

Estimation of Fracture Parameters Using Elastic Full-Waveform Inversion

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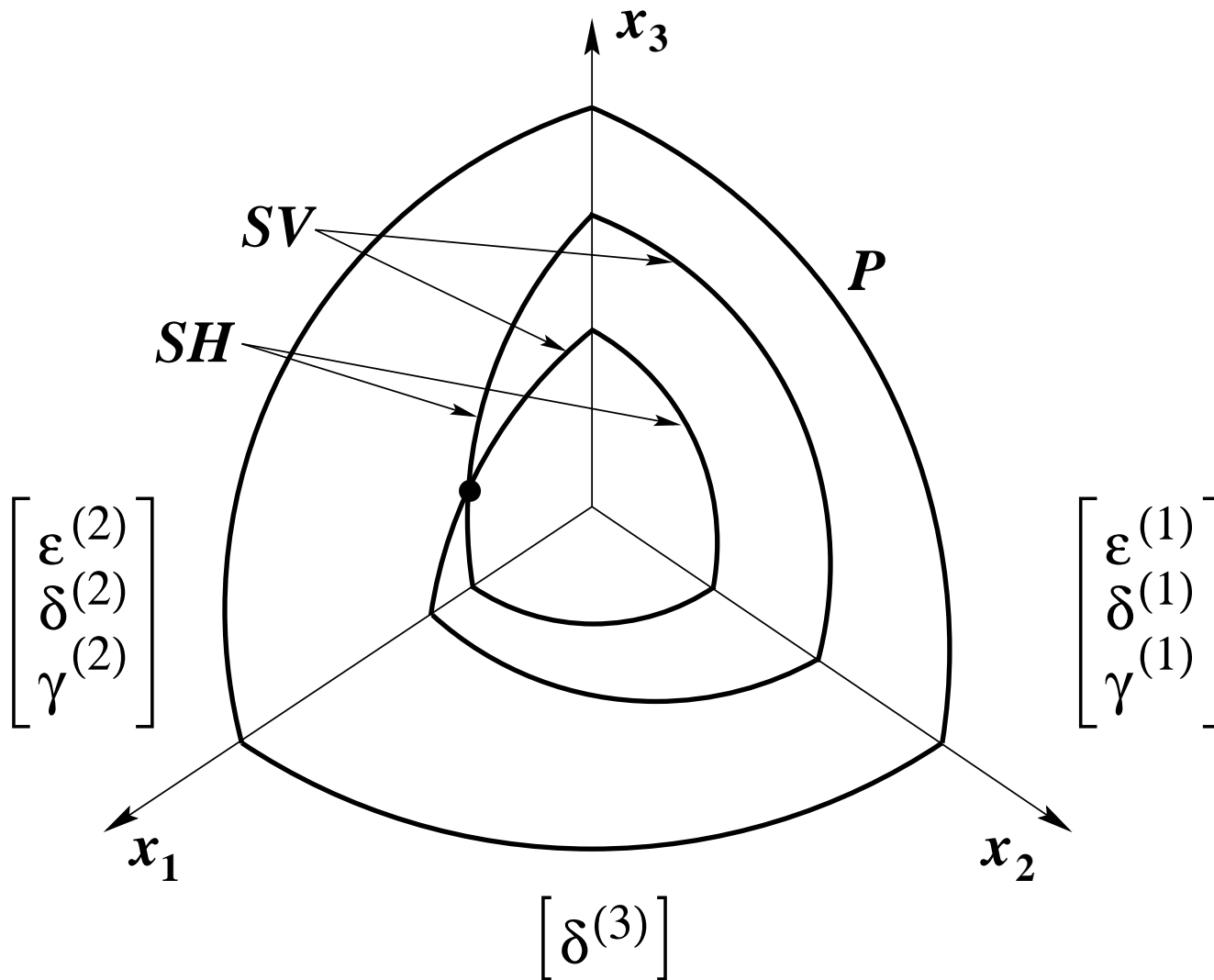


