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INTER-LABORATORY COMPARISON OF WAVE VELOCITY MEASUREMENTS IN A SAND UNDER HYDRATE-BEARING AND OTHER SET CONDITIONS

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ABSTRACT

This paper presents an eight-laboratory comparison of compressional and shear wave velocities measured in F110 Ottawa sand. The study was run to quantify the physical property variations one should expect in heterogeneous, multiphase porous materials by separately quantifying the variability inherent in the measurement techniques themselves. Comparative tests were run in which the sand was dry, water-saturated, partially water-saturated, partially ice-saturated and partially hydrate-saturated. Each test illustrates a collection of effects that can be classified as inducing either specimen-based or measurement-based variability. The most significant variability is due to void ratio variations between samples. Heterogeneous pore-fill distributions and differences in measurement techniques also contribute to the observed variability, underscoring the need to provide detailed sample preparation and system calibration information when reporting wave velocities in porous media.

Keywords: compressional and shear wave velocity, laboratory measurements, hydrates

NOMENCLATURE

e, Void ratio []
F_e, Void ratio correction []
G, Shear modulus [GPa]
k_0, Coefficient of Earth pressure at rest, given by the ratio of horizontal and vertical stress in a fixed-walled cell (k_0 = 0.45 in F110 sand)
K, Bulk modulus [GPa]
l, Specimen length [mm]
l_p, Characteristic water-saturated patch scale [μm]
S_w, Water saturation [] or [%] as indicated
t, Measured arrival time of waveform feature [μs]
t_0, Measured arrival time of waveform feature in the absence of a specimen (head-to-head)[μs]
T, Period of one wave cycle [μs]
V_P, Compressional (P) wave velocity [m/s]
V_S, Shear (S) wave velocity [m/s]
α, Wave velocity at 1MPa effective stress (assuming F_e = 1) [m/s]
β, Sensitivity of a material's velocity to the state of stress []
ϕ, Porosity [], or [%] as indicated
λ, Wavelength [μm]
ρ, Mass density [kg/m^3]
σ', Effective vertical stress [MPa]

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