation Rate Analysis (DRA) proposed by Yamamoto et al. (1990) that is one of the laboratory methods. Previous studies have shown that this method is applicable to the core samples recovered from boreholes not only in inland but also beneath seafloor.

[Deformation Rate Analysis (DRA)]

DRA is based on the rock property of in-situ stress memory, which is found in the inelastic strain behavior of rock under uni-axial loading of compression. Yamamoto (1995) has hypothesized the mechanism of this property as follows: When a stress is applied to a rock that is an inhomogeneous elastic material, stress concentrations are locally produced. If the applied stress is kept constant for a long time, the concentrations may be reduced by inelastic deformation of minerals in the rock. Therefore, when the sample recovers from the depth, the stress field in the sample may become non-uniform. DRA is the method to estimate the stress at which the stress field in the sample is the most uniform. In-situ stress memory is characterized by the property whereby the inelastic strain starts to increase at the time when the applied axial stress to a sample overcomes the in-situ stress. This hypothesis has been verified from experimental results that estimated vertical stress is almost equal to overburden pressure calculated from the sampling depth and the appropriate density of overburden rock. Usually, the samples used in DRA are of rectangular prism in shape of about 1.5cm x 1.5cm x 3.5cm in size. To estimate the principal stress, we need the core with about 30 cm in length at one depth.

[The objective estimation method of stress value in DRA]

It is often difficult to detect the axial stress at where the inelastic strain changes. Sato et al. (2000) proposed a statistical technique to identify some axial stresses for individual samples as candidates of in-situ stress. The azimuthal change in the crustal stress is expressed by a sinusoidal function of azimuth. By integrating the condition into the program, we have been able to reduce the number of the possible candidates.

[For the application to the deep sea core sample]

In order to estimate the shear strength of plate boundary, it is necessary to know the stress distribution for the distance from plate boundary. This may be possible by using DRA, if core samples are obtained from several depths near plate boundary. The depth of plate boundary is deep. It is necessary to apply the axial stress more than about 1.5 times of expected in-situ stress during the measurement in DRA. When the value of in-situ stress is not enough smaller than the strength of the sample, the identification of the in-situ stress becomes difficult because of large inelastic strain associated with applied axial stress near the strength of the sample. It has been theoretically shown that this difficulty is overcome by carrying out DRA under confining pressures. However, this has not been experimentally verified. The verification may be the first problem for successfully applying DRA to core samples recovered from large depths beneath seafloor and near plate boundary.