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# Evolution of rupture style with total fault displacement: insight from meter-scale direct shear experiments

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We report results with Indian metagabbro (Vs=3.62 km/s) that are obtained from a series of meter-scale direct shear experiments conducted at NIED. We focus on strain gage array data of stick-slip events loaded with 0.01 mm/s and under 6.7 MPa normal stress, and find the following: (1) During the early stage when the contact surface is relatively intact with less than 10 mm total displacement, ruptures mainly behave as slow-slip events (10 to 100 m/s). (2) With the accumulation of total fault displacement (up to several tens of mm), grooves indicative of strongly coupled local patches (i.e. asperities) are generated along the sliding surface, which are primarily elongated along the loading direction and are accompanied by notable gouge formation. The rest part of the surface continues being polished, indicated by a contrast in light reflectivity with respect to the initial level. At this stage, rupture speeds start to increase but are still well below the shear wave speed (˜1/4Vs). (3) After long enough total fault displacement (>500 mm), grooves and gouges of a sufficient amount are generated. The corresponding ruptures show, following a slow nucleation phase, fast propagation with speed comparable to the shear wave speed. Detailed strain data analysis shows that the above rupture style evolution is associated with an increasing efficiency in releasing the stored strain energy along the synthetic fault, which may have been facilitated by powder lubrication (Reches and Lockner, 2010) only after the formation of certain amount of gouges. Our study highlights the role of (evolving) fault surface properties in controlling propagation style of dynamic ruptures. It also calls for the need to conduct large-scale friction experiments over long displacement to better approximate natural fault conditions.

Keywords: Friction experiments, Dynamic rupture propagation, Fault lubrication