
Upscaling of Elastic Properties in Carbonates: A Modeling Approach Based on a Multiscale Geophysical Data Set

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Résumé

Linking ultrasonic measurements made on samples, with sonic logs and seismic subsurface data, is a key challenge for understanding carbonate reservoirs. To deal with this problem, we investigate the elastic properties of dry lacustrine carbonates. At one study site, we perform a seismic refraction survey (100 Hz), as well as "sonic" (54 kHz) and ultrasonic (250 kHz) measurements directly on outcrop and ultrasonic measurements on samples (500 kHz). By comparing the median of each data set, we show that the P wave velocity decreases from laboratory to seismic scale. Nevertheless, the median of the sonic measurements acquired on outcrop surfaces seems to fit with the seismic data, meaning that sonic acquisition may be representative of seismic scale. To explain the variations due to upscaling, we relate the concept of representative elementary volume with the wavelength of each scale of study. Indeed, with upscaling, the wavelength varies from millimetric to pluri-metric. This change of scale allows us to conclude that the behavior of P wave velocity is due to different geological features (matrix porosity, cracks, and fractures) related to the different wavelengths used. Based on effective medium theory, we quantify the pore aspect ratio at sample scale and the crack/fracture density at outcrop and seismic scales using a multiscale representative elementary volume concept. Results show that the matrix porosity that controls the ultrasonic P wave velocities is progressively lost with upscaling, implying that crack and fracture porosity impacts sonic and seismic P wave velocities, which is paramount for seismic interpretation based on deterministic approaches.

Mots-Clés: Acoustic, Upscaling, Carbonate, Multiscale, Geophysics, Modeling

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