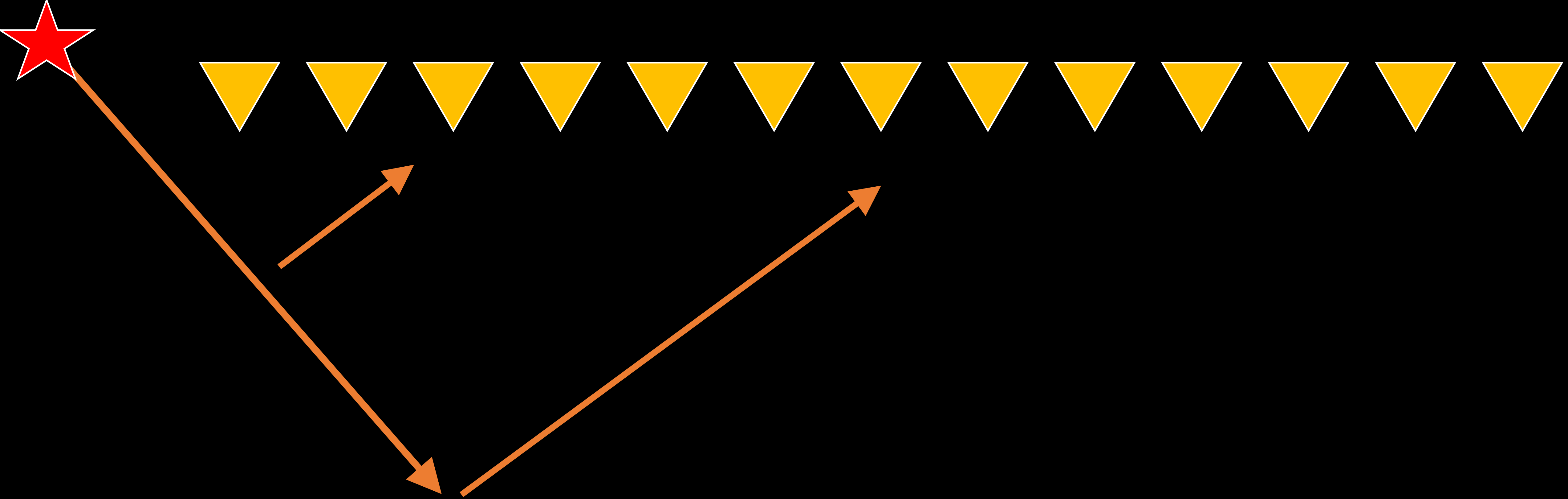
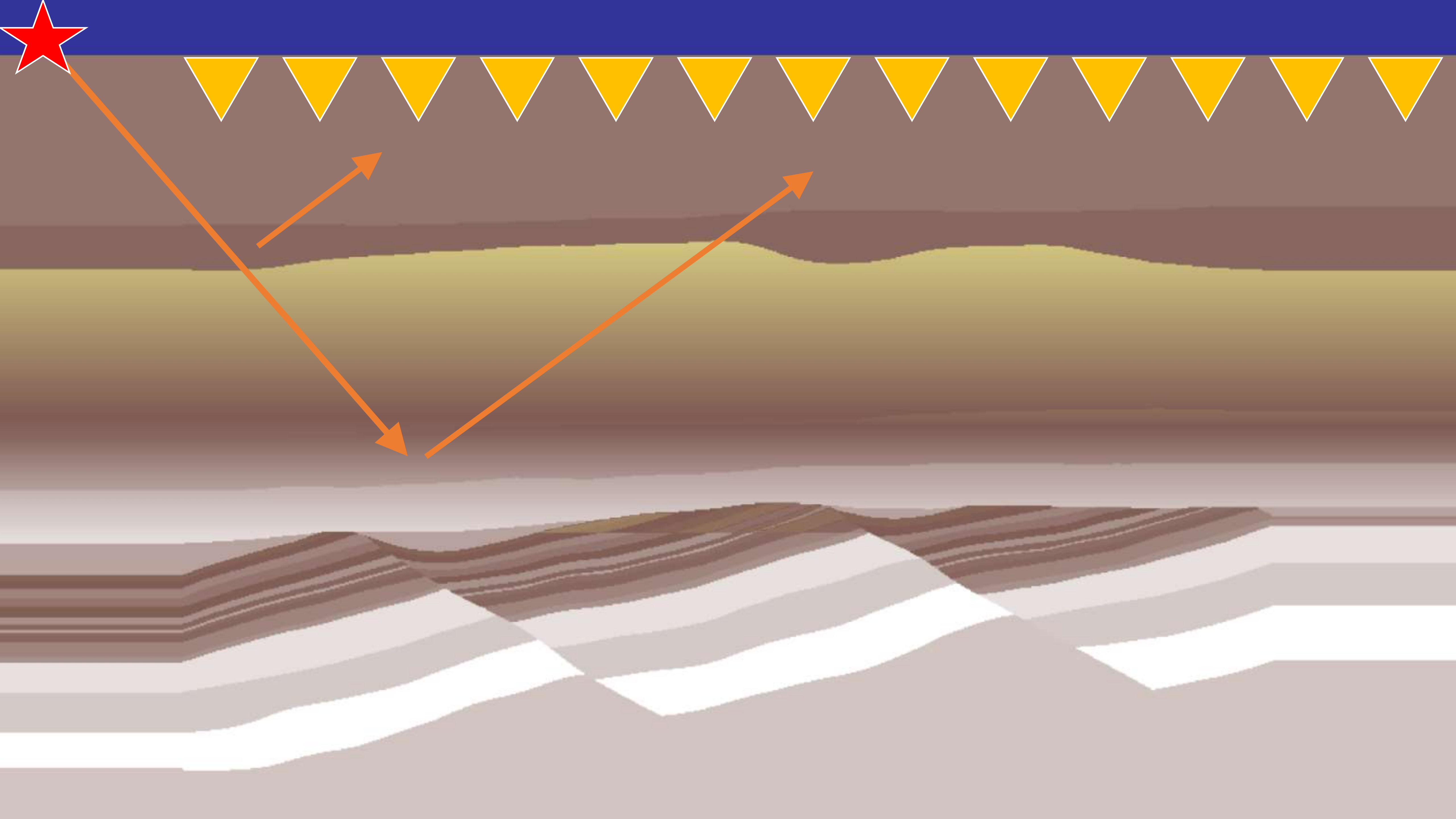
