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Fault structure and mechanics of the Pertusillo reservoir (southern Italy) induced seismicity

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The Val d'Agri basin in the southern Apennines seismic belt is one of the regions in the central Mediterranean with highest seismogenic potential (M7+). In the past forty years the basin only experienced a weak background seismicity (M<3). Background activity coexists with two well documented cases of anthropogenic seismicity associated to the exploitation of a giant oilfield and to the medium-sized Pertusillo water reservoir (PWR), respectively. Along the SE margin of the basin, re-injection of brine of the oilfield into a well has been inducing microseismicity (ML<2) since the beginning of disposal in 2006. To the SW of the basin, M3+ swarms recorded by local networks since 2001 strictly relate to seasonal oscillations of the PWR as high as 40 m, corresponding to storage changes of about 110 million m3. This temporal correlation led Valoroso et al. (2009) and Stabile et al. (2014) to interpret the Pertusillo lake earthquakes as protracted reservoir induced seismicity. While a throughout model of the Val d'Agri injection-induced earthquakes has been proposed recently (see Improta et al., 2017), the physical mechanism behind the Pertusillo Lake seismicity is still poorly understood.

In this work, we re-analyze 1044 earthquakes (ML<3) collected during the 2001-2014 in the Val d'Agri area by integrating three different permanent and temporary networks, focusing on the PWR seismicity. Starting from absolute 3D locations by Improta et al., (2017) we compute high-resolution relative locations by integrating cross-correlation and double-difference methods. High-precision locations help to reconstruct a detailed picture of the geometry and kinematics of the complex network of activated faults. We distinctly recognize 4 clusters of seismicity delineating NW-tending and oppositely (SW and NE) dipping faults at high-angle (50° to 70°). These faults have 1 to 2 km along-strike lengths, variable along-dip lengths (0.5-2km) and damage zones on the order of a few tens of meters. The faults illuminated by earthquakes alignment are confined to the top 2-5 km of the crust which locally consists of high-Vp (6 km/s), high-Vp/Vs (1.9-2.0) strongly fractured, water-saturated Mesozoic limestones. Extensional and strike-slip focal mechanisms along NW-SE and WSW-ENE striking planes completely agree with the faults geometry and the present extensional stress field trending NE-SW. For their geometry, these faults could be associated either to a known NW-trending Quaternary normal fault system that bounds the basin to the SW or to NW-trending Mio-Pliocene thrusts, which are favorably oriented in the present stress field.

The spatiotemporal seismicity distribution indicates a positive correlation between the seasonal oscillation of the PWR and the progressive activation of the 4 clusters of seismicity. Distant clusters from the PWR are delayed with respect to the closer ones, suggesting that seismicity migrates away from the reservoir following a pore fluid pressure triggering process. Fluid-related processes are also observed within the single minor faults, characterized by up-dip or along-strike seismicity migration. These results point to a pore-pressure diffusion triggering mechanism caused by poroelastic deformation of the fractured water-bearing carbonates in response to the seasonal loading of the PWR.