Episodic unlocking of fault and earthquake

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The earthquake nucleation process is inherently complex, due to an involvement of several deformation mechanisms with multiple spatial and time scales. Before large earthquakes, the number of smaller magnitude events often increases, retrospectively named foreshocks [e.g., Bouchon et al., 2013]. Recent seismic and geodetic studies of foreshock sequences suggest that partial unlocking of fault took place episodically through cross-interaction between fast and slow slip modes before large earthquakes such as the 2011 Tohoku-Oki, the 2014 Iquique and the 2016 Kumamoto earthquakes. The partial unlocking causes stress loading to the nearby fault segments, resulting to triggering of subsequent dynamic and unstable slip. However, the manner of the unlocking is “episodic”, not “smooth acceleration” which has been typically observed in laboratory experiment having simple fault zone structure. This episodic manner precludes a possibility of forecasting the subsequent large earthquake with a high degree of accuracy.

The triggering of a subsequent large earthquake on nearby fault segments depends on the areal extent of the critically-loaded seismic patches and how close these areas are to failure, even though the partial unlocking by both fast- and slow slip processes is observed. An important research area is the development of methods for assessing the degree of criticality within fault segments adjacent to already ruptured portions [Obara and Kato, 2016].

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