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A non-conventional seismogenic layer in Northern Apennines (Italy): laboratory investigations of physical and elastic properties of the Triassic Evaporites and implications for crustal modeling

Fabio Trippetta (1), Cristiano Collettini (1), Sergio Vinciguerra (2), and Philip G. Meredith (3)

(1) University of Perugia, Earth Sciences, Perugia, Italy (fabio.trippetta@unipg.it), (2) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy, (3) Department of Earth Sciences, University College London, England

Recently it has been shown that the strongest earthquakes (M $\sim$ 6) of the Northern Apennines of Italy nucleated within the Triassic Evaporites (TE) a lithology that is generally considered as a ductile horizons incapable of generating earthquakes. Seismogenic TE represent a sedimentary succession made of alternated sulphates (anhydrites and gypsum) and dolostones. The repeated seismic cycles lead to deformation, increasing the level of damage of the host rocks and hence changing their elastic moduli, which are key parameters for reliable modeling of deformation processes. Therefore, here we firstly report a petrophysical characterization based on laboratory measurements of density, porosity, Vp, Vs, and permeability at confining pressures from 0 to 100 MPa conducted on samples of TE collected from both outcrops and deep boreholes. Then we report for the same rocks the changes in elastic properties measured during increasing amplitude cyclic stressing experiments.

At ambient pressure, P-wave velocities are in the range 5.4-6.5 km/s for dolostones, 4.4-4.8 km/s for gypsum-dolostones and 5.3-6.3 km/s for anhydrites. At 100 MPa the velocity range is 6.6-7.3 km/s for dolostones, 5.1-5.5 km/s for gypsum and 6.1-6.5 km/s for anhydrites. Permeability is in the range 10^{-18}-10^{-22} m^2. Vp/Vs ratios are confining pressure independent with average values of $\sim$1.8 - $\sim$2.2 for sulphates and $\sim$1.9 - $\sim$2.2 for dolostones respectively for dry and saturated conditions. Cyclic loading test show high heterogeneities for the unconfined compressive strength values ranging from 10 MPa for outcrop gypsum to $\sim$ 200 MPa for borehole dolostones. In all experiments the Young's modulus and the Poisson's ratio increase over the total sequence of loading cycles with irregular trends. Microseismicity, was also recorded throughout each experiment in terms of acoustic emission (AE) output highlighting a little Kaiser effect for most of the samples. Calculated dynamic (velocity derived) and static (deformation-test derived) elastic moduli on the same rock samples have been also compared showing that dynamic modulus is always higher by two to three times respect to the static modulus.

Due to the availability of geophysical data and crustal scale models for the studied area, our laboratory data will be upscaled in order to fully characterize the seismogenic layer of the Northern Apennines and to test the applicability of laboratory data to crustal scale.