Particle analysis and energetics of fault rocks: An example from the Toyamagawa Fault, Central Japan

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The total dissipated energy during an earthquake is divided into three parts: fracture energy, radiated energy, and frictional heat. It is important to further our understanding of how the total dissipated energy during the earthquake is partitioned into those parts, because it determines the characteristics of an earthquake. The surface energy, a portion of the fracture energy, is the energy attributed to the production of fracture surfaces during earthquakes, and it can be estimated by measuring the surface density of cataclastic fault rocks called fault gouge or ultracataclasite. Microstructures of those fault rocks have been investigated through fault drilling projects, observations of fault outcrops, and experimental studies, but understanding of the spatial diversity of fracturing along fault strikes has made little progress.

The Toyamagawa Fault, whose total length is about 20 km and which consists of several subfaults, is a right-lateral paleoseismic fault crosscutting the Ryoke granitoids in Central Japan. A planar ultracataclasite layer is observed on a subfault on which the Matoze Outcrop, the largest outcrop along the fault, is located and is more than 10 km in length. The Matoze Outcrop is approximately 80 m in length along the strike, and the ultracataclasite layer is observed throughout the outcrop. This layer, 5-10 cm in thickness, consists of sublayers several millimeters thick, and these layers are subparallel to one another.

Ultracataclasite samples obtained from three points on this fault were examined under optical and scanning electron microscopes. The ratio of the long axis to the short axis of a particle (LSR) for each grain, as well as grain size distributions (GSDs) were obtained from these analyses. The result of LSR analysis showed little spatial diversity along the strike. This result suggests that the generating mechanism of the ultracataclasite layers is almost homogeneous along its strike for at least 80 m, the length of this outcrop. Surface creating energy was estimated from the total surface area derived from GSDs of ultracataclasite particles. The estimated surface energy was approximately 1 x 10^5 J/m^2, which corresponds to less than 10% of frictional heat energy, as well as to less than 10% of the summation of breakdown energy and radiated energy. This result supports the results of previous studies which suggested that the creation of surfaces does not contribute in a significant fashion to energy dissipation during earthquakes on mature faults.