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Imaging the Crust in the Northern Sector of the 2009 L'Aquila Seismic Sequence through Oil Exploration Data Interpretation

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The 2009 L'Aquila seismic sequence activated a complex, about 40 km long, NW-trending and SW-dipping normal fault system, consisting of three main faults arranged in right-lateral en-echelon geometry. While the northern sector of the epicentral area was extensively investigated by oil companies, only a few scattered, poor-quality commercial seismic profiles are available in the central and southern sector.
In this study we interpret subsurface commercial data from the northern sector, which is the area where is located the source of the strong Mw5.4 aftershock occurred on the 9th April 2009. Our primary goals are: (1) to define a reliable framework of the upper crust structure, (2) to investigate how the intense aftershock activity, the bulk of which is clustered in the 5-10 km depth range, relates to the Quaternary extensional faults present in the area.
The investigated area lies between the western termination of the W-E trending Gran Sasso thrust system to the south, the SW-NE trending Mt. Sibillini thrust front (Ancona-Anzio Line Auctt.) to the north and west, and by the NNW-SSE trending, SW-dipping Mt. Gorzano normal fault to the east. In this area only middle-upper Miocene deposits are exposed (Laga Flysch and underlying Cerrogna Marl), but commercial wells have revealed the presence of a Triassic-Miocene sedimentary succession identical to the well known Umbria-Marche stratigraphic sequence.
We have analyzed several confidential seismic reflection profiles, mostly provided by ENI oil company. Seismic lines are tied to two public wells, 5766 m and 2541 m deep. Quality of the reflection imaging is highly variable. A few good quality stack sections contain interpretable signal down to 4.5-5.5 s TWT, corresponding to depths exceeding 10-12 km and thus allowing crustal imaging at seismogenic depths. Key-reflectors for the interpretation correspond to: (1) the top of the Miocene Cerrogna marls, (2) the top of the Upper Albian-Oligocene Scaglia Group, (3) the Aptian-Albian Fucoid Marl horizon, (4) the top of the upper Jurassic "Calcari ad Aptici" Formation, (5) the top of the upper Triassic dolomites plus evaporites of the Burano Formation. Strong but discontinuous deep reflectors can be reasonably attributed to the Paleozoic-Trassic clastic sequence underlying the evaporites.
Neogene compression is responsible for a system of NNW-SSE trending fault-propagation folds which have often grown on top of popup-like structures. Extensional features include shallow-seated low-angle faults, likely related to gravitational readjustments on top of compressional features, and younger NNW-SSE trending high-angle faults. The major high-angle fault in the investigated area is represented by the Mt. Gorzano Fault, a regional structure the surface trace of which is at least 20 km long. The Mt. Gorzano Fault is a listric fault that dips around 60° in the first 2 s TWT and flattens at greater depths until it becomes sub-horizontal at about 5 s TWT, i.e. at a depth averaging 12 kilometers. Depth converted sections, calibrated by well data, indicate that the bulk of the aftershock activity is confined between the Triassic dolomites plus evaporites and the underlying Paleozoic-Triassic terrigenous deposits, without affecting the overlying carbonates. Events alignment revealed by accurate Double-Difference relative locations suggests that the Mw5.4 aftershock activated a 12 km-long segment of the Mt. Gorzano Fault at depths ranging from 5 to 10-12 kilometers. Aftershocks cluster in the hanging-wall of the deep portion of the fault recognized in the stack sections, whose geometry is consistent with the fault plane highlighted by earthquakes alignment.