Stress field in accretionary prism inferred from geological structures in Mugi melange, the Northern Shimanto Belt

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The Mugi mélange in the Northern Shimanto Belt is a mixture of terrigenous and pelagic materials. Sandstone, acidic tuff and basalt blocks are surrounded by matrix of black shale. Intermittent bedding planes trend ENE-WSW to E-W and dip steeply northward. The Mugi mélange has a duplex structure and is thought to be tectonic mélange because of repetitious basalt layers with brittle shear zones (Ikesawa et al., 2002) and P-T conditions derived from vitrinite reflectance (Omori (Ikehara) et al., personal communication) and analysis of fluid inclusions (Matsumura et al., 2003). In this study, for the purpose of determining the stress field in accretionary prism, orientations of geological structures, including striations on cleavages of shale, kink folds in shale and meso-scale faults, are analyzed.

The cleavages of shale are roughly parallel to bedding planes, but some are disturbed by folds or vary with horizons. The striations on them are dominantly directed to the dip directions of cleavage planes.

The kink folds locally occur in black shale in the upper part of the Mugi mélange. All of them are reverse kinks that have compressional displacements, and some are conjugate. Since they appear to have deformed coaxially due to their small displacements, the conjugate fault analysis is available. As a result, orientations of principal stress axes with E-W trending horizontal sigma_1 are obtained.

The multiple inverse method (Yamaji, 2000) was applied to meso-scale faults. The classical inverse method (Angelier, 1979, 1984) can determine the orientations of three principal stress axes and stress ratio (phi = (sigma_2-sigma_3)/(sigma_1-sigma_3)) from fault slip data set. The multiple inverse method has relatively high resolution to distinguish plural stress tensors. Since numerous faults of various attitudes were observed in the Mugi mélange, the existences of plural stress fields are indicated. Then, the multiple inverse method appears useful. However, in the application of the method a serious problem has to be noted. That is the estimation of the rotation of rock body is rather difficult because of steeply plunging bedding planes and the long term deformation history of the Mugi mélange. In this study fault slip data were unavoidably analyzed without any restoration. Consequently some stresses are obtained, and all of them have N-S trending horizontal sigma_1.

The deformation history of the Mugi mélange can be divided into three stages. The first stage is characterized by the separation of competent layers and the formation of block-in-matrix structure. According to observation of outcrops, the separation occurs as formation of boudinage structure and furthermore some boudins are cut by Riedel shear planes. These structures have asymmetric shapes due to shear on bedding planes or cleavages of shale. The striations on cleavages probably represent the shear direction if the shear directions of later stage had not rewritten them. Mélanges are thought to be formed below subhorizontal decollement, and the orientations of striations rotated around strikes of cleavages to arrange them horizontal, that is N-S horizontal, are consistent with the convergent direction of plates.

Secondly, the formation of duplex structure and accretion process come. The meso-scale fault analysis did not produce a result that appears to be the origin of duplex-forming thrusts. Considering that the thrusts, which trend E-W and dip northward, could not release the E-W trending compressional stress, the kink folds, that were formed by E-W compression in the material of low ductility, possibly released the residual stress related to the thrusts.

Finally, in the upwelling process the N-S compressional stress obtained by meso-scale fault analysis is likely to dominate the deformation. The consistency between this stress and that of off-scraped rock body has to be verified.