

## Changes in elastic stiffness and permeability upon reaction-transport processes

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Almost all rocks are porous and, to some degree, they are injected with natural or anthropogenic fluid phases. Following Biot (1941), the linear elastic deformation of a porous medium is conveniently described as a purely physico-mechanical problem—the macroscopic fluid flow and strain tensor for the porous medium is expressed as relating strain and fluid mass content to stress and pore pressure through three material constants: the elastic moduli ( $K$  and  $\mu$ ) and the bulk volume change ( $H$ ) induced by a pore pressure change while maintaining the applied stress constant. However, almost as water controls biological systems, Earth fluids control the behavior of porous rocks not only as physical modifiers of pore pressure but also as agents of chemical mass transfer and reactions. Because of the experimental difficulties this fascinating chemo-mechanical coupling remains baffling; often elusively described as “fluid lubrication” or “medium weakening” being seldom quantified. The research being presented refer to a series of experiments that are performed in our laboratory, which provide unique experimental evidence of large, dynamic changes in permeability and elastic stiffness of cemented-volcanic ash and carbonates, respectively, upon carbonation (i.e.,  $\text{CO}_2$  uptake) and decarbonation (i.e.,  $\text{CO}_2$  formation ad release) reaction processes. Rock properties are monitored together with micro-scale changes through dynamic 3D Ct-scan imaging. Changes reported in this study are particularly relevant as rock formations undergoing these reaction processes are often the sites for a great number of earthquake nucleation as well as high  $V_p/V_s$ , generally associated to high pore fluid pressure. *But why does pore pressure increase? And what does that increase entail?* The rock physics of the dynamics of these rock-fluid processes shows a decrease in elastic stiffness, which is accompanied by the formation of a new fibrous calc-silicate phase, a decrease of the  $V_p/V_s$  ratio upon  $\text{CO}_2$  enrichment, and an increase upon  $\text{CO}_2$  depletion. Permeability, instead, decreases upon carbonation until crack formation occurring upon the release of the adsorbed  $\text{CO}_2$  inverts the trend. Dynamic imaging shows the growth of new mineral phases involving both precipitation and solid volume reduction as well as porosity and crack development. Since these processes are active in geological barriers such as faults and caprocks, changes in permeability and elastic stiffness due to crustal reactive processes under constant stress may be responsible for changes in the friction rate parameters. These experiments show that the elastic moduli ( $K$  and  $\mu$ ) and bulk volume change ( $H$ ) of a rock system undergoing those reactive-transport processes often invoked to drive changes in friction constitutive properties, cannot be automatically treated as time-invariant parameters.