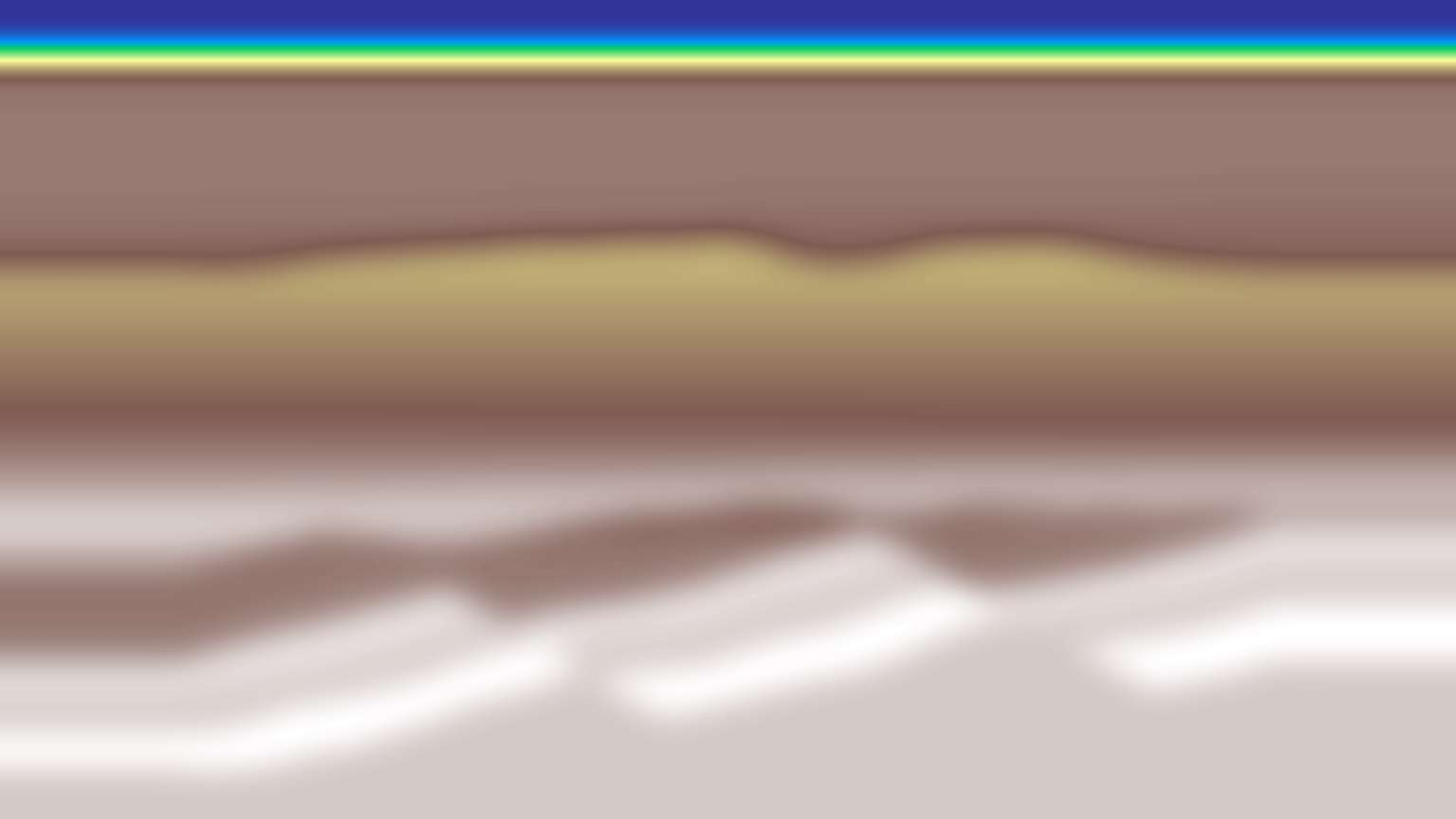
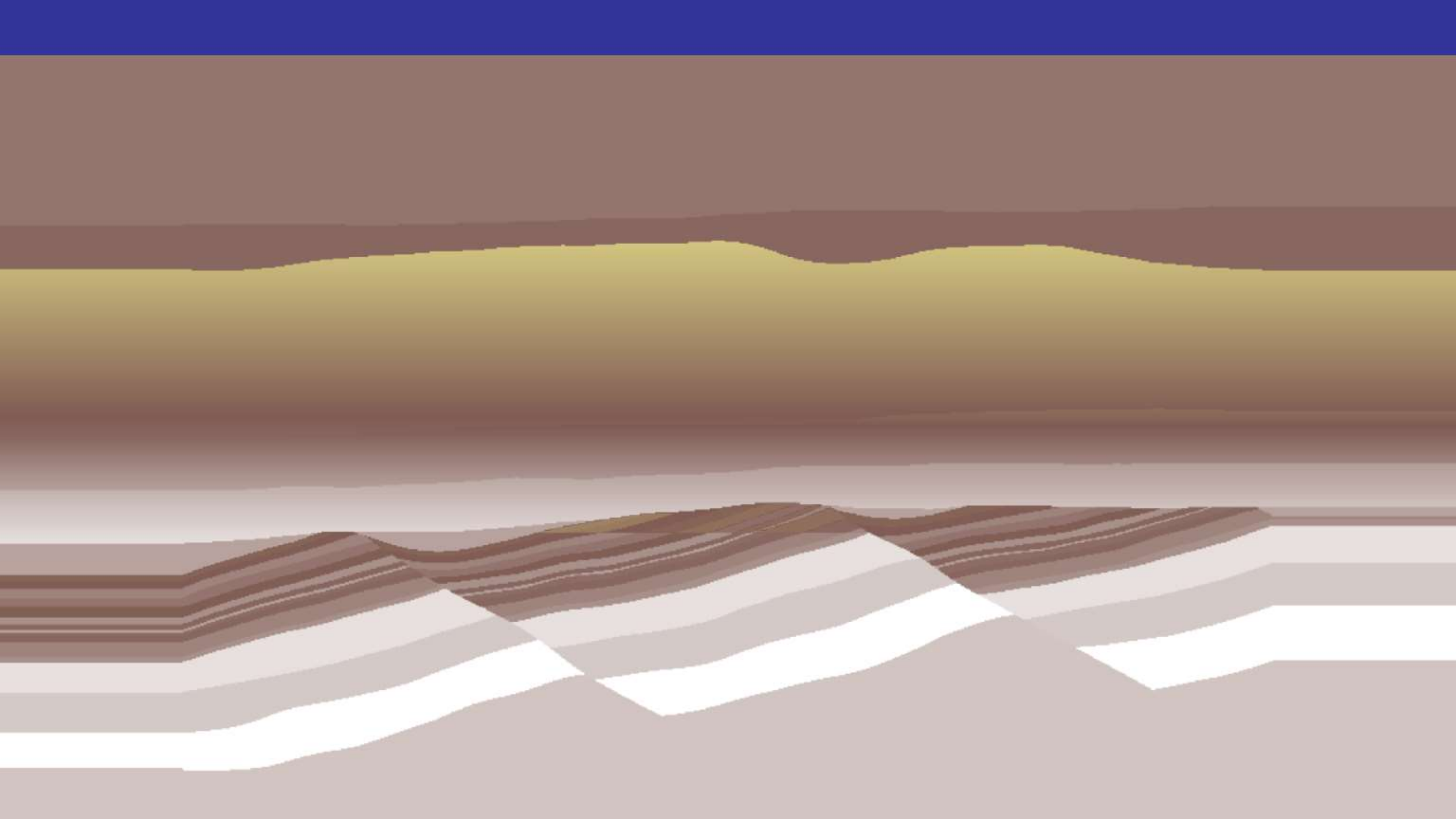
Seismisk inversjon

