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NIED国際地震観測網データを用いて推定したフィリピン地殻内応力の空間変化: フィリピン断層の不均質すべりによる影響
Strong spatial variations of stress within the Philippines produced by slip heterogeneity along the Philippine fault

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A detailed knowledge of the stress state of crust is a key factor to understand earthquake occurrence. Previous studies showed that the stress patterns are primarily controlled by the plate boundary forces [e.g. Zoback et al., 1989]. However, it has also be pointed out that observed complicated stress field is affected by other factors. To address this point it is important to investigate the stress state of various tectonic regions around the world.

The Philippines is located in a region of high crustal seismicity, bounded to the east and west by oblique subduction zones. In the last few years, seismic and volcanic observation network have substantially improved in the Philippines in particular during the SATREPS cooperative project ″ Enhancement of Earthquake and Volcano Monitoring and Effective Utilization of Disaster Mitigation Information in the Philippines ″ between PHIVOLCS and NIED. Using waveform from regional broadband seismic stations, moment tensor solutions are routinely determined at NIED. In this study, we investigated the stress states in the Philippine archipelago by using those moment tensor solutions.

As a first step, we classified focal mechanisms into three groups: 1) events within the overriding plate, 2) those along the interplate, and 3) those within the subducting plate. Then we applied the stress tensor inversion method developed by Michael (1987) to focal mechanisms within the overriding plate. The estimated $\sigma 1$-axis is oriented to WNW-ESE, which is parallel to the slip vectors of the interplate events.

In order to investigate the spatial distribution of stress across the archipelago, we performed additional stress tensor inversions by dividing the entire region in sub-regions eastern and western of a stripe containing the NNE-SSW striking Philippine fault, which is a 1200km long strike-slip fault cutting through the islands. Additionally the region was subdivided along the strike of the fault. In the central and eastern sub-regions, $\sigma 1$-axis are parallel to the orientations of relative plate motions. On the other hand, in the western region, orientations of $\sigma 1$-axis are significantly different from those of the relative plate motions. In particular, the orientations of $\sigma 1$-axis in southern part (Bohol) are substantially different from those of the relative plate motions. Also, the orientations of $\sigma 1$-axis in northern part (Mindoro) are different from those in the entire Philippines.

The $\sigma 1$-axes and $\sigma 3$-axes in Bohol and Mindoro are opposite. The $\sigma 1$-axis in Bohol and $\sigma 3$-axis in Mindoro are almost parallel to the strike of the Philippines fault, which is consistent with the stress produced by left-lateral slip on the central part of the Philippines fault. This range corresponds to the Masbate fault characterized by a larger number of moderate-sized earthquakes, while the northern and southern extensions correspond to the segments which have generated several historical earthquakes [Bessana & Ando, 2005]. Our study suggests that more strain is released along the Masbate fault by moderate-sized events, while the northern and southern extensions are accumulating more strain which may be released as large earthquakes in the future. From the calculated stresses produced by the Philippines fault, based on dislocations in an elastic half-space model [Okada, 1992], as well as assuming a interplate coupling, we successfully reproduced the spatial features of stress orientations.

We also propose that a model considering the bending deformation of the overriding plate is also able to roughly explain the observed $\sigma 1$-axes, based on a 2D finite element modeling, although it does not explain the strike-slip stress regime. By taking account of oblique subduction effects, we may reproduce the observations in more detail. However, we prefer the strike-slip on the Philippines fault as the cause of stress variation, because this simple model alone can sufficiently explain all the observations.

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