

Detecting Shear Wave Arrival in Highly Porous Chalk

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Abstract:

Acquisition of elastic rock parameters may be obtained from density and elastic wave velocity of propagating compressional (P) and shear (S) waves. Determination of elastic wave velocities involves propagation distance and picking of wave arrival time from recorded wave train. Picking P-wave arrival is straightforward as the P-wave is faster than the S-wave, and its arrival marked as the first deflection on the wave train (Fig. 1a). On the contrary, picking S-wave arrival on wave trains may be difficult as part of the S-wave energy converts to P-waves, which may obscure the S-wave arrival. To reduce the uncertainty of picking S-wave arrivals, we propose a strategy based on visual representation of stacked wave trains and arguments founded in rock physical modelling. In the laboratory, we continuously recorded P- and S-wave trains on highly porous oil- and water-saturated chalk plugs during uniaxial strain compaction. Using individual wave trains, we observed two distinct wave features, which could both be interpreted as the S-wave arrival. We denoted those features as an early and late arrival. We proceeded by stacking recorded wave trains in a strain-time-amplitude domain and observed that the two wave features have different behavior for progressing compaction (Fig. 1a & Fig. 1b). To determine the authentic S-wave, we determined wave velocities to derive apparent shear modulus for early and late arrival. By including P-wave data, we derived bulk modulus as input to the Isoframe model and observed that the early arrival results in an unphysical bulk modulus before pore collapse, and thus we deduct that the late arrival is the authentic S-wave. Further, visual representation of stacked wave trains shows that the authentic S-wave trajectory is distinctly different from the P-wave (Fig. 1a, bottom) but fully comparable and detectable in the stress-strain domain (Fig. 1b).

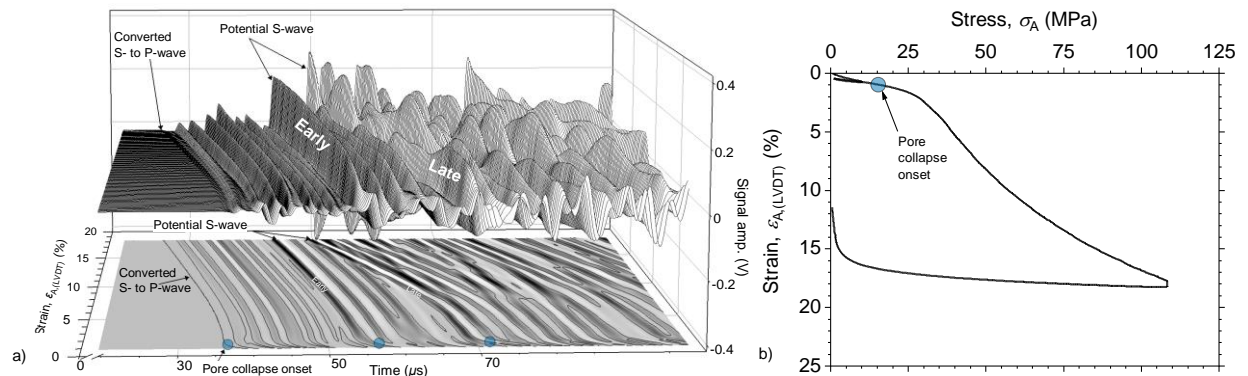


Figure 1 a) Stacked wave trains from S-transducer in the strain-time-amplitude domain from an oil-saturated chalk plug during uniaxial strain. Zero amplitude contour lines are projected on the strain-time plane. b) The stress-strain domain of the test.