tilnærminger og usikkerhet









Utfordringer

- Gjenskape et så naturtro ekko som mulig
- Hvor mange detaljer skal man ta med?
- Hvor er det lurt å lytte etter ekkoet?
- Hva skjer hvis vi ikke tar med nok informasjon?

$$\mathbf{L}(\mathbf{u},\mathbf{m}) = \rho(\mathbf{x})\ddot{\mathbf{u}}(\mathbf{x},t) - \nabla\boldsymbol{\sigma}(\mathbf{x},t) = \mathbf{f}(\mathbf{x},t),$$

$$\Psi = \Psi(\mathbf{u}(\mathbf{m},\mathbf{x}_r),\mathbf{d}_0)$$

$$C_{ijkl} = \lambda\delta_{ij}\delta_{kl} + \mu(\delta_{ik}\delta_{jl} + \delta_{il}\delta_{jk}),$$

$$\mathbf{J}(\mathbf{m}+\delta\mathbf{m}) \simeq \mathbf{J}(\mathbf{m}) + \nabla_m\mathbf{J}(\mathbf{m})\delta\mathbf{m} = 0.$$

$$\mathbf{J}(\mathbf{m}+\delta\mathbf{m}) = \nabla_m\Psi(\mathbf{m}+\delta\mathbf{m}),$$

$$\sigma_{ij} = C_{ijkl}\partial_k u_l,$$

$$\mathbb{H}(\mathbf{m}) = \nabla_m\mathbf{J}(\mathbf{m}) = \nabla_m\nabla_m\Psi(\mathbf{m}).$$

$$\alpha = \left\{\alpha \middle| \min\Psi(\mathbf{u}(\mathbf{m}+\alpha\delta\mathbf{m},\mathbf{x}_r),\mathbf{d}_0)\right\}.$$

$$\boldsymbol{\sigma}\mathbf{n}|_{x\in\partial G} = 0, \quad \mathbf{u}|_{t\le 0} = \dot{\mathbf{u}}|_{t\le 0} = 0.$$

