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The relationship between pre-existing geological structures and seismicity induced by wastewater disposal in Val d'Agri (Southern Apennine, Italy)

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The Val d'Agri Quaternary basin is located within the Southern Apennine extensional belt, hosting the largest oilfield in Europe. Wastewaters coming from oil production were re-injected since 2006 by a single high-rate disposal well into a deep reservoir represented by the carbonates of the Apulian platform. Induced micro-seismicity (219 events, ML < 2.3) was recorded soon after the beginning of injection and within 5 km of the well.
A detailed analysis of oilfield underground dataset was performed in order to define a reliable 3D geological model of the injection site to be related to injection-linked seismicity. A pre-existing thrust system inherited by a Plio-Pleistocene compressional tectonic phase constituted by NE-verging moderate-angle thrusts and SW-verging back-thrusts interesting the Apulian carbonates can be modeled. A peculiar E-dipping back-thrust completely developed between two major thrusts can be modeled just below the injection well.
The depth conversions of seismic interpretation based on sonic logs, VSP and seismic check-shots highlighted that the back-thrust geometry and the accurate 3D absolute location of induced events are compatible.
The spatio-temporal distribution of events suggests that disposal activity firstly caused the reactivation of the deeper portion of the back-thrust, and then seismicity mostly migrated up-dip toward shallower depths, interesting the upper portion of the fault. Induced seismicity remained almost confined within the reservoir volume, and close to the injection well.
Analysis of focal mechanisms show a predominant extensional kinematic for those events, while a certain compound of strike-slip kinematic is present. These results suggest both the inversion of the backthrust itself and the existence of transverse fault structures within the original compressive fault system.
Induced events presumably occurred on a small and high-permeability patch of the backthrust fault zone, favorably oriented with respect to the present-day SW-NE trending extensional stress field, perhaps at the junction with a high angle transverse fault.
Finally, results can be read in the light of understanding the impact that induced seismicity due to the reactivation of pre-existing/inactive faults might have on seismic hazard and seismogenic potential evaluations, especially in tectonically active areas like the Southern Apennine.