A more accurate estimation of fracture weaknesses constrained using facies

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Abstract

Establishment of model constraints is crucial for seismic inversion. To implement a better estimation of fracture weaknesses, we propose a two-stage inversion method, which is implemented as: 1) estimating azimuthal elastic impedance (AEI) and fracture facies; and 2) predicting fracture weaknesses using the estimated AEI as the input and model constraints constructed using the predicted fracture facies.

Introduction

In hydrocarbon reservoirs, natural fractures are important channels for hydrocarbon accumulation and migration, and geophysicists place the effort on how to employ seismic data to estimate fracture indicators and improve the accuracy of inversion for fracture parameters (e.g. fracture density, fracture filling modulus).

A reliable estimation of facies contributes to the characterization of reservoir lithology. Grana (2018) proposed the method and workflow of seismic inversion for petrophysical-properties estimation based on statistical rock physics and implemented the lithology-fluid probabilistic classification for reservoir characterization.

We present a method of employing azimuthal partially incidence-angle-stacked seismic data to estimate azimuthal elastic impedance (AEI) and fracture facies at different incidence angles and azimuths. Using the estimated fracture facies, we build model constraints for AEI inversion for fracture weaknesses.

Methods

Using the Bayesian Markov chain Monte Carlo (MCMC) method, we implement the inversion of azimuthal partially incidence-angle-stacked seismic data for estimating AEI of different incidence and azimuthal angles. We employ the naive Bayesian classification method to obtain the fracture facies at different incidence and azimuthal angles. To obtain the unique and final fracture facies from all the estimated results at different incidence and azimuthal angles, we present a simple procedure that among the predicted fracture facies results, the one with the highest number of occurrences at all given incidence angles and azimuths is considered the most likely unique and final result.

Using the estimated EI and fracture facies, we implement the inversion for elastic parameters and fracture weaknesses, and we employ model constraints constructed based on the estimated fracture facies to improve the accuracy of estimation of fracture weaknesses.

Results

Figure 1 shows the azimuthal partially incidence-angle-stacked seismic data.

