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Analysis of surface rupture complexity sheds light on coseismic slip during the last earthquakes along the Bulnay-Tsetserleg fault zone (Mongolia)

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In 1905, two M ~ 8 continental strike-slip earthquakes occurred along the Bulnay fault system, in the northwestern part of Mongolia. After a first earthquake that ruptured the Tsetserleg oblique fault strand, the second event ruptured the main Bulnay fault 14 days later. With a total rupture of 676 km, these two earthquakes constitute the largest continental strike-slip earthquake sequence ever documented. Hence, the Mongolian earthquake ruptures offer a unique opportunity to document large-magnitude earthquake continental ruptures. Indeed, due to dry climatic conditions, limited erosion and anthropization, the surface ruptures have been preserved almost unaltered. This allows for accurate documentation of the rupture trace and coseismic slip distribution along the Bulnay fault, based on field observation and satellite imagery.

Along the Tsetserleg rupture, the available coseismic offset measurement data coming from high-resolution satellite imagery show a significant variability, ranging between 1.5 and 4 m for the horizontal component. It is presently difficult to assess the most representative value for the 1905 slip, which in turn impacts the magnitude estimation for this event. Another factor to take into account is the possibility of a vertical slip component, which is only poorly constrained.

In order to have a better estimate of the 3D coseismic slip, drone images were acquired on selected sites along the Bulnay 1905 rupture, near the junction with Tsetserleg fault, and along the Tsetserleg rupture. We favored sites showing structural complexities and significant surface fracture development (succession of cracks and ridges, stepovers, branching zones...).

High-resolution DEMs and orthophotomosaics were produced using the MicMac software. The geometrical characteristics of the complexities and their fracture network were then measured in order to compute the volumetric changes associated to the 1905 earthquake. These data were finally converted to 3D surface slip estimates. On certain sites, we also discussed the presence of features inherited from previous ruptures, overprinted by the 1905 earthquake.