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Evolution of information entropy of fault displacement direction and principal strain direction during fault meta-instability stage

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In rock biaxial tests, the curve of differential stress vs. time during a stick-slip period can be generally divided into four stages: linearity, deviation from linearity, meta-instability, and instability. The meta-instability stage (MIS) is between the peak differential stress and the onset of fault instable sliding (Ma, et al., 2012). Identification of MIS has crucial implications for earthquake prediction and risk assessment. We utilized digital image correlation method to analyze the deformation field of the upper sample surface during stick-slip periods. Local pre-slip areas with coherent right lateral slip are detected in the deviation from linearity stage. They undergo a process from slow to accelerated extension during the MIS and then lead to right lateral instable sliding of the whole fault. The coherent right lateral slip within a local pre-slip area implies the synergetic activity of the local pre-slip area. Thus, the growth of the local pre-slip area will certainly improve the slip synergy of the whole fault. In order to quantify the synergy of fault deformation field and recognize the character of the MIS, information entropy of fault displacement direction and principal tensile strain direction (denoted by Sinf_dd and Sinf_sd, respectively) are defined based on the concept of Shannon entropy. The values of Sinf_dd and Sinf_sd are between 0 to 1, and the closer the Sinf_dd and Sinf_sd are to 0, the higher synergetic the deformation field is. It was revealed that Sinf_dd and Sinf_sd stay in high values (almost equal to 1) in the linearity stage, and begin to reduce slowly in the deviation from linearity stage, and decrease sharply in the MIS. The slow and accelerated decreases of the two coefficients just correspond to the appearance and growth of local pre-slip areas, respectively. It indicates that the growth of local pre-slip areas is a process from independent to synergetic activities of each fault segment during a stick-slip period, and that the accelerated synergy of deformation field is a character of the MIS. According to the results, it may be possible to identify the MIS in the field based on long-term deformation field monitoring.