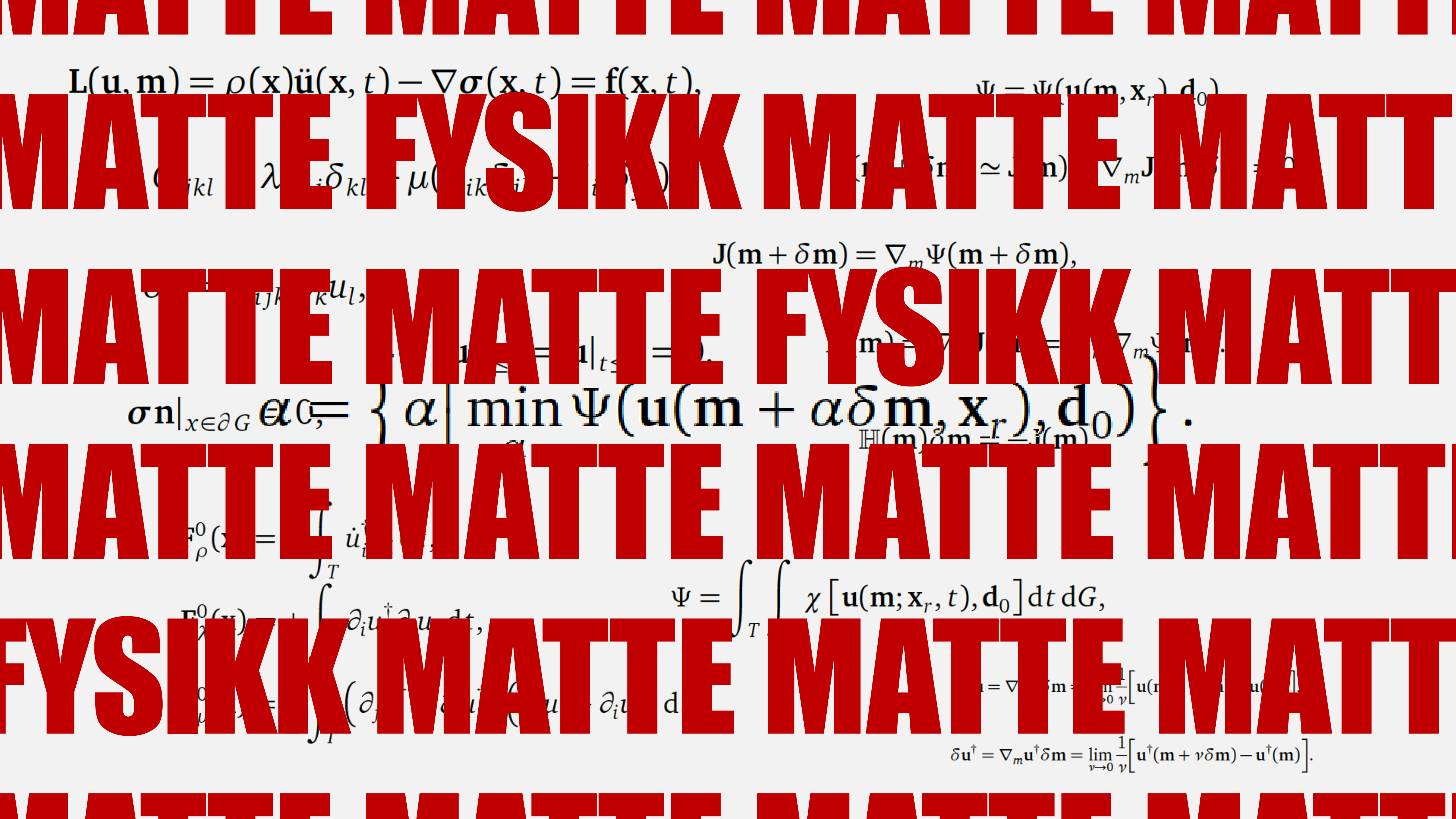
$$\mathbb{H}(\mathbf{m})\delta\mathbf{m} = -\mathbf{J}(\mathbf{m})$$

$$\begin{aligned}
\mathbf{F}^0_\rho(\mathbf{x}) &= -\int_T \dot{u}_i^\dagger \dot{u}_i \,\mathrm{d}t,\\
\mathbf{F}^0_\lambda(\mathbf{x}) &= +\int_T \partial_i u_i^\dagger \partial_j u_j \,\mathrm{d}t,\\
\mathbf{F}^0_\mu(\mathbf{x}) &= \frac{1}{2}\int_T \left(\partial_j u_i^\dagger + \partial_i u_j^\dagger\right)\left(\partial_j u_i + \partial_i u_j\right)\mathrm{d}t,
\end{aligned}$$

$$\Psi = \int_T\int_G \chi\left[\mathbf{u}(\mathbf{m};\mathbf{x}_r,t),\mathbf{d}_0\right]\mathrm{d}t\,\mathrm{d}G,$$

$$\delta\mathbf{u} = \nabla_m\mathbf{u}\delta\mathbf{m} = \lim_{\nu\to 0}\frac{1}{\nu}\Big[\mathbf{u}(\mathbf{m}+\nu\delta\mathbf{m}) - \mathbf{u}(\mathbf{m})\Big],$$

