Changes in stress state associated with the 2019 Ridgecrest, California, earthquakes

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*楠城 一嘉[1]
*Kazuyoshi Nanjo[1]

1. 静岡県立大学
1. University of Shizuoka

The 2019 Ridgecrest earthquakes, which occurred near the town of Ridgecrest, California, included a magnitude (M) 7.1 earthquake that struck on 5 July 2019 (UTC) as well as active foreshocks and aftershocks. A M6.4 earthquake preceded the M7.1 quake 34 hours later. The broad context of the Ridgecrest earthquakes is that they occurred under the current tectonic stress that created the Eastern California Shear Zone (ECSZ).

Crustal deformation due to the occurrence of large earthquakes causes stress perturbation in nearby regions. From the viewpoint of physics of earthquakes, the probability of a subsequent large earthquake depends on the stress conditions set up by the previous events and long-term tectonic state. Given the tectonic stress of the ECSZ, an investigation into the spatiotemporal state of stress along and near the faults coseismically ruptured by the M7.1 and M6.4 quakes can play a crucial role in understanding the distribution of post-seismic hazards after these quakes. A Coulomb stress model can be used, but such approaches have so far not been successful in forecasting upcoming large earthquakes any better than statistical models. This is partly due to the fact that the locations of potential faults, essential inputs to the calculation of change in Coulomb stress, are unknown.

Here, we used an alternative statistics-based approach to infer the changes in stress state, based on the b-value of the Gutenberg-Richter law. The b-value is sensitive to differential stress, and its inverse dependence on differential stress has been confirmed many times in both laboratory and field studies. We found that the rupture initiation from an area of low-b-values, indicative of high stress, was common to both M6.4 and M7.1 quakes. The post-M7.1-quake sequence revealedthat another low-b-value zone, which avoided its ruptured area, fell into the remaining unruptured area. This shows that if a high-likelihood future rupture were to occur, this might influence the nearby Garlock fault that hosted large earthquakes for several thousand years.

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