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Morphotectonic analysis of the long-term surface expression of the Paganica - San Demetrio Fault System (2009 L'Aquila earthquake, Central Italy)

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On April 6, 2009 a Mw6.1 earthquake struck a densely populated area in the Abruzzi Apennines (central Italy), causing heavy damage in the town of L'Aquila and surrounding villages and resulting in ∼300 fatalities and thousands of injured.
Seismological and geodetic data all converge in identifying a ∼15km-long, NW-SE oriented, SW-dipping normal structure, coincident with the Paganica-San Demetrio fault system (PSDFS, hereinafter) as the 2009 earthquake causative fault.
We performed a detailed morphotectonic analysis on the surface expression of the PSDFS, mainly based on the availability of high-resolution LiDAR topographic data.
The extent of the long-term morphological expression of the PSDFS (characterized by the presence of pre-existing composite fault scarps with throws of several meters) and of the modeled seismologic/geodetic coseismic fault contrasts with the limited size of the primary coseismic surface ruptures (∼3km-long with maximum throw of 0.15m). This discrepancy raises two main questions:
(1) are repeated coseismic centimetric displacements at the surface able to build the decametric-high long-term composite fault scarps, or there is need for larger coseismic slip at the surface?
(2) how does the PSDFS cumulate slip over time and space?
Both these questions represent serious caveats for the assessment of the seismic hazard of the area and envisage the hypothesis that the PSDFS can generate larger magnitude events, with respect to that of April 2009.
Through our detailed morphotectonic analysis we imaged the long-term morphological expression of the PSDFS and highlighted its complex geometrical arrangement (length, number of fault splays and boundaries) at the surface. We also defined a first-order hierarchy among the numerous fault splays across the fault system. The PSDFS appears to be a ∼19km-long structure comprising two main sectors: (1) the Paganica sector to the NW, characterized by a narrow deformation zone and a relatively small Quaternary basin affected by few fault splays and (2) the San Demetrio sector to the SE, characterized by a strain distribution at the surface that is accommodated by several tectonic structures, with the system opening into a set of parallel, km-spaced fault splays that exhume and dissect a wider Quaternary basin.
The preliminary reconstruction of the PSDFS morphology suggests the persistence of the deformation through time and for its whole length. In fact, the cumulative displacement distribution along strike of the PSDFS approximates a symmetric bell-shaped curve, reproducing a throw profile comparable to that typical of an individual extensional fault. On this basis, the tips of the curve represent the fault boundaries that can be considered stationary at least for the last morphogenic phase (up to ∼2Ma).
In terms of seismic hazard our results, when compared with what observed in 2009, suggest that the PSDFS forms its long-term geomorphic expression by repeated surface ruptures interesting either the whole 19km-long structure (master rupture) or smaller sections as it occurred in 2009, suggesting a variable slip along strike behavior. The master ruptures are likely related to more energetic earthquakes with respect to the 2009 event, in agreement with the magnitude of several historical earthquakes occurred in the region.