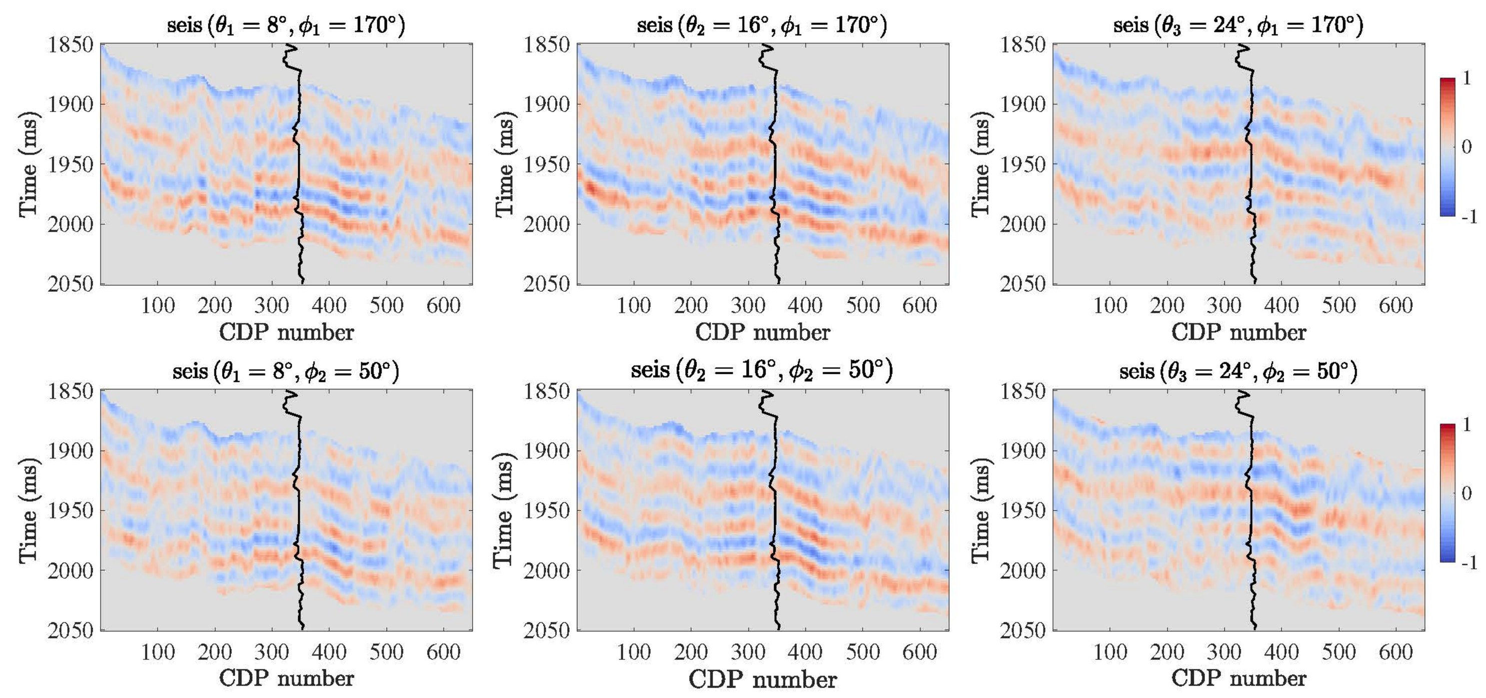

Figure 1: Seismic data of different incidence and azimuthal angles.

Figures 2 and 3 show the estimated AEI and fracture facies.

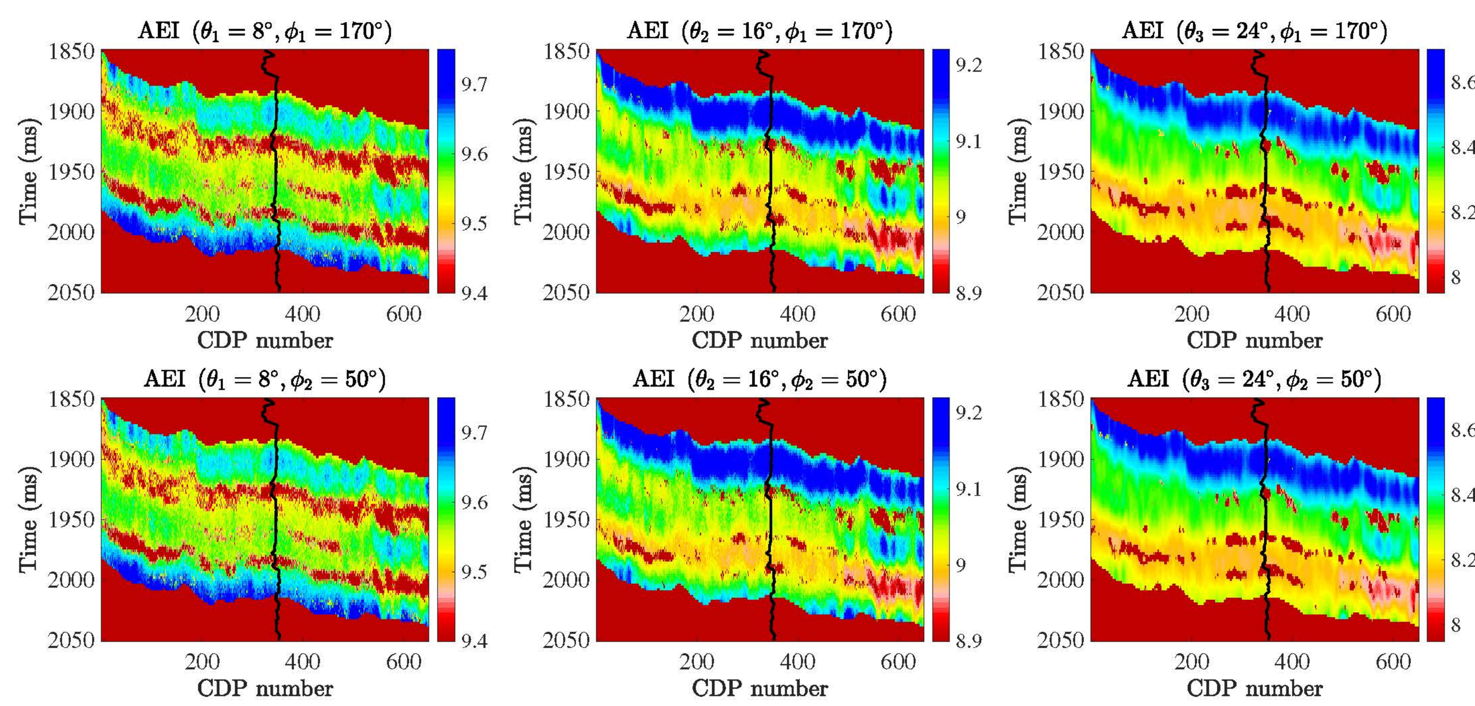

Figure 2: The estimated AEI.

