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Integrated morphometric and 3D-structural analysis to detect subtle evidence of active faulting in the central Italy extensional environment

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Central Italy has been recently affected by the 2016-2017 seismic sequence which activated two well-known Late Quaternary-active intra-Apennine extensional structures: the Mt Vettore-Mt Bove (VBF) and the Mt Gorzano faults. Most of the energy release of the sequence has been related to the activation of VBF during the August 24 (MW6.0) and October 30 (MW6.5) main shocks. This is confirmed by evidence of coseismic displacements along the VBF fault scarp broadly documented in the literature.
A third significant event (MW 5.9) occurred on October 26 is instead poorly correlated with the VBF trace and its inferred subsurface geometry. Following this event, the spatial distribution of aftershock seismicity and the DinSAR measurements highlighted the possible existence of a still unknown active source located along the northern continuation of the main seismogenic source. Nevertheless, while the VBF is well recognizable in the field, no clear active faulting is recognizable northwards nor is yet reported in the literature. This lack of knowledge is possibly hindered by the less resistant rock types (marls and flysch deposits) that outcrop in the sector.
We explored the possibility that the deformation occurring along the active extensional belt in central Italy is accommodated along a still unknown structure, north to the VBF.
In order to document subtle evidence of surface deformation driven by the fault activity, we exploited a methodological approach which integrates 1) High Resolution Topography analysis, 2) structural-geological analysis of the long-term deformation and seismological data integration for 3D fault model building.
We first computed DEM-derivatives (e.g. local relief, profile curvature) along the well-mapped VBF in order to test the efficiency of such topographic metrics in detecting Late Quaternary tectonic signature on the local landscape. Afterwards, we applied the same methodology in the study area and we integrated the mapped lineaments with information from a set of geological cross-sections drawn using available geological maps (1:25.000 scale). Where possible, we also exploited information from geomorphologic mapping. Finally, we constrained the surface- and long-term evidence of deformation with the 3D spatial distribution of hypocenters and with the kinematics of the available Mw$\geq$4.0 focal mechanisms.
We found that 1) DEM-derivatives well fit the topographic anomalies led by the VBF system; 2) the methodology highlights many "discontinuities" in the morphologic features also northwards. Most of them are located where the geological sections show problems in the stratigraphic layering reconstruction and/or where the hypocenter distribution suggest the existence of a tectonic discontinuity.
Our approach highlights a newly found active extensional fault, along with the northernmost sector of the 2016-2017 seismic sequence epicentral area. This fault strikes in $\sim$NNW-SSE direction for about 20 km, dips WSW-wards with a 55° average dip angle and is arranged in a right-lateral en echelon geometry with respect to the VBF. The reconstructed geometry is coherent with the possible occurrence of Mw$\geq$6.0 earthquakes in a sector considered almost aseismic up today. This implies a northward extent of the intra-Apennine extensional domain and could have significant implications in terms of seismic hazard assessment in central Italy.