$$\delta\mathbf{u}^\dagger = \nabla_m\mathbf{u}^\dagger\delta\mathbf{m} = \lim_{\nu\to 0}\frac{1}{\nu}\Big[\mathbf{u}^\dagger(\mathbf{m}+\nu\delta\mathbf{m}) - \mathbf{u}^\dagger(\mathbf{m})\Big].$$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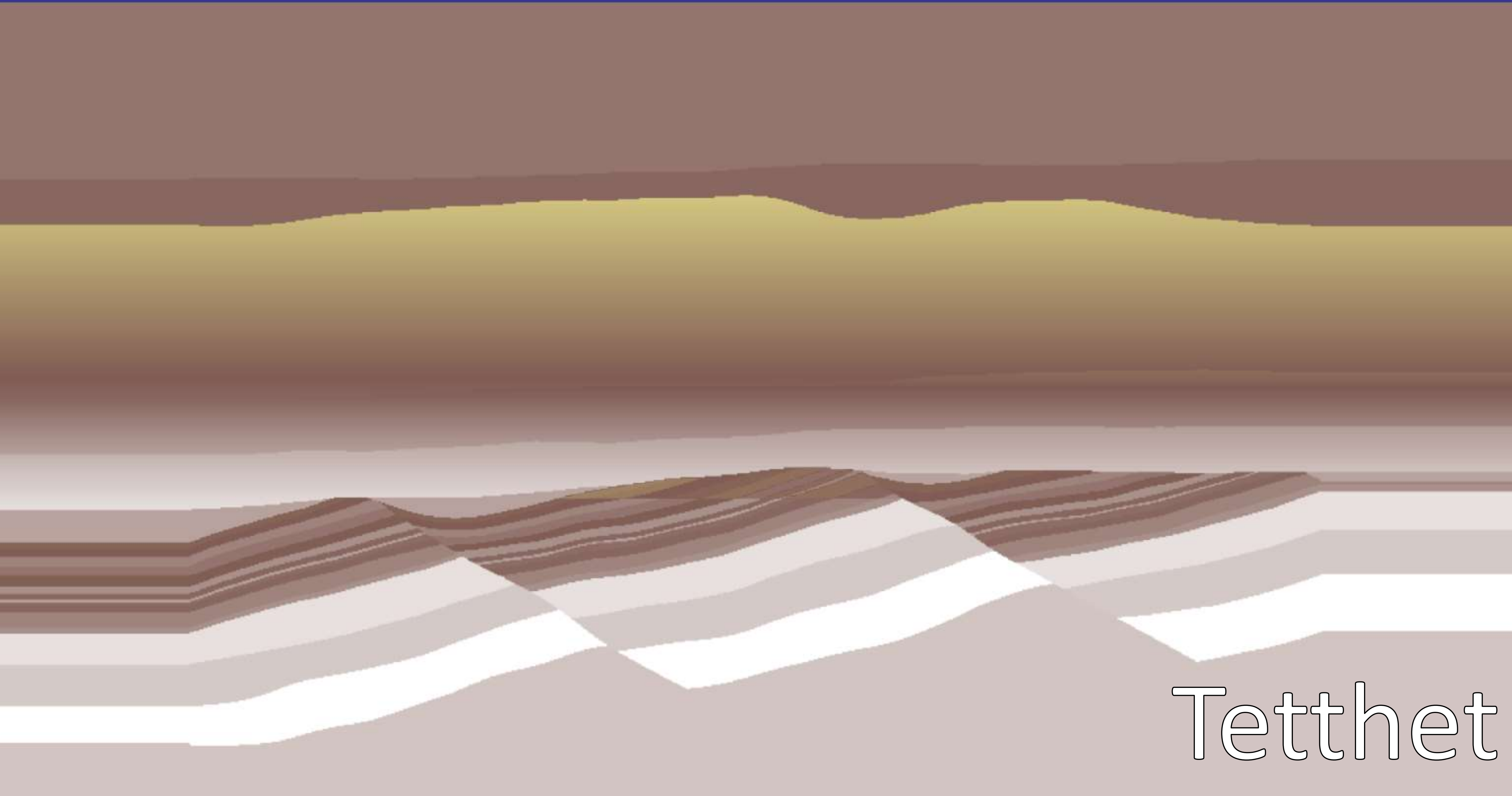
L(u, m) = ρ(x)ü(x, t) − ∇σ(x, t) = f(x, t),
J(m + δm) = ∇mΨ(m + δm),
Ψ = ∫T ∫ χ [u(m; xr, t), d0] dt dG,
δu† = ∇mu†δm = lim ν→0 1/ν [u†(m + νδm) − u†(m)].

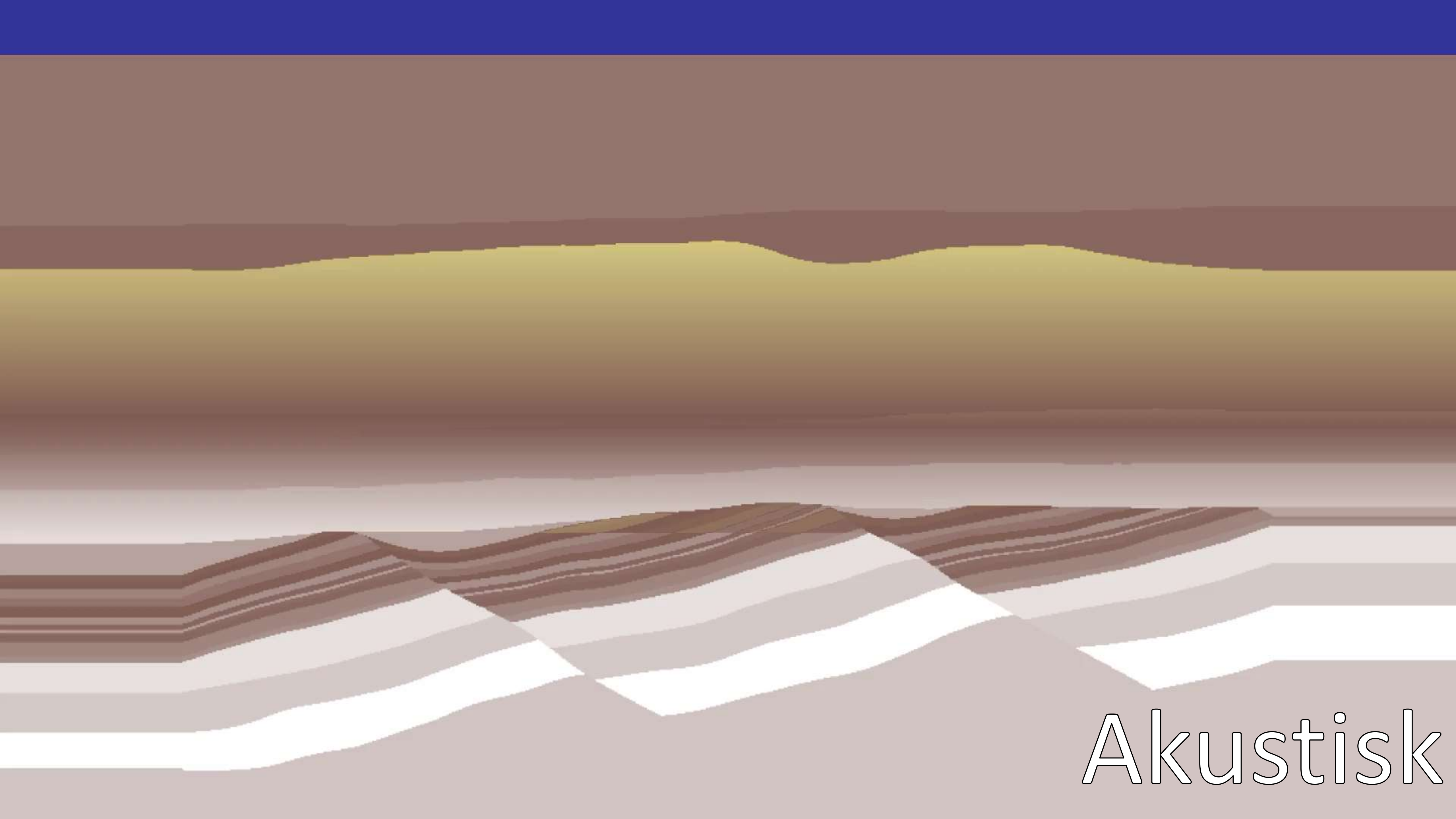
Hvor mye fysikk skal vi inkludere?

