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New evidence for prehistoric co-seismic surface rupturing in the Lower Rhine graben area

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We studied two paleoseismic trenches on the central section of the Geleen fault, a branch of the southwestern border fault of the Roer Valley graben. This section of the fault runs through the Belgian Maas River valley, where relatively young (Late Glacial and Holocene) sediments are at the surface. The geomorphic expression of this normal, slowly slipping fault is strongly reduced compared to the northwestern (Bree fault scarp) and southeastern sections. Only in a few places a subtle fault scarp, less than 1 m high, can be recognized. The surface trace of the fault was mapped using electric tomography and GPR, and shows a distinct bend associated with a stepover. At present, it is not clear whether this stepover represents a segment boundary or not. The trenches provide strong arguments for two surface-rupturing earthquakes. The event horizon of the most recent paleoearthquake is situated less than 1 m below the present-day surface. Its identification is not straightforward because most stratification at this depth is obliterated due to post-depositional soil development. In the first trench, this paleoearthquake has resulted in 1 m vertical displacement of Late Glacial fluvial gravel and overlying eolian sands and silts. We observed a discontinuity truncating fault splays, on one wall coinciding with a prehistoric, man-made stone pavement. Thin-section observations demonstrate that the material below this horizon represents an in-situ argillic soil horizon, while that above contains reworked fragments of this soil. This is strong evidence for colluvium overlying an event horizon. In the second trench, the most recent paleoearthquake has displaced, also by ca 1 m, a Holocene soil developed in Late Glacial eolian silty sands. We identified the top of this soil profile, which is interpreted as the surface at the time the earthquake occurred. Thin-section analysis provides some evidence that the sediment immediately

below occupied a shallow position in a soil profile, and that the overlying sediment is colluvial in nature. In both trenches this event is associated with liquefaction, including a field of sand blows in one trench and a gravel dike in the other. These features are unambiguous evidence for strong co-seismic shaking. Combined OSL and radiocarbon dating in the second trench constrain the event between 2.4 and 3.7 kyr BP. In both trenches there is evidence that it occurred at a time when humans cultivated the area. In the second trench we observed additional 0.4 m offset for fluvio-eolian sands below an erosional gravel pavement correlating with a regional deflation horizon. This gravel pavement also truncates several soft-sediment deformations, and is interpreted as the event horizon. However, the associated colluvial wedge was not found, most likely because it was eroded as well. OSL dating constrains the age of this event between 14.7 and 18.9 kyr BP. The penultimate event is not recorded in the other trench, where the oldest deposits have been OSL-dated at 12.9 +/- 3.8 kyr BP. The ages obtained for the two paleoearthquakes are in good agreement with those obtained in our earlier trenches on the Bree fault scarp, suggesting that the Geleen fault may define a single, 30-km-long segment.