Absolute Strength of the San Andreas Fault Inferred from Tectonic Loading Simulation and CMT Data Inversion

Toshiko Terakawa[1]; Mitsuhiro Matsu'ura[1]

[1] Dept. of Earth & Planetary Science, Univ. of Tokyo

The absolute strength of the San Andreas Fault (SAF) has been an essential question in controversy for the last three decades. In the present study, on the basic idea that a balance between the tectonic stress accumulation and release is kept on a long-term average, we tried to determine the absolute strength of the big-bend segment (BBS) of SAF in southern California by combining the 3-D numerical simulation of tectonic loading and the analysis of CMT data with a new stress inversion method.

In the numerical simulation of tectonic stress accumulation we modeled BBS by a 200 km-long vertical interface with a 20 degrees oblique strike to the direction of relative plate motion, which divides a 30 km-thick elastic lithosphere overlying a viscoelastic asthenosphere into two plates. BBS is smoothly connected to the semi-infinitely long transcurrent plate boundaries at both ends. Then, the relative plate motion V at BBS causes two different sorts of tectonic stress fields due to the steady-state frictional sliding at Vcos20 and the plate convergence at Vsin20. With the increase of normal stress due to the plate convergence, the absolute strength of BBS increases with time, and so the stress field due to the steady-state frictional sliding increases with time until the accumulated tectonic stress reaches a critical level at surrounding faults. We supposed that thrust faulting around BBS plays a role of adjuster to keep the tectonic stress at a certain level. With the 3-D tectonic loading model based on elastic dislocation theory, we numerically computed the absolute tectonic stress fields around BBS for three representative cases with different friction coefficients (0.6, 0.3 and 0.1) of SAF. In order to compare these theoretical results with seismological data, we extracted only the stress field related to shear faulting, called seismogenic stress field hereafter, from the computed absolute stress field. The patterns of the seismogenic stress fields in these three cases are significantly different from each other within the distance range of 50 km from SAF. In this range, the rotation angle of the MHCPS axis measured from the strike of SAF changes from 45 degrees to 90 degrees with distance from SAF. The range of the stress rotation becomes broader as the absolute strength of BBS becomes higher. The expected type of faulting in this range also depends on the absolute strength of BBS.

With the method of CMT data inversion, on the other hand, we analyzed seismic events in southern California and obtained the spatial pattern of the seismogenic stress field around BBS. The type of faulting expected from the inverted stress field changes with distance from SAF as follows: thrust faulting with a strike oblique to SAF in the vicinity of the big-bend segment, thrust faulting with the dip-angle of 45 degrees and the strike parallel to SAF in the range of 50-100 km from SAF, and vertical strike-slip faulting with a strike oblique to SAF in the region farther than 100 km from SAF. From the inverted stress field we can find a fault-parallel zone with a high moment release rate at about 40 km southwest of BBS, which can be considered to play a role of adjuster to keep the tectonic stress at a constant level. The spatial range of stress rotation extends to about 55 km from SAF.

From comparison of these characteristics of the inverted stress field with the results of numerical simulation, assuming the friction coefficient of surrounding thrust faults to be 0.6, we can conclude that the friction coefficient of SAF at BBS is 0.3, which is a half of the standard value expected from rock experiments. However, this does not mean a weak SAF. In this case the absolute strength of BBS itself reaches 140 MPa at the intermediate depth (6 km) of the seismogenic zone, because of the high normal stress due to plate convergence at BBS.