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Elastic and transport properties of steam-cured pozzolanic-lime rock composites upon CO_2 injection

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Understanding the relationship between pozzolanic ash-lime reactions and the rock physics properties of the resulting rock microstructure is important for monitoring unrest conditions in volcanic-hydrothermal systems as well as devising concrete with enhanced performance. By mixing pozzolanic ash with lime, the ancient Romans incorporated these reactions in the production of concrete. Recently, it has been discovered that a fiber-reinforced, concrete-like rock is forming naturally in the depths of the Campi Flegrei volcanic-hydrothermal systems (Vanorio and Kanitpanyacharoen, 2015). We investigate the physico-chemical conditions contributing to undermine or enhance the laboratory measured properties of the subsurface rocks of volcanic-hydrothermal systems and, in turn, build upon those processes that the ancient Romans unwittingly exploited to create their famous concrete. We prepared samples by mixing the pozzolana volcanic ash, slaked lime, aggregates of Neapolitan Yellow tuff, and seawater from Campi Flegrei in the same ratios as the ancient Romans. To mimic the conditions of the caldera, we used mineral seawater from a well in the Campi Flegrei region rich in sulfate, bicarbonate, calcium, potassium, and magnesium ions. The samples were cured by steam. We measured baseline properties of porosity, permeability, P-wave velocity, and S-wave velocity of the samples. P and S-wave velocities were used to derive bulk, shear, and Young's moduli. Subsequently, half of the samples were injected with CO_2-rich aqueous solution and the changes in their microstructure and physical properties measured. One sample was subjected to rapid temperature changes to determine how porosity and permeability changed as a function of the number of thermal shocks. Exposure of CO_2 to the concrete-like rock samples destabilized fibrous mineral forming and decreased the samples' ability to deform without breaking. We show that steam- and sulfur-alkaline- rich environments affect both transport and elastic properties of the samples and how the properties of the rock may change in response to microstructural changes due to potential chemical instabilities such as possible new flux of CO_2 into a volcanic-hydrothermal system.