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Can seismicity image the complexity of fault architecture? A radiography of the 2009 MW 6.1 L'Aquila normal fault system (Central Italy).

Luisa Valoroso (1), Lauro Chiaraluce (1), Raffaele Di Stefano (1), Davide Piccinini (2), David P. Schaff (3), and Felix Waldhauser (3)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Centro Nazionale Terremoti, Rome, Italy (luisa.valoroso@ingv.it, +390651860541), (2) Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Pisa, Italy, (3) Lamont-Doherty Earth Observatory, Columbia University, New York (USA)

On April 6th 2009, a MW 6.1 normal faulting earthquake struck the axial area of the Central Apennines (Italy). We present high-precision locations of 70,000 earthquakes recorded by a very dense seismic network of 60 stations operating for 9 months after the main event. Events span in magnitude (ML) between -0.9 to 5.9, reaching a completeness magnitude of 0.7, for the whole aftershocks sequence.

The dataset has been processed by means of an accurate automatic picking procedure together with cross-correlation analysis and relocated with the double-difference relative location method. The combined use of these procedures results in earthquake location uncertainties in the range of a few meters to tens of meters (i.e. lower than the spatial dimension of the source of the earthquakes). This extraordinary large and high quality dataset allows us to image the complex geometry of the normal fault system defining first and second order structures, from the kilometre to the meter scale.

The main shock fault plane is clearly imaged showing a 14-km-long NW-trending planar normal fault plane dipping 50° to SW. The fault reaches the surface and extends to 10 km depth. The second major segment, activated by two Mw>5 events, is located to the North and shows a shallower dip angle (about 35°), with a tendency to flattening towards the deepest portion, defining a clear listric geometry. The northern segment is recognisable for about 10-12 km of length, always NW-trending and forming a right lateral step with the main fault plane. The result is an en-echelon system overlapping for about 6 km.

We show minor antithetic and synthetic faults located both in the hanging-wall and footwall of the major fault planes. Minor fault segments are in the order of hundred of meters in length and tens of meters in thickness and image complex pattern that are analogous to fault architecture observed by field geologists on fault outcrops.

High-precision locations of this large dataset allow us, for the first time, to investigate important issues such as: the relationship between seismic fault zone width and geologic damage zone; the complex architecture of the fault zone toward the surface; characteristic patterns of brittle failure; the structure and role of secondary faults in the seismogenic process.

Finally, the seismological dataset we present has the potential to build bridges with field geology and rock-physics, by unifying the scale of observation of brittle deformation phenomena.