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High resolution 3D imaging of the Irpinia active fault zone part 2: Modeling of rock physical properties

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The aim of this work is to investigate the nature and role of fluids in controlling the earthquake fracture processes generating the intense micro-seismicity occurring along the Irpinia active fault zone (southern Italy). The area is known to originate moderate-to-large earthquakes both in historical and recent times. The idea of the present work stems from and complements the results obtained from velocity and attenuation 3D tomography (Amoroso et al. 2014, 2016).

Starting from the rock modeling developed by Pride et al. [2005], based on the Biot's [1962] theory, we performed an up-scaling approach to predict the expected seismic velocity and attenuation (macro-parameters) for a given host rock characterized by a set of micro-parameters (porosity, percentage of fluid saturation and permeating fluid type), which describe the physical properties of the solid and fluid phases [Dupuy et al., 2016]. The up-scaled values of the macro-parameters were then compared with those inferred from the velocity and attenuation tomography [Amoroso et al., 2014, 2016] for improved rock models.

We focused our rock physics modeling on the volume between 8 and 10 km depth, where the Qp quality factor reaches the largest values, just above the volume where a peak of micro-seismicity is observed [De Landro et al., 2014].

For the up-scaling approach, we assumed that the simulated rock has a mineralogical composition dominated by dolomite (as indicated by deep oil wells which reached the base of the Apulian Platform succession), with the consolidation parameter (Cs), i.e. the degree of consolidation of a rock, varying in the range [5.5,7.5] associated to carbonate rocks at high effective pressure [de Ceia et al., 2015]; with porosity, varying in the range [0%, 5%] (from measure on core samples and previous simulations); with pores and fractures filled by a two-phase fluid (brine-CO_2; brine-CH4 and CO_2-CH4, from the gas emission measurements at the surface). From these assumptions, we calculate values of the macro-parameters by varying the relative saturation percentage of fluids.

Results indicate that even though we use for Cs 7.5, maximum value of possible range, the correspondent porosity at 8-10 km depth is [3%,5%], much larger than those expected for carbonate rocks at the depth-interval investigated. All the explored fluid mixing are plausible at 8-10 depth. We consider the modeled volume as fluid-saturated and highly fractured [Amoroso et al., 2014], and propose that hydraulic fracturing and fluid overpressure [Iriarte et al., 2012] contribute to create a significant amount of fracture porosity and enhance the preservation of porosity at depth. These results are in agreement with conclusions obtained by Amoroso et al. [2014], who hypothesized that the investigated volume is fed by fluids rising along the major active boundary faults which, therefore, represent a barrier for their lateral migration. Thus, as a conclusion of the present work, we suggest that the triggering mechanism of seismicity occurring in the target fault zone is strongly controlled by the presence of brine-gas fluid phases, which induces a pore pressure increase in the saturated and highly fractured medium embedding the faults.

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