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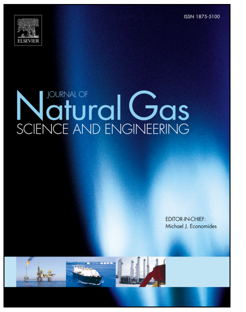

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Elastic impedance parameterization and inversion for fluid modulus and dry fracture quasi- weaknesses in a gas- saturated reservoir

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SUMMARY

A single set of aligned vertical fractures embedded in a purely isotropic background can be considered as an effective long-wavelength transversely isotropic (HTI) medium with a horizontal axis of symmetry. Understanding the separated effect of fluid and fracture properties on seismic characteristics is important for the characterization of a gas-saturated fractured reservoir. Our goal is to demonstrate a direct approach to separate the effects of fluid and fracture properties on PP-wave reflection coefficient, and utilize the azimuthal seismic reflection data to estimate the fluid modulus and dry fracture quasi-weaknesses simultaneously in a gas-saturated fractured reservoir. Starting from Gassmann's poroelasticity theory and linear-slip model, we first derive expressions for the effective elastic stiffness matrix of a gas-saturated fracture-induced porous HTI medium. Using the assumption of small perturbations in rock moduli and small weaknesses, we then derive an expression for linearized PP-wave reflection coefficient for the case of a weak-contrast interface separating two weakly HTI media in terms of fluid modulus and dry (gas-filled) fracture weaknesses based on the perturbation matrix and scattering function, separating the effects of fluid and fracture properties on PP-wave seismic response. With a novel parameterization for dry fracture weaknesses, we propose a method of elastic impedance variation with offset and azimuth (EIVOA) inversion for fluid modulus and dry fracture quasi-weaknesses to reduce the uncertainty of the characterization of fluid and dry fracture properties. Combing Bayesian seismic inversion and regularization constraints, the fluid modulus and dry fracture quasi-weakness parameters are reasonably estimated in the case of synthetic and real seismic data containing a moderate noise in a gas-saturated fractured reservoir.

Keywords*:* HTI medium, Gassmann's poroelasticity theory, small weaknesses, elastic impedance