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Seismotectonic analysis of the Lunigiana and Garfagnana extensional basins (Northern Tuscany, Italy)

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We investigated the active and potentially seismogenic sources of the Lunigiana and Garfagnana extensional basins by integrating geological and morpho-structural surveys with seismological and seismic reflection data. The Lunigiana and Garfagnana basins are NW-SE grabens, originated in the hanging wall of a E-NE dipping low-angle detachment faults outcropping in the northern Tuscany Apennines. The conjugate faults bounding the basins join with the detachment at depths varying from 1 to 2.5 sec TWT, from W to E. The outcrop expression of the two fault sets is similar but the east-dipping faults show, on average, lower dip-angles (i) (30°<i<60°, increasing from W to E) and higher cumulative displacement (D) values (D>4 km) than the west-dipping ones (50°<i<70°, D$\tilde{2}$.5 km). The kinematic analysis shows that the more recent movements are normal or oblique and are coherent with an extensional stress field characterized by a NE-SW-trending sigma3 axis.

In the Lunigiana, the depth geometry of the detachment and of the main high-angle faults has been accurately defined by interpreting three seismic lines down to the depths of 4.5-5 sec TWT ($\tilde{1}$2-15 km). The east-dipping Mulazzo and Olivola faults and the west-dipping Groppodalosio and Compione faults show the strongest geomorphic signature and are the most likely active faults. This is also confirmed by the geomorphic analysis carried out integrating aerial photograph interpretation and medium resolution DTM analysis. In the Garfagnana, the NW-SE striking Casciana-Sillicano and Bolognana-Gioviano east-dipping faults show morpho-structural evidence of Late Quaternary movements and can be interpreted as active and potentially seismogenic structures. Along the eastern side, the major antithetical Quaternary faults crop out along the M. Prato- M. Mosca ridge.

The geometry of the active faults has been compared with the distribution of seismicity. Our instrumental dataset consists of about 500 earthquakes (0.4≤Ml≤4.2) recorded by the Lunigiana-Garfagnana local Seismic Network from 1999 to 2006 and accurately re-located. In the Lunigiana, the seismicity concentrates in the Pontremoli and Aulla grabens whereas in the Garfagnana only very low background seismicity, with few epicentres occurred. On SW-NE oriented vertical sections, the hypocentres mainly locate within the upper 15-20 km and affect, from W to E, progressively thicker crustal volumes. A concentration of the hypocentres within a narrow volume dipping at $\tilde{3}$0° eastward is also observed.

A revision of the available earthquake focal mechanisms, from 1939 to 2006, indicates the existence of a 30 km-wide extensional belt, extending from the Lunigiana-Garfagnana grabens to the Apennine chain (mechanisms with average sub-horizontal N40°-E stretching direction).

Resuming, the integrated analysis of geological and seismological data, including historical earthquakes (e.g. February 14, 1834, I=VIII-IX M$\tilde{5}$.6; May 7, 1481, I=VIII-IX M$\tilde{5}$.8 earthquakes), suggests as active and potentially seismogenic structures, the Mulazzo and Olivola-Soliera faults (NE-dipping) and the Groppodalosio and Compione-Comano faults (SW-dipping).

A further interesting subject is the seismogenic role played by the North Apuane Fault Zone (NAFZ), a right-lateral fault-set bounding northward the Apuane metamorphic core and transferring extension from the Lunigiana to the Garfagnana. We associate to the NAFZ the October 1995 earthquake (M = 4.9), the April 11, 1837 earthquake (I=IX-X, M$\tilde{5}$.7) plus a number of small-magnitude earthquakes (4.5≤M≤5.2) occurred in 1767, 1902, 1928 and 1962. The September 7, 1920 earthquake, which is the largest event of the Lunigiana-Garfagnana area (I=IX-X, M$\tilde{6}$.5), could be associated to a complex rupture involving the entire Casciana-Sillicana fault plus the eastern portion of the NAFZ.