Present-day seismic activity in the Mugello Basin and adjoining areas (Northern Apennines, Italy)

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The Northern Apennines is a NW-SE striking fold-and-thrust belt composed of a pile of NE-verging tectonic units that developed during Cenozoic collision between the European plate (Corso–Sardinian block) and the Adria plate. Seismicity and geodetic data indicate that contemporaneous crustal shortening (in the external, Adriatic part) and extension (in the internal, Tyrrhenian side) characterize the current tectonic activity of the Apennines. The region around the Mugello basin (Northern Tuscany) represents one of the most important seismogenic areas of the Northern Apennines. Large historical earthquakes have occurred, such as the M=6.0, 1542 and the M=6.4, 1919 events. Its proximity to densely-urbanized areas and the potential impact of strong earthquakes on the cultural heritage in the nearby (~30km) city of Florence makes a better knowledge of the seismicity in the Mugello basin a target of paramount importance. Unresolved issues regard (i) the exact location and geometry of the fault(s) which produced the 1542 and 1919 earthquakes, (ii) the mechanism driving the abrupt transition from an extensional to compressional stress regime at the internal and external sides of the belt, respectively, and (iii) geometry of and role played by a close-by transfer zone oriented transversely (NE-SW) to the main strike of the belt. To address these problems, in early 2019 we initiated a project aiming at improving the knowledge about the seismo-tectonic setting of the basin and adjoining areas. At first, we integrated all the available seismic catalogs for the area, obtaining more than 12000 earthquakes spanning the 2005-2019 time interval. These data have been used to derive a minimum-misfit, 1-D velocity model to be subsequently used for a travel times inversion 3D tomography. At the same time, we installed 9 temporary seismic stations, complementing the permanent networks presently operating in the area. This new deployment recorded a Mw=4.5 earthquake that struck the NW margin of the basin on Dec. 9, 2019. The mainshock and the ~200 aftershocks precisely delineate a 5-km-long, NW-striking and SW-dipping fault which extends over the 6-9 km depth interval. The focal mechanism of the mainshock yields consistent results, indicating a normal fault striking N105°E and dipping about 45°. This fault appears to be distinct from that (those) activated during the two last important sequences in the area, which occurred in
2008 and 2009. The earthquake caused unexpected, large accelerations (PGA~0.24g at ~7km epicentral range), provoking damages that resulted in the evacuation of more than 150 residents and economic losses of several millions of euro. Sample horizontal-to-vertical spectral ratios at the most damaged sites report significant amplification within the 1-5 Hz frequency range, likely responsible for the anomalous ground shaking. Given the proximity of the aforementioned fault to that inferred for the 1542 (and, possibly, 1919) earthquake(s), a detailed study of the 2019 seismic sequence is expected to shed new light into the overall dynamics of the basin.