Orthorhombic symmetry: Physical reasons

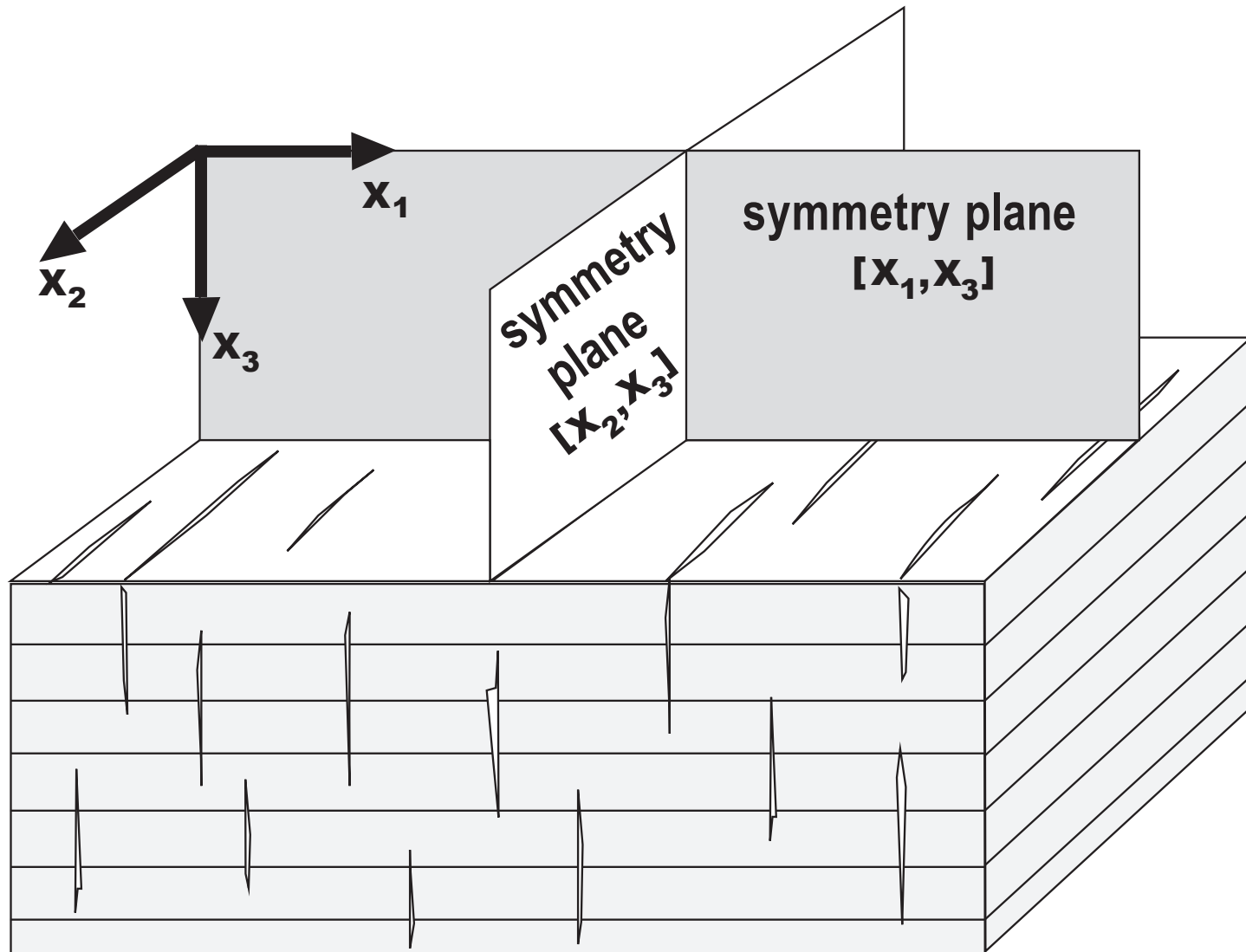
- vertical transverse isotropy
+ vertical penny-shaped cracks
- two orthogonal or identical fracture sets
- nonhydrostatic (triaxial) stress
- multiple fracture sets \approx ORTH

