The Absolute Strength of the San Andreas Fault Type of Transcurrent Plate Boundaries

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There has been a longstanding debate regarding the absolute strength of the San Andreas fault. The absence of anomalously high heat flow in the vicinity of the fault supports that the fault has low strength. On the other hand, many laboratory experiments of friction of rock imply that the fault has normal high strength. Since the first challenge to this problem called the stress / heat-flow paradox, it has been about 40 years, but we have not yet obtained the clear answer. The absolute strength of faults, which is the stress level at which faults break down, is important to estimate the triggering effects of a main event on the earthquakes in the surrounding area. In general, it is difficult to measure the absolute fault strength. In the present study we try to estimate the absolute strength of the northern and the central San Andreas fault segments by calculating the absolute stress fields around the San Andreas fault on the basis of the elastic dislocation theory and comparing them with the seismic activities around the fault.

The San Andreas Fault, which is a transcurrent plate boundary between the Pacific and the North American Plates, plays the roll of an interface that releases plate-to-plate interaction by slipping at the rate of 4cm/yr. Interaction at the plate interface causes the tectonic stress field around it. Therefore, the stress field around a pure strike-slip fault consists of the following three components; the lithostatic pressure, the steady stress field caused by steady slip under a frictional resistance, and the stress perturbation associated with earthquake cycles. Giving a depth, the density of rocks, and the gravitational acceleration, the lithostatic pressure at the depth is estimated. The stress perturbation is also estimated by the analysis of seismic events. Therefore, the unknown to estimate the absolute stress field is only the steady stress field. The steady stress field caused by steady plate motion depends on the absolute strength of the plate boundary and the viscosity of the athenosphere.

On this consideration we numerically computed the absolute stress fields around the San Andreas fault, giving three different strength distributions of the plate boundary. To simplify the problem, we neglected the effect of the viscous resistance of the athenosphere. From the results of the numerical computations, we found that the stronger the plate boundary is, the higher shear stress field is generated. However, the spatial distribution of the directions of principal stress axes itself is independent of the strength of the plate boundary. We also found that the weaker the plate boundary is, the more significant stress change is observed during an earthquake cycle. But in the present case of a simple strike-slip situation, the expected change in focal mechanism patterns around the plate boundary is not remarkable. These computed results imply that the statistical analysis of seismic activity concentrated around the plate boundary may be useful to estimate the absolute strength of the San Andreas fault.

From the statistical analysis of seismic activity we found that the absolute strength of the northern locked segment (the 1906 San Francisco earthquake segment) is twice as strong as that of the 1989 Loma Prieta earthquake segment, and three times as strong as that of the central part of the creeping segment. Furthermore, we can conclude that the difference in the rotation of the directions of principal stress axes in the northern locked and central creeping segments depends on the change in absolute strength along the San Andreas fault, rather than the difference in the absolute strength itself.