- Akustisk (sann for væske og gass)
- Elastisk (sann for isotropt fast stoff)
- Anisotropi (litt mer sann for fast stoff)

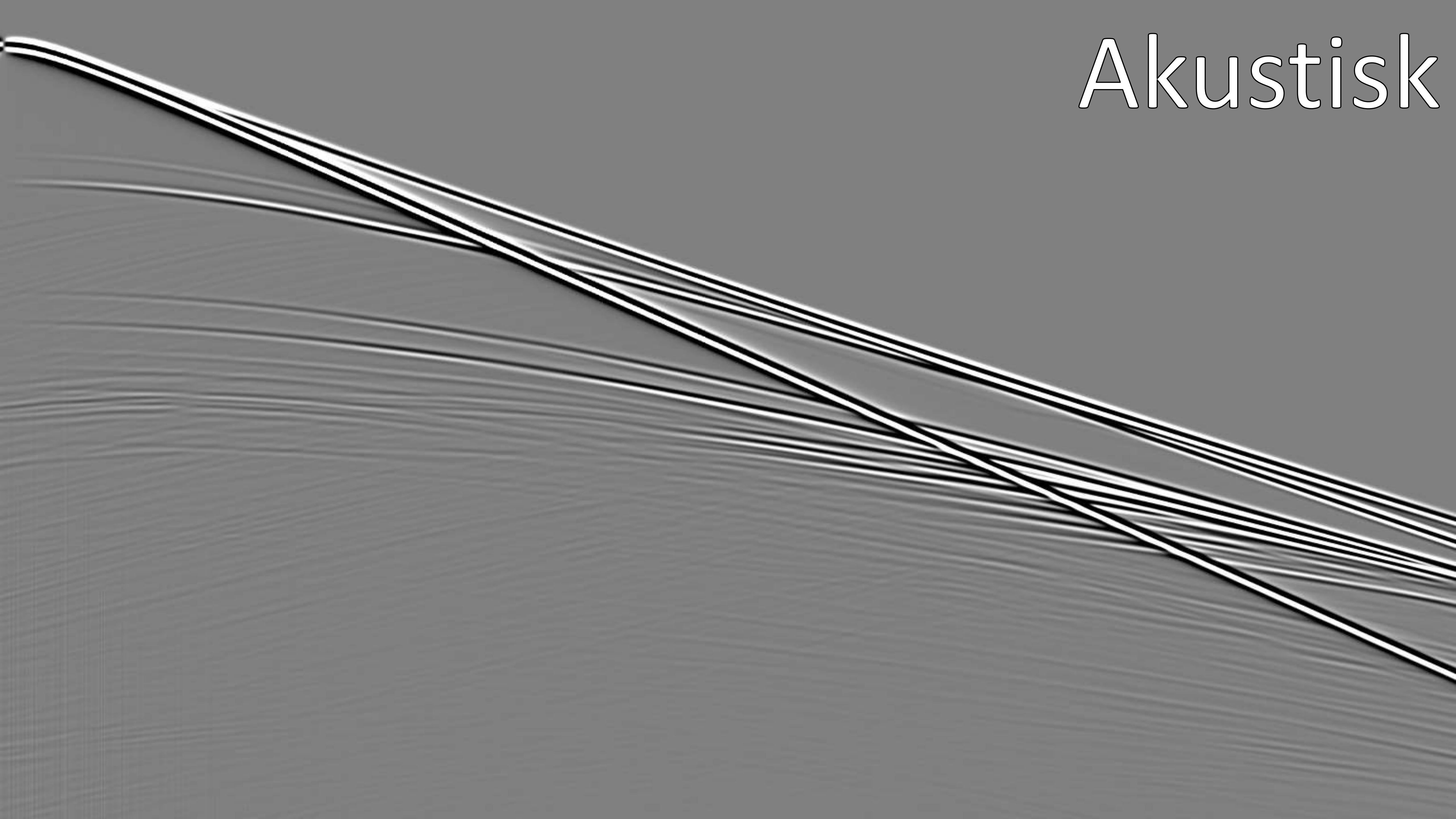
Tetthet



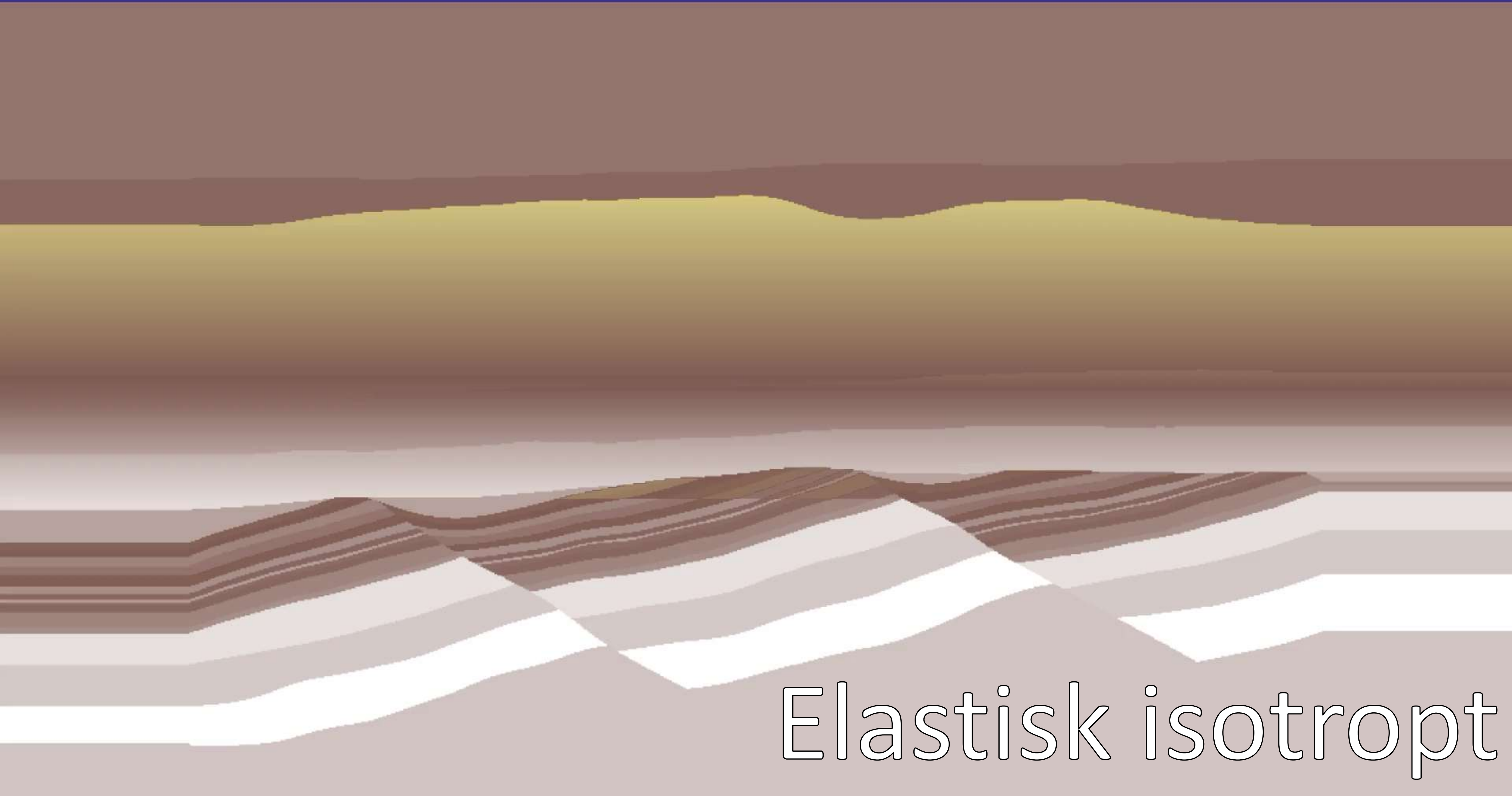

Trykkbølge-hastighet


Akustisk