Parameters of ORTH media:

$$V_{P0}, V_{S0}, \epsilon^{(1,2)}, \delta^{(1,2,3)}, \gamma^{(1,2)}$$



Vertical fractures in VTI background



Model parameters

VTI background:

- V_{P0} , V_{S0} , ϵ , δ , γ

Fracture parameters:

- Δ_N – normal weakness
- $\Delta_T \approx 2e$ – tangential weakness
- ϕ – azimuth (strike)

e – crack density

Incorporating fractures: Effective medium theories

Hudson

- add crack contribution to stiffness

$$c_e = c_b + A e$$

$$A < 0 \rightarrow$$

$$c_e < 0?$$

- might be unphysical

Schoenberg (linear-slip)

- add crack contribution to compliance

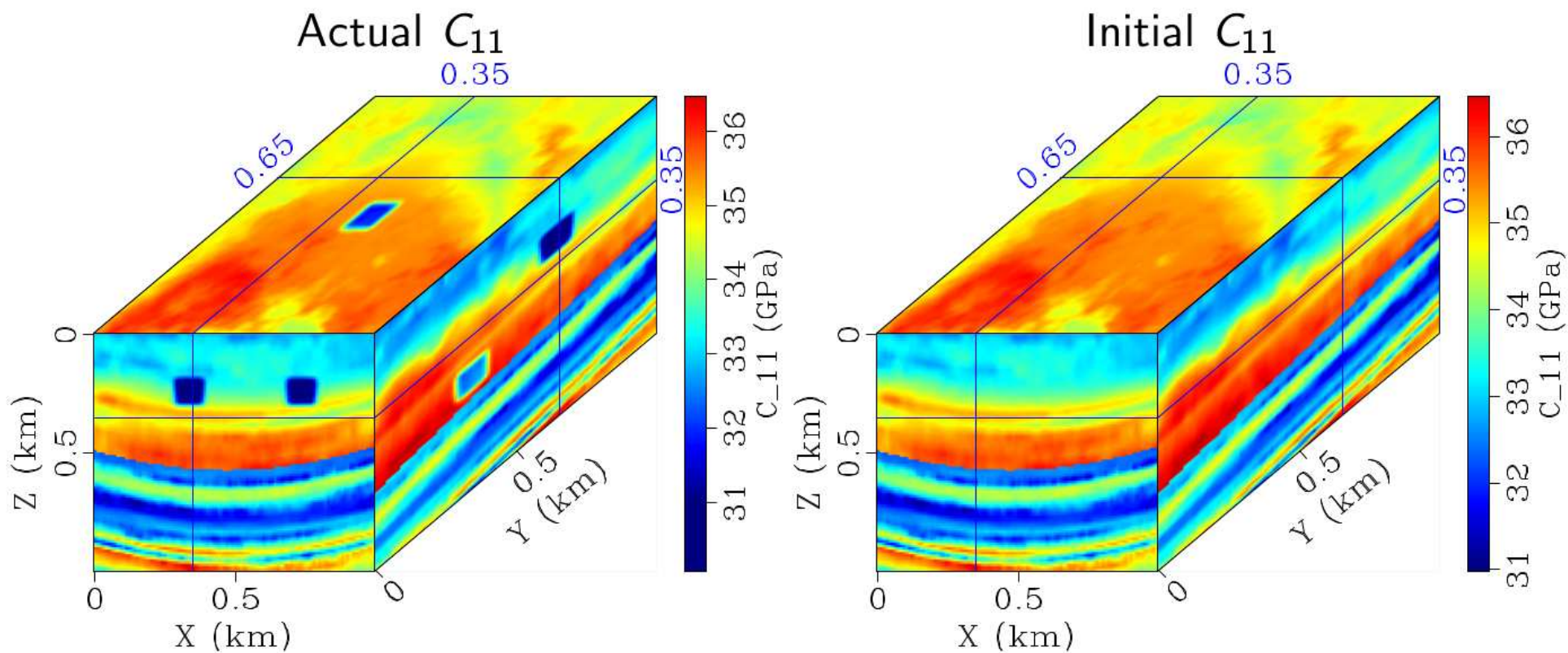
$$s_e = s_b + B e$$

$$B > 0 \rightarrow$$

$$c_e = s_e^{-1} > 0$$

- always plausible

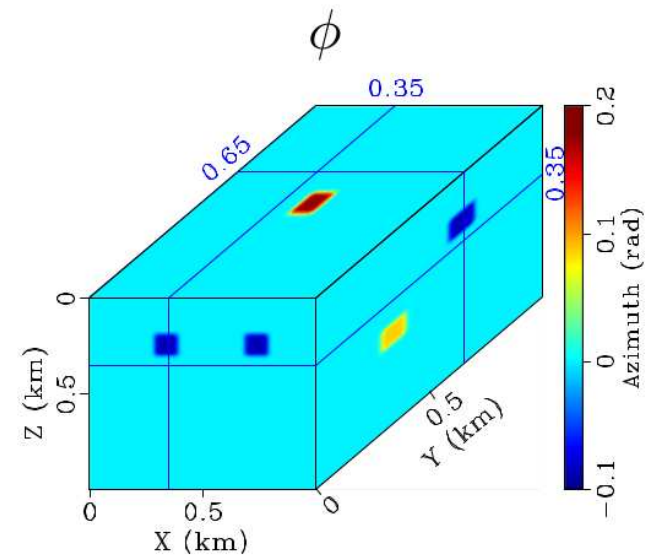
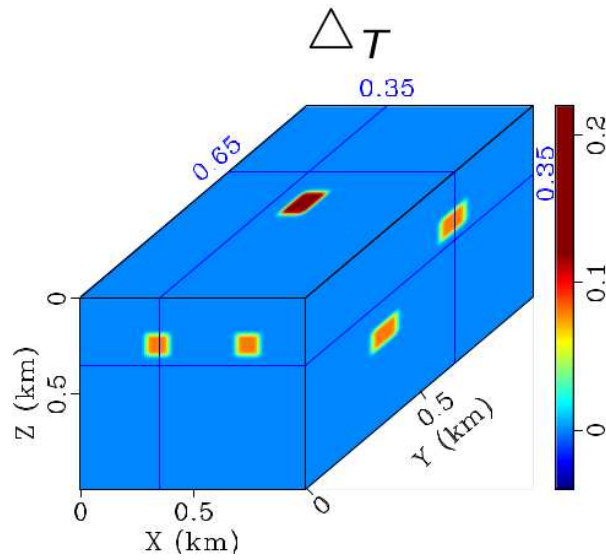
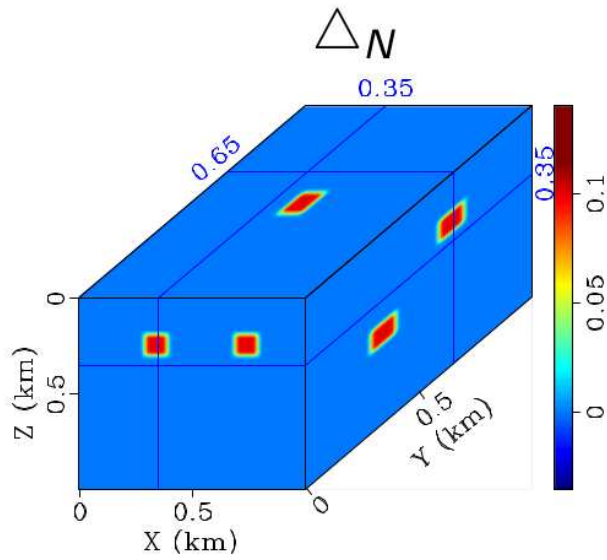
ORTH model: VTI + fracture clusters



Synthetic test: Five fracture clusters

- part of 3D SEAM VTI model as background
- orthorhombic elastic FWI
- wide-azimuth 3C surface data
- frequencies: 3 Hz, 5 Hz, 7.5 Hz
- inversion for Δ_N , Δ_T , and ϕ

Fracture parameters



Inversion results

