Time-lapse tomographic images of the Irpinia Fault System (Southern Italy) reveal Vp/Vs ratio changes that correlate with micro-seismicity production and evolution

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This study focuses on the the active fault system that caused the 1980 M_S 6.9 Irpinia earthquake (Irpinia fault zone (IFZ)) that is presently interested by a continuous and frequent micro-earthquake activity occurring within the volume in the volume enclosed by two antithetic faults. It is therefore important to improve the knowledge of the IFZ dynamics, with reference to potential future occurrence of moderate to large earthquakes, especially in terms of earthquake triggering mechanisms. Several previous works evaluated the spatial distribution of elastic/anelastic fault-embedded medium properties and related rock physical micro-parameters in connection with the seismicity rate. These studies showed a spatial correlation between high Vp/Vs, low seismic attenuation in rock volumes where most of seismicity occurs, suggesting that fluid-driven pore-pressure changes may plays a key role in controlling the seismicity production at the IFZ.

Here we reconstruct accurate 4D seismic velocity images of the volume embedding IFZ which allows to detect and track space-time changes of medium elastic properties possibly induced by fluid pore pressure migration and investigate the related seismicity production.

We analyzed the arrival time phase catalogue of about ten years (2005-2016) of Mw < 3.1 events recorded by the ISNet (Irpinia Seismic Network) and INGV network. We divided the catalog in 5 not-overlapping epochs by selecting in each of them, approximately the same number of events and an uniform volume coverage, in order to ensure that the 3D P and S velocity models could be equally well resolved for each epoch. By comparing the Vp, Vs and Vp/Vs images at each epoch in the equally resolved volume, we are able to detect medium velocity changes. Some regions, in the first 6 km of depth of NE part, do not show velocity changes with time, which is interpreted as the main effect of unperturbed lithology mainly controlling the average seismic velocity. In other regions, in the central part of the model at about 8-10 km depth, we clearly detect velocity changes causing an up to 10% Vp/Vs variation between different epochs. Based on the rock physical modelling, we associate the time-varying Vp/Vs and the observed amplitude of variation to fluid-driven changes in rock physical properties related to their spatial migration or pore-pressure induced changes. The regions where large Vp/Vs changes occur appear correlated with the largest seismicity production volumes, suggesting a direct link between the physical processes associated with fluid mobility and/or pore pressure migration and earthquake generation at the IFZ.