Distributed surface rupturing: there is a crack in everything – that's how the light gets in

T41H - 0355

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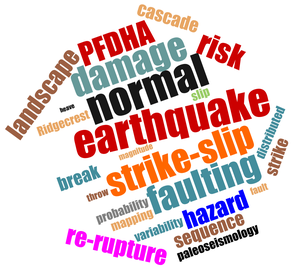
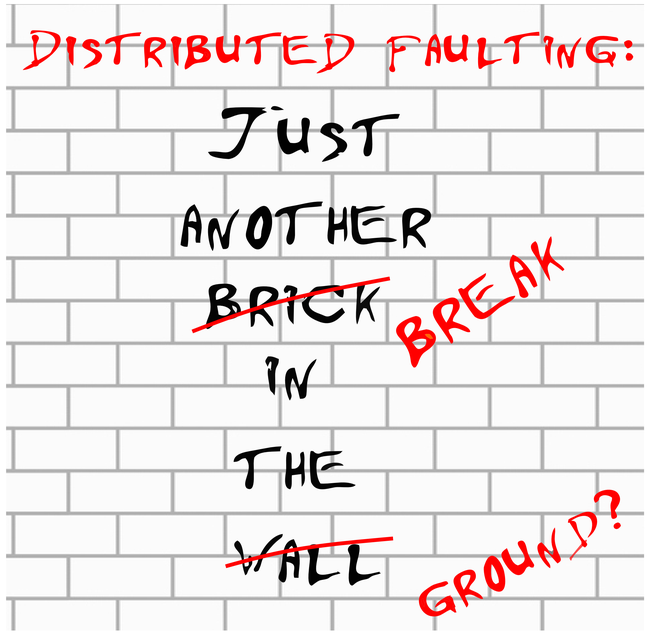


1 Background

Strong (Mw 6 - 7) to large (Mw 7 – 8) earthquakes are capable to produce surface faulting both along the primary fault and distributed faults (sensu Youngs et al., 2003). The availability of modern technologies clearly highlighted the complexity of surface faulting associated with recent earthquakes worldwide, providing a dataset with unprecedented detail. Surface faulting and deformation pose a threat for critical facilities, lifelines and infrastructures; the assessment of the probability of occurrence of fault displacement is thus vital for risk mitigation and a proper planning. Current practice relies on methods developed several years ago (e.g., Youngs et al., 2003 for normal faults), which exploit a dataset acquired few to tens of years ago.

Many recent earthquakes were not yet analyzed in the perspective of a probabilisitc fault displacement hazard assessment. We here provide data on distributed faulting on a dataset of 13 normal and 19 strike-slip events. **For normal faulting, we show that current scaling relations tend to underpredict the actual occurrence of faulting**, confirming previous results derived from a smaller dataset (Ferrario & Livio, 2018).

Aim of the work



2 Dataset

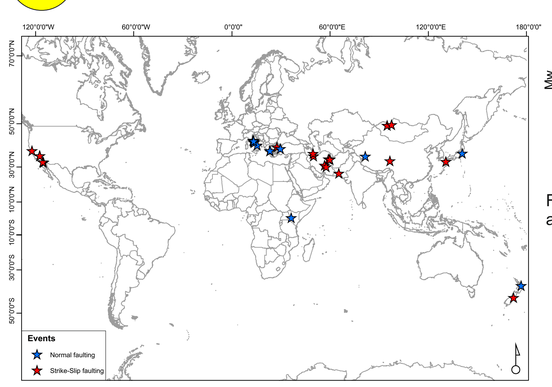


Figure 1: Map of the events constituing the database (13 normal faulting, 19 strike-slip).

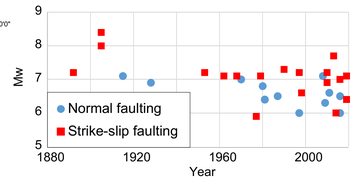


Figure 2: Event distribution in terms of age and Mw.

3 Methods

We assessed the probabilistic fault displacement hazard (PFDH) by computing the conditional probability of occurrence for distributed faulting, following the «earthquake approach» proposed by Youngs et al. (2003; Figure 3) and using a pixel size of 500 m and 200 m for normal and strike-slip faults, respectively.

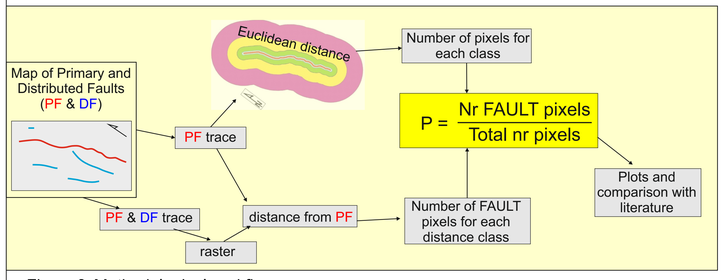


Figure 3: Methodological workflow.