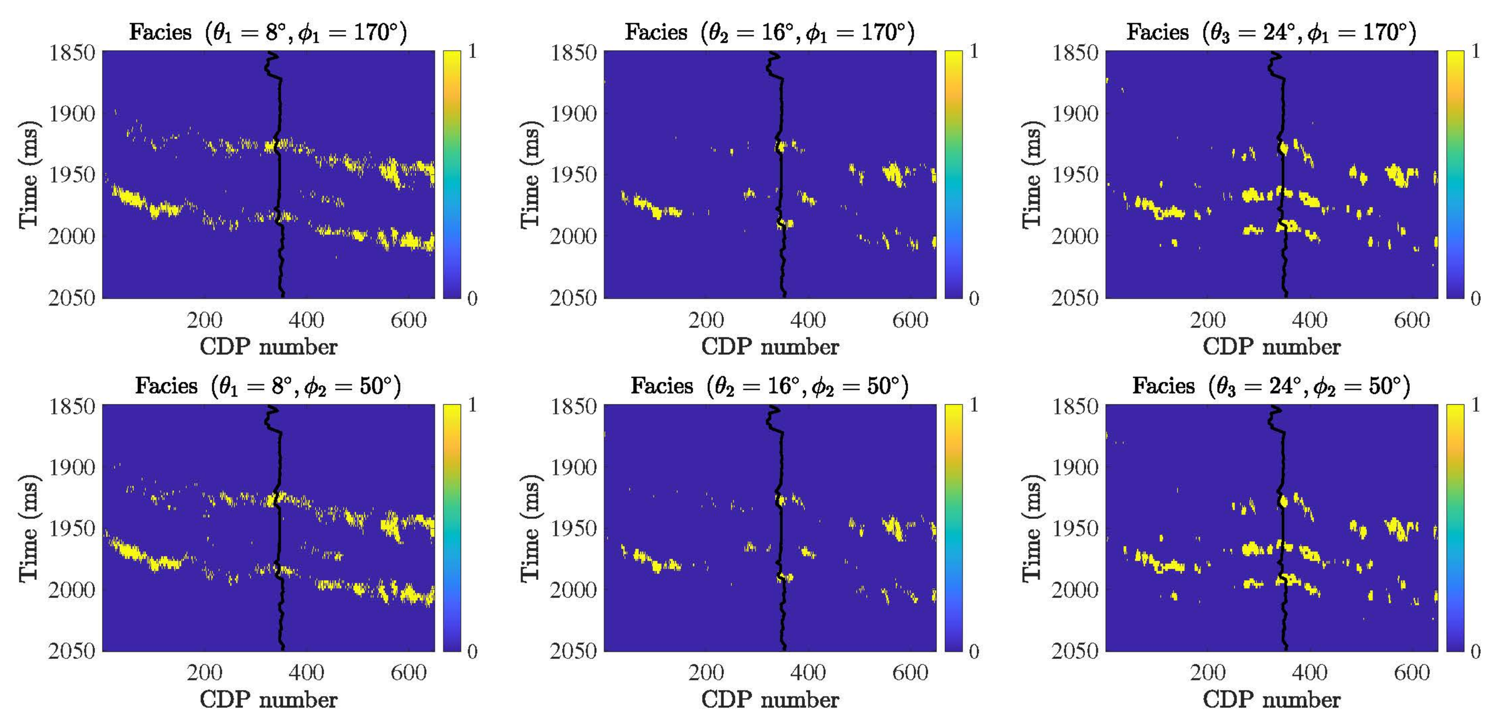

Figure 3: The estimated facies.

Figure 4 shows the final estimated fracture facies, which is employed to build the new model constraints for the sequential inversion.

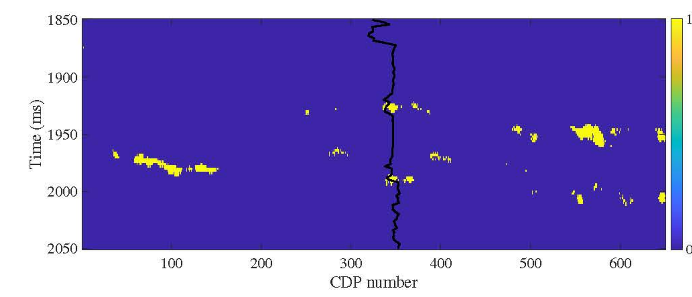

Figure 4: The final result of facies.

