Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

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The 2018 Palu, Indonesia, earthquake occurred along the Palu-Koro fault in the Sulawesi Island on 28th September. The Palu-Koro fault defines the boundary of the microplates, North Sula block and Makassar block. The information of the stress field around the Palu-Koro fault is necessary to understand the complicated tectonic system consisting of several micro-plates nearby Sulawesi Island as well as the basic mechanism underlying this earthquake event. Little, however, has been reported on the stress field probably due to relatively small seismic activity of this area. This study aims to estimate the stress field around the Palu-Koro fault based on the observed surface displacement and the fault slip pattern of 2018 Palu earthquake.

First, we compared SAR images taken before and after the earthquake by the pixel offset method to obtain the data of the surface displacement. The overall left-lateral displacement was observed with local variations in the geometry of the surface offsets. Then, we constructed the model of the Palu-Koro fault based on the surface displacement data and the previously-obtained geomorphological data. Finally, we simulate the surface displacement caused by dynamic rupture of the model of the Palu-Koro fault under given stressing conditions, and compare the result with the observation to infer the causative regional stress field.

The simulation is FDP-BIEM(fast domain partitioning - boundary integral equation method) [1]. The numerical cost of the original BIEM is in proportion to the cube of the total time steps. In contrast, that of FDP-BIEMis in proportion to the square of the total time steps. The simulation was performed on the physical assumption that one of the axes of principal stress is vertical, that the vertical principal stress equals to lithostatic pressure, and that the initial principal stress ratios are constant spatially. There are 3 free parameters. One is the azimuth of the axis of the maximum horizontal principal stress, and the others are the principal stress ratios.

This study constrains the azimuth of the axis of the maximum horizontal principal stress is within a certain range of about 25 degrees by considering the condition necessarily to explain the overall fault ruptures exhibiting left-laterally. If the azimuths of the horizontal principal stress axes are determined by independent observation such as the stress tensor inversions using focal mechanism solutions, this technique can also estimate principal stress ratios. More detailed modeling of the dynamic rupture process may also constrain the stress state around this fault zone.

[1]R. Ando, “On Applications of Fast Domain Partitioning Method to Earthquake Simulations with Spatiotemporal Boundary Integral Equation Method,” Mathematical Analysis of Continuum Mechanics and Industrial Applications II, Springer Nature Singapore Pte Ltd., 2018

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