4 Case history: 2016 Central Italy sequence

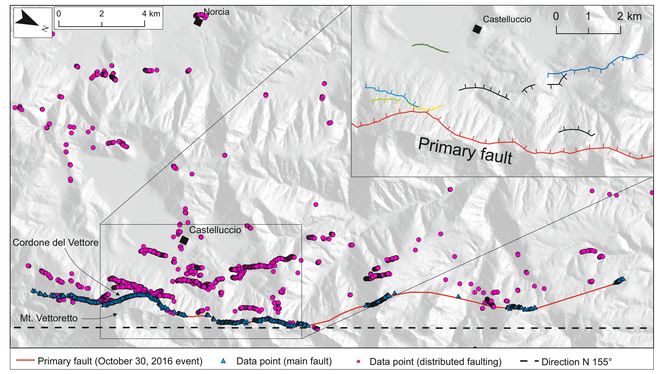


Figure 4: Map showing data points for primary and distributed faulting of the 30 October 2016 event (Central Italy, Mw 6.5). Modified after Ferrario & Livio, 2018.

Figure 5: Examples of the primary fault (left) and secondary ground breaks (right) activated following the 30 October 2016 event in Central Italy.

5 RESULTS: Conditional probability of surface faulting

Our results generally show that the empirical relations proposed by Youngs et al. (2003) underestimate the DF occurrence for the corresponding magnitude range (Figure 6). This is particularly true for the footwall sector, at 5-10 km from the primary fault, where antithetic faults are expected, assuming an average crustal thickness.

Normal faulting

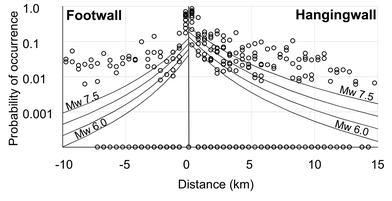


Figure 6: Conditional probability of faulting as a function of distance from the primary fault (dots: dataset analyzed in this study). Solid black lines are empirical relations proposed by Youngs et al. (2003) for different magnitudes.

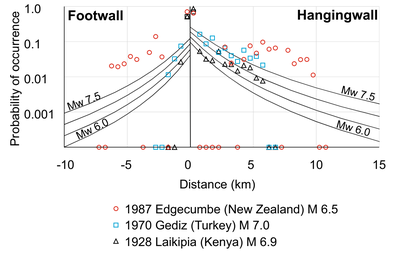


Figure 7: Conditional probability of faulting as a function of distance from the primary fault for 3 normal faulting earthquakes.

Strike-slip faulting

We analyzed 4 out of the 19 events collected so far. Preliminary results (Figures 8 - 9) suggest a general agreement or slightly higher DF occurrence with respect to the empirical relations derived by Petersen et al. (2013).

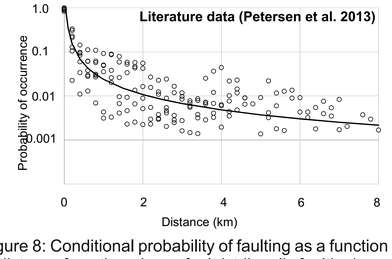


Figure 8: Conditional probability of faulting as a function of distance from the primary fault (strike-slip faulting).

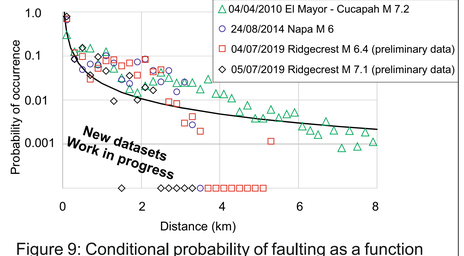


Figure 9: Conditional probability of faulting as a function of distance from the primary fault for 4 strike-slip faulting earthquakes.

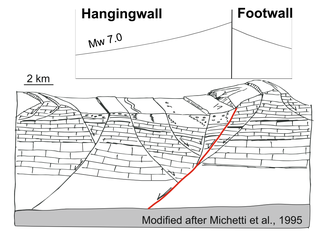
6 Perspectives

Distributed faulting due to a large earthquake on one hand, and repeated ruptures at the same spot in a short time interval (e.g., Central Italy, 2016; Searles Valley and Ridgecrest 2019) on the other hand, are the end-members of a **spectrum of surface faulting behavior**. Useful information on the faulting style can be retrieved by studying the **typical seismic landscape** of a region. If not taken into account during the interpretation of paleoseismological data, different modes of fault rupture can significantly bias the derived earthquake parameters and, consequently, inferences on the regional tectonic activity.

Comments? Ideas? Bring a sticker and leave your comment!

I'm looking for other case histories... do you want to share your data?

Seismic landscape - normal faults (Mw 7)



Seismic landscape - strike-slip faults

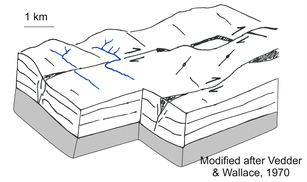


Figure 10: Sketches of the typical seismic landscape for normal and strike-slip faults.

MFF is supported by CRUST as winner of the 1° Crust Award to young researchers in seismotectonics for an outstanding poster at the CRUST interdisciplinary Workshop, 8-10 July 2019, Perugia (Italy).