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Experimental study of seismic attenuation in partially saturated porous media

Julien Barrière, Clarisse Bordes, and Pascale Sénéchal
MIGP Laboratory, University of Pau & CNRS, Pau, France

Nowadays, it is well admitted that hydrogeological properties of the porous media (porosity, fluid saturation and permeability) can influence seismic properties. In geophysics, the major theory which links hydrogeological and seismic parameters is poroelasticity proposed by Biot (1956). The Biot relaxation process is due to the relative displacement of fluid in comparison to the solid which causes a significant attenuation of seismic waves, notably in unconsolidated medium. In partially saturated medium, pore fluids are considered as a perfect mixture and so called "effective fluid". However, in more consolidated rocks, the Biot theory is not sufficient to explain the attenuation level as measured from field seismic and sonic log data. In the last decade, some authors provide new theories to understand the attenuation caused by the interaction of the different fluids.

Most experiments are done in the ultrasonic frequency range, where sources of attenuation (like scattering or local fluid flow) are different as in the low frequency range where the wavelength is greater than heterogeneities size. In this way, we propose a forward-looking experiment with the use of a vertical impulsionnal seismic source which have a strong amplitude spectrum ranging from 100Hz to 8kHz. We study three different unconsolidated porous media at atmospheric pressure: fine-grained sand, coarsed-grained sand and coarse gravel. Water content is measured with a calibrated capacitance probe and temperature effects are corrected. Seismic wave propagation is recorded by piezoelectric accelerometers designed for frequencies below 10kHz. The water injection is done by imbibition.

We propose to analyse the attenuation in the [100Hz-1.5kHz] frequency range for the studied media with various water saturation levels. The attenuation varies according to the porous medium and the water content and appears more significant at dry condition and at high saturation level. The weak cohesion at dry condition probably explains the strong attenuation while the water injection consolidates the porous media and consequently increases the quality factor. At high saturation level, other phenomenona could be responsible for this increase of attenuation. We try to explain these observed physical phenomenona with models using different theories. The input parameters are principally poroelastic modulis, porosity and permeability. They will be estimated from theoretical values and geotechnical laboratory measurements.