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3D modelling approach for the mitigation of central Italy seismic hazard: the Sulmona and Caramanico case studies.

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The Central Apennines is characterized by the presence of several active Plio-Quaternary normal faults, potentially capable of generating damaging earthquakes (as occurred in the recent past).

The seismicity registered for central Italy in the last 20 years by the seismic network of INGV (National Institute of Geophysics and Volcanology) highlights the presence of a regional seismic gap in the Sulmona and Caramanico Plio-Quaternary intermountain basins. In the study area, the magnitude of historical earthquakes ranges of from 5 to 6.8 Mw (from the 2nd century A.D. to 1933), while paleoseismological studies assigned a possible magnitude of 6.7 ± 0.1 to 4 earthquakes in the Sulmona basin (based on the fault length and the average of slip rate per event, estimated to be 1m). The high magnitude recorded for the destructive 1915 Avezzano earthquake (about 7 Mw), located in the Fucino basin (about 25 km to the west of the Sulmona basin), could suggest a similar potential seismic hazard also for the Sulmona and Caramanico normal faults. However, uncertainties remain on the activation mechanism related to the possible earthquake, expected in the study area. To reduce these uncertainties, we use a 3D modelling approach to perform a detailed calculation of the "active" rock volume of the hanging wall of the Sulmona and Caramanico faults (brittle volume), making an estimation of the possible maximum magnitude associated with these normal faults (testing different scenarios on the earthquake enucleation).

To reach this goal, a 3D structural and geological model was carried out starting from the available geological cartography, exploration wells, geophysical data (such as seismic sections and relocated earthquakes), and geological models from the literature. As a first step, several 2D balanced geological cross-sections were built across the Central Apennines to define the main structural picture at the regional scale (still discussed in literature). Cross-sections were built using MOVE (Petroleum Experts), while 3D modelling was completed using Petrel (Schlumberger) software. For the 3D modelling phase, the brittle-ductile transition (BDT) was used to localize the bottom of the potential brittle volumes at depth (assumed as maximum depth of the hypocenter). Following this methodology, the maximum magnitudes were estimated of the Sulmona (7.1 Mw, BDT at 17 km) and Caramanico (7.2 Mw, BDT at 20 km) normal faults. With the aim of simulating a more

conservative scenario, the effects of a possible shallower structural cut-off for the Sulmona (8 km) and Caramanico (10 km) areas were investigated. The resulting reduced brittle volumes led to lower magnitude values estimate (6.6 Mw for the Sulmona, and 6.8 Mw for the Caramanico faults).

This approach allowed to make an estimate of the expected magnitudes for future seismic events associated to the Sulmona and Caramanico regional extensional faults, considering two different fault activation models (because of the regional structural uncertainties). Our work also demonstrates the importance of implementing robust 3D geological models to support seismogenic potential evaluation and seismic hazard studies.