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Coseismic throw variation across along-strike bends on active normal faults: implications for displacement/length scaling of earthquake ruptures.

Francesco Iezzi (1), Zoe Mildon (2), Joanna Faure Walker (3), Gerald Roberts (1), Huw Goodall (4), Maxwell Wilkinson (5), and Jenni Robertson (1)

(1) Birkbeck, University of London, London, United Kingdom (francesco.iezzi.15@ucl.ac.uk), (2) Plymouth University, Plymouth, United Kingdom , (3) Institute for Risk and Disaster, University College of London, London, United Kingdom, (4) University of Leeds, Leeds, United Kingdom, (5) Geospatial Research Ltd., Durham University, Durham, United Kingdom

We suggest that fault bends play a key role in explaining the scatter seen in maximum displacement (Dmax) vs length relationships shown in existing fault scaling relationships, focussing on normal faulting earthquakes. Primary detailed field measurements of the fault geometry and coseismic throw in the 2016-2017 central Italy earthquake sequence, together with observations of other large historical normal-faulting earthquakes within the literature, provide multiple examples where coseismic throw increases across bends in the strike of faults. We can quantify the expected change in throw across a bend by applying the "geometry-dependent throw-rate theory" (Faure Walker et al., 2015) to a single rupture, based on conservation of the strain-rate across the variable fault geometry.

We measured the geometry and kinematics of earthquake surface ruptures for the 24th August and 30th October 2016 earthquakes (Mw 6.0, Mw 6.5) in central Italy. Both datasets show that across an along-strike fault bend in the southern part of the Mt. Vettore fault, although the slip-vector azimuth and the coseismic heave vary by <10-20%, the coseismic Dmax increases by a factor of 2-3 where the strike of the host fault changes by ∼30º and the dip increases by 20-25º. We observed a large increase of throws across fault bends also for at least other three historical large-offset normal faulting earthquakes, which ruptured across along-strike fault bends. We can explain the anomalous increase of throw for each example by calculating strain-rate conservation across the varying geometry and kinematics of the fault.

The maximum displacement measured in the field for each of the five studied earthquakes is always larger than the maximum displacement predicted by Wells & Coppersmith (1994), Dmax vs fault length scaling relationship. We use these findings to suggest that the varying geometry of faults, expressed in variation of fault strike and dip across along-strike fault bends, represents one of the possible causes of the scatter of values in Dmax vs fault length scaling relationships. Hence, along-strike fault bends should be strongly considered when scaling relationships are used to infer stress drop variability for earthquakes or maximum magnitudes from vertical offsets in palaeoseismic datasets.