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Interactive comment on “On the complexity of surface ruptures during normal faulting earthquakes: excerpts from the 6 April 2009, L’Aquila (central Italy) earthquake (M_w 6.3)” *by* L. Bonini et al.

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The paper provides an interesting new interpretation of some aspects of the l’Aquila fault system explaining the surface ruptures during the earthquakes (eg. at the Paganica fault) by surface bending above a blind normal fault at depth. The authors conclude that slip during the main event occurred at a “blind” fault, which is upwards confined by a shallow-dipping former thrust fault. Faults above that discontinuity, which extend to surface, are interpreted to result from surface bending.

Their l'Aquila model, i.e., the finding that the earthquake occurred on blind fault and the interpretation that all surface ruptures are only indirectly related to the seismogenic master fault, leads the authors to an interesting discussion of the significance of surface faulting for seismic hazard assessment.

The authors base their l'Aquila model on the reviews of the impressively large data set available from the l'Aquila earthquake, and the comparison of the observed faults with the results of analogue models. Modeling results (models WK1 and WK2) are used to show the possible effects of pre-existing shallow faults on a normal growth fault nucleating at depth and growing towards the surface. The paper shows convincing similarities between the evolution of the analogue model WK2, which essentially results in two separate faults/fault arrays at dept and at surface, and the fault reconstructions from the fore-and aftershocks of the l'Aquila earthquake.

Although I generally accept the arguments leading to the l'Aquila model, some parts of the ms. not very convincing. These are:

1) The interpretation of a shallow-dipping previous thrust fault from aftershock lockations (Fig. 3). It is not stringent to draw the orange shallow-dipping fault in Fig. 3. Is there additional evidence from first motion studies or moment tensor solutions that highlight the activation of such a shallow-dipping fault? Do constructed geological cross-sections indicate a thrust of that orientation and at the indicated depth? (I assume that the cross section in Fig. 6 are models rather than data driven sections.)

2) The interpretation of the second set of analogue models performed with sand needs to be elaborated. It is unclear why the authors used a completely different model setup for the kaolinite and quartz models. I see more differences than similarities between the models WK2 and quartz 2, which both should support the overall conclusions of the paper.

3) In the overall conclusions the authors differentiate 5 categories of faults with relevance for hazard assessment. Although generally correct, I doubt that the classification

is widely applicable: Categories I (seismogenic master faults) and II (inherited subsurface faults) are distinguishable e.g., in the Alps (virtually all seismogenic faults are Miocene structures), the Variscan basement N of the Alps (all seismogenic faults are Variscan structures), or the Rhine graben (Oligocene faults). A distinction makes no general sense. Categories III to V may be very hard to distinguish from each other, and from 1 and II, although their identification would be very useful for hazard assessment.

Other comments:

Chapter 4.1 2053 Line 5-9 It is unclear how the experiments were done. Have several runs of the same setup been done stopping at different cumulative displacements? Or is the sequence of deformations shown in Fig. 4 result of a single experiment, and pictures were made through a glass window laterally confining the experiment? Such a window would probably induce unwanted boundary conditions: please add explanation.

2053 Line 29 What is the evidence that the fault at the surface of the models are interpreted as Mode I fractures?

2054 Line 24-26 A marked difference between the final products of the Kao experiments may be the location of the surface breaking fault; unlike in the no-discontinuity model (WK1) experiment the surface breaking fault in the discontinuity model WK2 is located on the top of the “scarp” in the surface topography.

2055 Line 16 The wide open gash in Fig. 5g may result from strain compatibility above the concave-up fault bend of the final connected normal fault.

Cahpter 4.2 The authors state that the quartz sand experiments were performed to evaluate eventual unwanted effects of high cohesion of the wet Kao model. However, both, Kao and quartz models use quite distinct model setups which may question the authors’ conclusions. Results for the no-discontinuity model are admittedly very similar. However, results for the models WK2 and quartz #2 are not. At close inspection the

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experiment quartz sand #2 even shows reverse faults in the “hangingwall” in front of the bending antiform. It is difficult to believe that this should only be due to the different material cohesion and that the model setup has no influence.

Chapter 5. 2057 Line 2-4 Please give more explanation to the statement “the size and the shape of the basin related to the growth of upward-propagating faults depends on the growth rate of the faults”: First, why growth RATE? Second, the basin shape cannot be seen in Fig. 5, as the experiments WK1 and WK2 start from different non-planar model surfaces: WK1 starts from higher topography above the footwall, WK2 from a higher topography above the hanging wall. It is therefore not straight forward to compare the final “basin topography”.

2057 Line 7-9 “. . .when a propagating failure meets a mechanical discontinuity, such as a weak layer or a pre-existing fault, the failure may stop, penetrate it, or be deflected along it”: ok, this sentence lists all possibilities, but does not help understanding the models.

2058 Line 8 ff “Unfortunately, neither field nor trenching observations allow the nature of the Paganica fault gouge to be assessed”: This is surprising. No trenching results and no high-resolution reflection seismic is available from that fault to show whether it extends to depth or not?

Chapter 5.3, Line 17 ff “Lower seismicity cut-off (9–10 km). . . can be interpreted as due to the presence of another inherited thrust surface”: this interpretation should be supported by other data, e.g., a regional cross section showing the basal detachment of the Apennine fold-thrust belt.

Figure 2. The figure is not well legible, especially 2a (contour lines) and 2c (photographs of surface ruptures etc.). The photographs should be enlarged arranged in a separate figure.

Figure 3. The interpretation of the shallow-dipping discontinuity (drawn in orange)

based on the distribution of the aftershocks is not stringent. The authors should include additional evidence to support their interpretation, e.g., a regional geological cross-section to show that a thrust fault is expected in that depth.

Interactive comment on Solid Earth Discuss., 5, 2043, 2013.