3D Tectonic Stress Fields in and around Japan, inferred from the CMT Data Inversion

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The Japanese Islands are located in a very complex tectonic setting, where the four plates of the Eurasian, North American, Pacific and Philippine Sea Plates are interacting with each other. The mechanical interaction at the complicated plate interfaces causes the tectonic stress field in and around Japan, which generates diverse seismicity with wide-range of magnitudes. In order to understand the occurrence of various seismic events, we definitely need to know the present stress state in the Earth's crust.

From the observational point of view the most reliable information on the internal tectonic stress field is obtained through the analysis of seismic data. In the present study we applied the CMT data inversion method (Terakawa & Matsu'ura, 2008), which is a robust inversion method to estimate the crustal stress state from the centroid moment tensors (CMT) of seismic events by using a Bayesian information criterion (ABIC), to 15,000 moment tensors of seismic events in and around Japan, which provides the first standard image of the stress pattern objectively determined from seismic data with the unified method.

We show the 3-D pattern of tectonic stress fields in and around Japan. From the horizontal pattern of stress fields we can clearly find a good correlation of stress patterns with complex tectonic features. From the across-arc vertical pattern of stress fields we can find common characteristics and regional different characteristics. Two common characteristics are trench-normal extension in the shallow part of the oceanic plate beneath the outer rise and trench-normal compression in the shallow part of the subducting slab. Stress patterns in the overlying plate differ region by region: arc-normal compression (T-type) in the Northeast Japan Arc, stresses characterized by strike-slip faulting (SS-type) in the Kuril and Southwest Japan Arcs, and arc-normal extension (N-type) in the Ryukyu and Izu-Bonin Arcs. From relation between seismicity and the stress pattern in the overlying plates, we can find that seismicity is more active in the region of T-type, SS-type and N-type in this order. Since the shear strength of thrust, strike-slip and normal faults is higher in this order, the stress pattern may indicate the absolute level of stress fields in the overlying plate.