Laboratory monitoring of P-waves in partially saturated sand

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Energy dissipation is observed on seismic data when a wave propagates through a porous medium due to relative fluid/solid motion. We focus here on the role of partial fluid saturation in that dissipation, looking in particular at P-waves phase velocity and attenuation. The study consists in running an experiment in a sand-filled tank partially saturated with water. Seismic propagation in the tank is generated in the kHz range by hitting a steel ball on a granite plate. Seismic data are recorded by buried accelerometers and the partial saturation is controlled by injecting or pumping water. Several imbibition/drainage cycles were performed between the water and gas residual saturations. A Continuous Wavelet Transform applied on seismic records allowed us to extract the direct P-wave at each receiver. We observe an hysteresis in phase velocities and inverse quality factors between imbibition and drainage. Phase velocities and inverse quality factors are then jointly inverted to get final poro-visco-elastic models that satisfactorily reproduce the data. These models consist in generalizing the Biot's theory to effective properties of the fluid and medium (permeability and bulk modulus) and to complete them by grain to grain losses. This study shows that fluid distribution at microscopic scale has strong influence on the attenuation of direct P-waves at macroscopic scale and confirms that seismic prospection may be a powerful tool for the characterization of transport phenomena in porous media.