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Surface fault rupture during the Mw 7.8 Kaikoura earthquake, New Zealand, with specific comment on the Kekerengu Fault - one of the country's fastest slipping onland active faults

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The Mw 7.8 Kaikoura earthquake of 14 November, 2016 (NZDT) was a complex event. It involved ground-surface (or seafloor) fault rupture on at least a dozen onland or offshore faults, and subsurface rupture on a handful of additional faults. Most of the surface ruptures involved previously known (or suspected) active faults, as well as surface rupture on at least two hitherto unrecognised active faults. The southwest to northeast extent of surface fault rupture, as generalised by two straight-line segments, is approximately 180 km, though this is a minimum for the collective length of surface rupture due to multiple overlapping faults with various orientations. Surface rupture displacements on specific faults involved in the Kaikoura Earthquake span approximately two orders of magnitude. For example, maximum surface displacement on the Heaver's Creek Fault is cm- to dm-scale in size; whereas, maximum surface displacement on the nearby Kekerengu Fault is approximately 10-12 m (predominantly in a dextral sense).

The Kekerengu Fault has a Late Pleistocene slip-rate rate of 20-26 mm/yr, and is possibly the second fastest slipping onland fault in New Zealand, behind the Alpine Fault. Located in the northeastern South Island of New Zealand, the Kekerengu Fault – along with the Hope Fault to the southwest and the Needles Fault offshore to the northeast – comprise the fastest slipping elements of the Pacific-Australian plate boundary in this part of the country. In January 2016 (about ten months prior to the Kaikoura earthquake) three paleo-earthquake investigation trenches were excavated across pronounced traces of the Kekerengu Fault at two locations. These were the first such trenches dug and evaluated across the fault. All three trenches displayed abundant evidence of past surface fault ruptures (three surface ruptures in the last approximately 1,200 years, four now including the 2016 rupture). An interesting aspect of the 2016 rupture is that two of the trenches received surface fault rupture, and are now dextrally offset by about 9 m, while the third trench did not have any 2016 surface rupture pass through it. In this instance, ground-surface rupture along this trace of the fault died out within tens of metres of the trench.

Another salient aspect of the Kaikoura earthquake is that the determined (or estimated) recurrence intervals of the faults that ruptured the ground surface vary by an order of magnitude or more. This strongly implies that the ensemble of faults that ruptured with the Kekerengu Fault in the 2016 earthquake has not always been the same for past earthquakes. Possible reasons for this could include the state of stress at the time of a specific earthquake, the direction of rupture propagation, and whether or not rupture on one fault system cascades into rupture on another as is suspected to have happened in the Kaikoura earthquake.