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The 2016-17 seismic sequence as a tile of the normal faults system activated in the last 20 years in the Central-Northern Apennines

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In the last 20 years, three seismic sequences (Colfiorito 1997; L'Aquila 2009 and Amatrice-Norcia-Visso 2016-2017) occurred in between the northern and central Apennines of Italy, activating a NW-trending and 130km long, contiguous normal fault system composed by a set of 12-18 km long fault segments rupturing the first 10 kilometres of the upper crust. This is an exceptional opportunity to explore the processes driving such complex earthquake sequences at high spatial resolution and displaying relevant similarities as well as fundamental differences in their preparatory phase, seismicity pattern and fault complexity.

The anatomy of these fault systems shows heterogeneity of rupture histories and complexity of activated fault segments raising questions on our understanding of long term segmentation, strain partitioning and dynamic control of coseismic ruptures. We will make use of the imaged rupture histories during moderate magnitude earthquakes and seismicity evolution to discuss the similarities between seismological observations (faults generating earthquakes and recognised by aftershocks distribution) and Quaternary geological fault structures (faults mapped at the surface) pointing out their geometric and kinematic correspondence. The high resolution achieved in reconstructing the faults anatomy by locations of small magnitude earthquakes (local magnitude > 0.5), allows to characterize the fault zone structure and its evolution, an essential factor for better understanding earthquake mechanics and rupture evolution. The strong similarities between seismological and geological images of fault structure indicate that earthquakes have a key role in the evolution of fault architecture

We will also discuss the differences between native normal faults composed by planar segments rupturing the whole seismogenic layer and normal faults rupturing (and inverting) inherited thrusts with the tendency of flattening at depth along sub-horizontal horizons.

Segmentation controlled by crustal heterogeneities and intersecting structures inherited from past tectonics seems to be very efficient. These older structures, often separating diverse geological domains, affect the evolution of seismicity and control dynamic rupture propagation and coseismic slip distribution. Also the persisting seismic gaps along the whole fault system highlighted by the lack of seismic activity, may be related to the presence of specific geological domains and inherited structural settings. However, observations and inferred rupture histories raise concern on the concept of maximum expected magnitude.

Two nearby sequences experienced foreshocks activity located along structural discontinuities between the main faults [1997 Colfiorito] and along the main fault plane [2009 L'Aquila]. These sequences lasting for months, marked the onset of large variations in elastic properties of the crustal source volumes modelled in terms of dilatancy and diffusion processes, corroborating the hypothesis that fluids play a key role in the nucleation process of extensional faults as testified by main fault planes sometimes activated before the occurrence of the largest event on the fault plane itself. Differently the 2016-2017 seismic sequence did not show any standard foreshocks activity, while it seems to be loaded by strain partitioning affected by a mid-crustal layer characterized by seismic activity showing changes in the rate of earthquake production during the months before the sequence onset and during the aftershock sequence.