Lithological and structural control on the seismicity distribution in Central Italy

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In the seismically active region of Central Italy, national (permanent) and local (not-permanent) seismic networks provided very accurate location of the seismicity recorded during the major seismic sequences occurred in the last 25 years (e.g. 1997-1998; 2009; 2016-2017), as well as of the background seismicity registered in the intervening periods. In the same region, a network of seismic reflection profiles, originally acquired for oil exploration purposes, is also available, effectively imaging the geological structure at depth, to be compared with the seismicity distribution.

This comparison reveals that, if the position of the brittle/ductile transition exerts a role at regional scale for the occurrence of crustal seismicity, at a more local scale the depth and thickness of the seismogenic layer is mostly controlled by the contrasting rheological properties of the different lithological groups involved in the upper crust.

The upper crust stratigraphy, including the sedimentary cover and the uppermost part of the basement, consists of alternated strong (rigid, e.g. carbonates and dolostones) end weak (not-rigid, e.g. shales, sandstones, and phyllites) layers. This mechanically complex multilayer is involved in a belt of imbricated thrusts (Late Miocene-Early Pliocene), displaced by subsequent extensional (normal) faults (Late Pliocene-present), responsible for the observed regional seismicity. The top of the basement s.l. (composed of clastic sedimentary and slightly metamorphosed rocks) is involved in major thrusts. For these different lithological units, combined field and lab studies of fault rock properties have documented localized and potentially unstable deformation occurring in granular mineral phases (carbonates) and distributed and stable slip within phyllosilicate-rich shear zones (shales and phyllites).

By comparing the geological structure with the seismicity distribution, we observed that:

- The seismicity cut-off (i.e. the bottom of the seismogenic layer) is structurally (not thermally) controlled, and grossly corresponds to the top basement; the upper boundary of the seismogenic layer corresponds to the top of carbonates.

- Most seismicity occurs within the rigid layers (carbonates and evaporites), and do not
penetrate the turbidites and basement rocks.

- Close to the axial region of the mountain range, where the larger amount of shortening is observed, the presence of thrust sheets from the previous compressional phase, significantly affect the seismicity distribution and propagation.

- Major east-dipping extensional detachments, recognized in the seismic profiles, are also marked by distinctive seismicity alignments.