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Spatial stress heterogeneity imaging by using difference between reduced stress tensors

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Space variations in stress states are important to understand crustal dynamics and development. Methods for determining the present state of tectonic stress from earthquake focal mechanisms have been proposed (e.g. Angelier 1984; Jour. Geophys. Res. 89, 5835-5848; Michael, 1987; Jour. Geophys. Res. 92, 357-368). Otsubo et al. (2008; Tectonophysics 457, 150-160) proposed a method to separate heterogeneous stresses from earthquake focal mechanism data from spatially varying state of stress, and it shows the spatial heterogeneity in the crust. However estimated state of stress from Otsubo et al. (2008) is spatially discrete, and the discrete information of the stress state is insufficient to illustrate the overview of the heterogeneity.

We propose a technique to image an overview of the stress state in the crust from the difference between the reference stress state and the stress state determined at various locations. The measurement of the difference between the stress tensors determined at various locations is essential to evaluate the stress heterogeneity. A few approaches have been proposed for this stress heterogeneity estimation (e.g. spatial distribution of stress axes directions). However, the difference of stress tensors should not be evaluated based on only their directional attributes. The evaluation of the difference should be achieved based upon all six components of the respective tensors. We introduce the stress difference (SD) defined by Orife and Lisle (2003; Jour. Struct. Geol. 25, 949-957) to calculate the difference between the stress tensors that are represented by three principal stress axes and stress ratio (s2-s3/s1-s3). The difference shows the similarity or dissimilarity between the stress tensors. SD ranges from 0 to 2. SD = 0 for identical tensors, while SD = 2 when the two tensors are negative tensors to each other. Therefore, the spatial distribution of SD can be illustrated as spatial stress heterogeneity.

We apply the technique to natural data from Japan islands that are located in region of subduction zones. The stress imaging technique provides important potential to compare the stress state and spatial geophysical information (e.g. geodesic data, seismic velocity structure and gravity anomaly).

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Keywords: stress inversion, focal mechanism, multiple inverse method, faulting, earthquake, crustal dynamics