Seismic attenuation and rheology of crustal rocks: results from numerical tests

Maria Aurora Natale Castillo¹, Magdala Tesauro¹,², and Mauro Cacace³
¹University of Trieste, Department of Mathematics and Geosciences, Trieste, Italy (mariaaurora.natalecastillo@phd.units.it)
²Dept. of Earth Sciences, Utrecht University, Utrecht, Netherlands (M.Tesauro@uu.nl)
³German Research Centre for Geosciences (GFZ) Potsdam, Germany (cacace@gfz-potsdam.de)

Seismic attenuation of the rocks mainly depends on their intrinsic anelasticity, which is the dissipation of seismic energy as it propagates through the medium. Several studies have already demonstrated that seismic attenuation, described by the Q-factor, is intrinsically related to the rocks' viscosity, considering their common dependency on composition, grain size, fluid content, and T-P conditions. However, viscous deformation of the rocks occurs through different mechanisms: diffusion creep, numerous mechanisms of the dislocation creep, pressure solution, which are expressed by several Arrhenius-type constitutive laws. This makes more complex the investigation of quantitative relationships between seismic attenuation and viscous rocks' rheology.

The main purpose of this study is to investigate the mutual dependence of the seismic attenuation and viscous deformation of the crustal rocks. To this aim, we performed several numerical tests to check the variability of some physical properties (e.g., elastic modulus, Poisson's ratio) and improve the existing relationships between seismic attenuation and viscous deformation of several natural rock samples. The Burgers mechanical model and Arrhenius relation are included in these test series to achieve a closer approximation of the rocks' viscous deformation.

In this way, it will be possible to predict the viscous rheology of rocks from the laws describing the seismic attenuation and viceversa. The obtained results will be used to (1) constrain the Q-factor and rheological (creep) parameters, which are still subjected to high uncertainties, (2) validate/modify the existing seismic attenuation and rheological laws, (3) increase the robustness of the geodynamic and rocks' mechanics numerical codes and our understanding of the role that rocks' rheology exerts on the tectonic processes.