Unexpectedly rapid decrease of meter-sized rock friction at high work rate

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We here report rapid decrease of meter-sized rock friction at high work rate revealed by large-scale biaxial experiments at NIED. In the experiments, we used a pair of meter-sized Indian metagabbro as specimens, whose contacting area was 1.5 m long and 0.1 m wide. The experimental conditions were normal stress up to 6.7 MPa and loading velocity up to 3 $\times 10^{-2}$ ms^{-1}. We confirmed the work rate dependency of rock friction as previously reported with centimeter-sized experiments (Di Toro *et al.*, 2011, Nature), but further found that the meter-sized rock friction starts to decrease at a work rate of 10^{-1} $MJm^{-2}s^{-1}$, which is one order of magnitude smaller work rate (still high in absolute sense) than that of the centimeter-sized one. After each meter-sized experiment, we found localized damages (i.e. grooves) were generated on the fault surface and gouge materials were distributed in and around them. Especially, we often found heavily comminuted gouge in the grooves, which swelled up relative to the surrounding fault surface. Mechanical, visual and material observations suggest that slip-evolved stress heterogeneity on the fault accounts for the differences of frictional properties between meter and centimeter sizes. Based on these observations, we propose that slightly stress-concentrated areas pre-exist in which frictional slip produces more gouge than in areas outside, resulting in further stress concentrations at these areas. The overall shear stress on the fault is primarily sustained by the stress-concentrated areas that undergo a work rate higher than the average, so those areas should weaken more rapidly and cause the macroscopic frictional strength to decrease abruptly. To verify this idea, we conducted numerical simulations assuming that local friction follows the frictional properties observed on centimeter-sized rock specimens. The simulations reproduced the macroscopic frictional properties observed on the meter-sized rock specimens. This result suggests the rapid reduction of macroscopic frictional strength at the work rate lower than the expected one with centimeter-sized results should be taken into consideration, since such slip-evolved heterogeneity should be common in nature. Further details related to this presentation can be found in Yamashita *et al*. (2015, Nature).

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