Figure 5 shows the inversion results of elastic parameters and fracture weaknesses, which are obtained using new models of P- and S-wave moduli, density and fracture weaknesses.

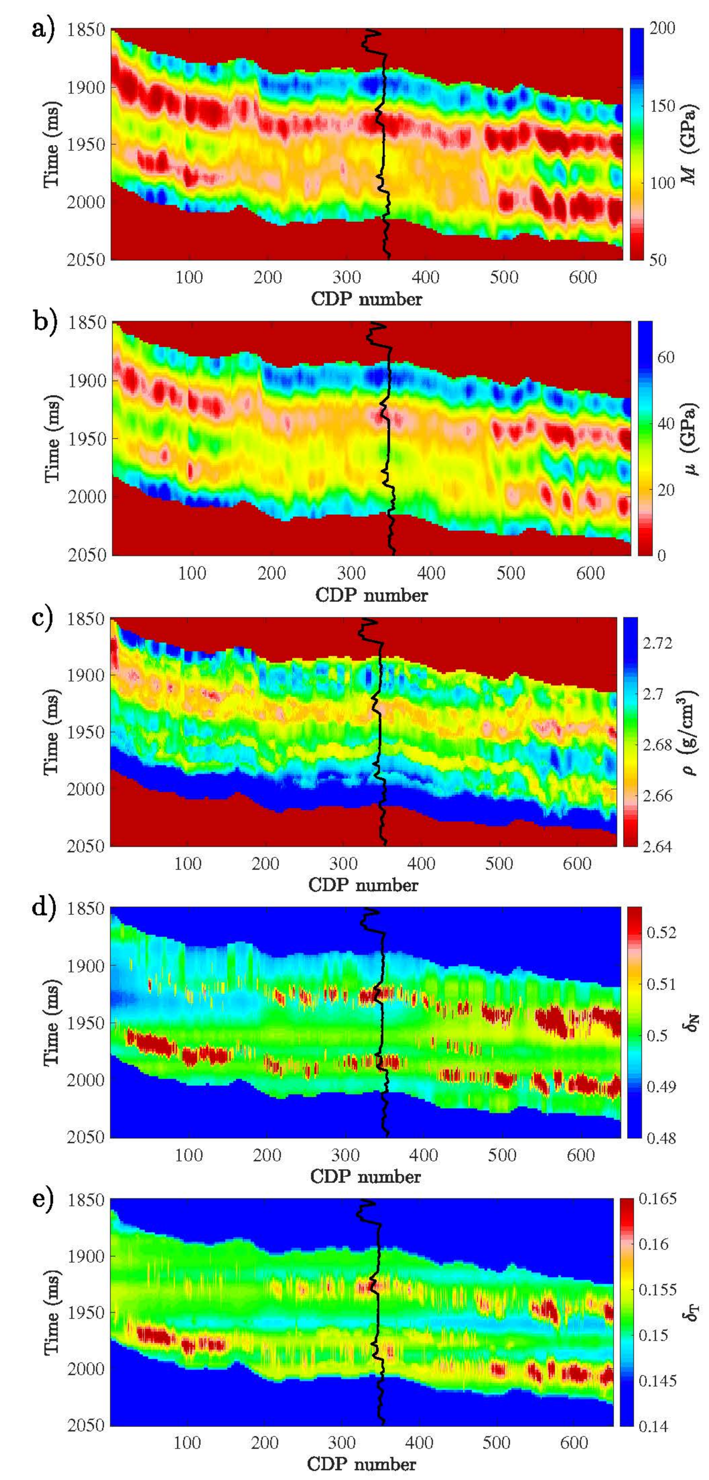

Figure 5: The estimated elastic parameters and fracture facies.

Conclusions

- To improve accuracy of estimating fracture weaknesses of underground layers, we propose a two-stage inversion method.
- Example shows that the proposed two-stage inversion method can be used to generate reliable fracture weaknesses.

References

Grana, D., 2018, Joint facies and reservoir properties inversion: Geophysics, **83**, No. 3, M15–M24.