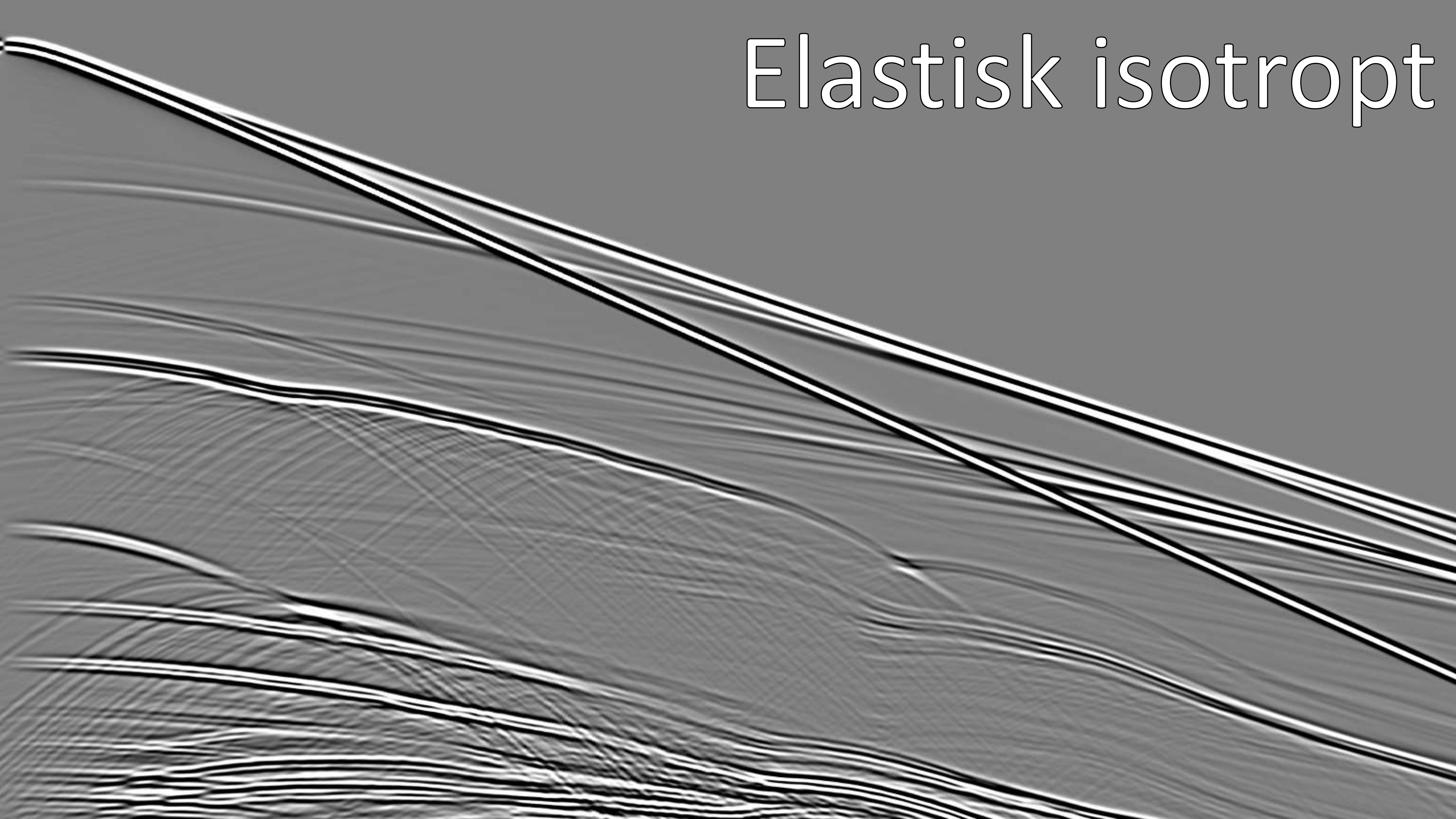
Akustisk



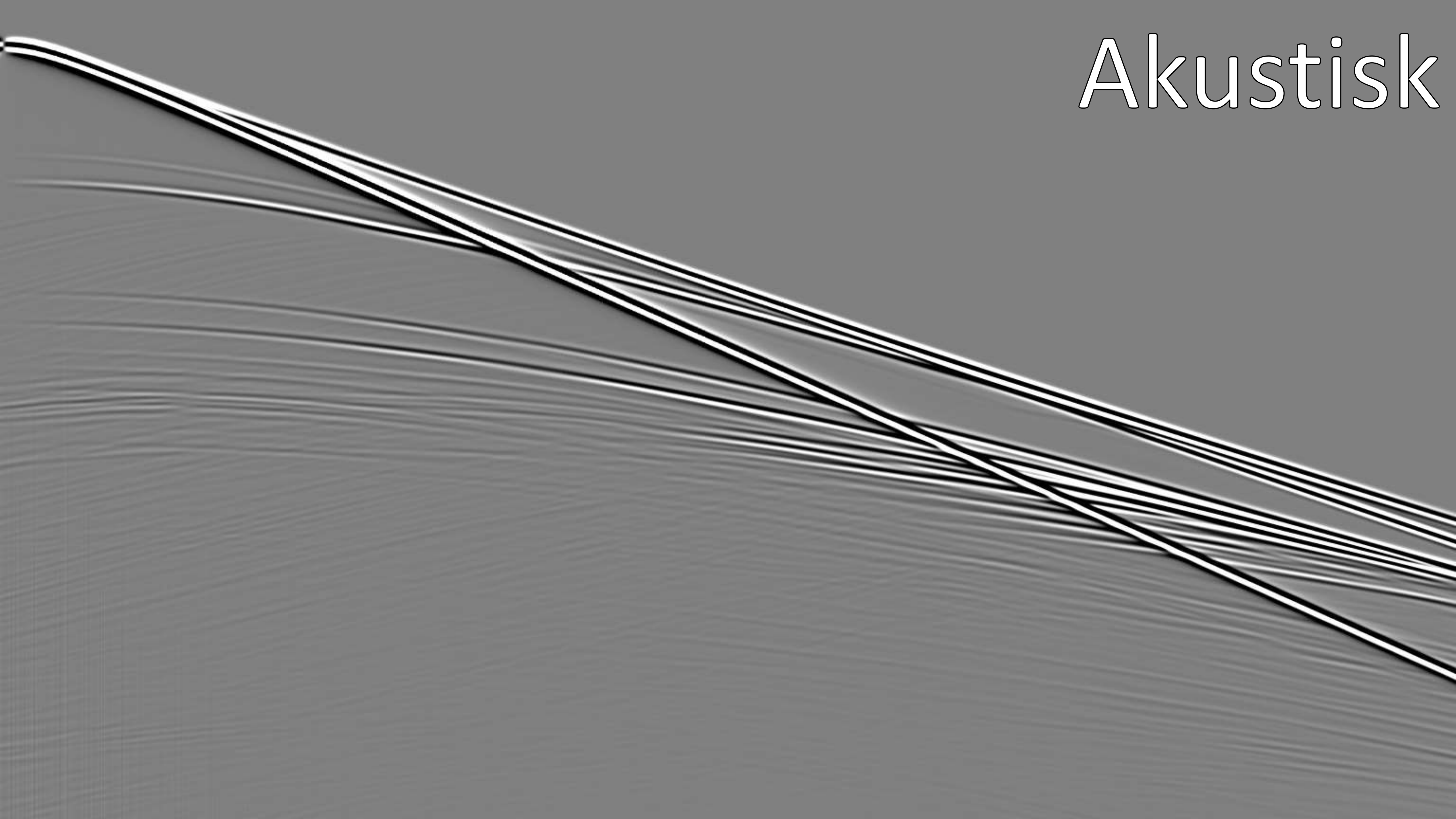
Skjærbølge-hastighet


Elastisk isotropt

Elastisk isotropt

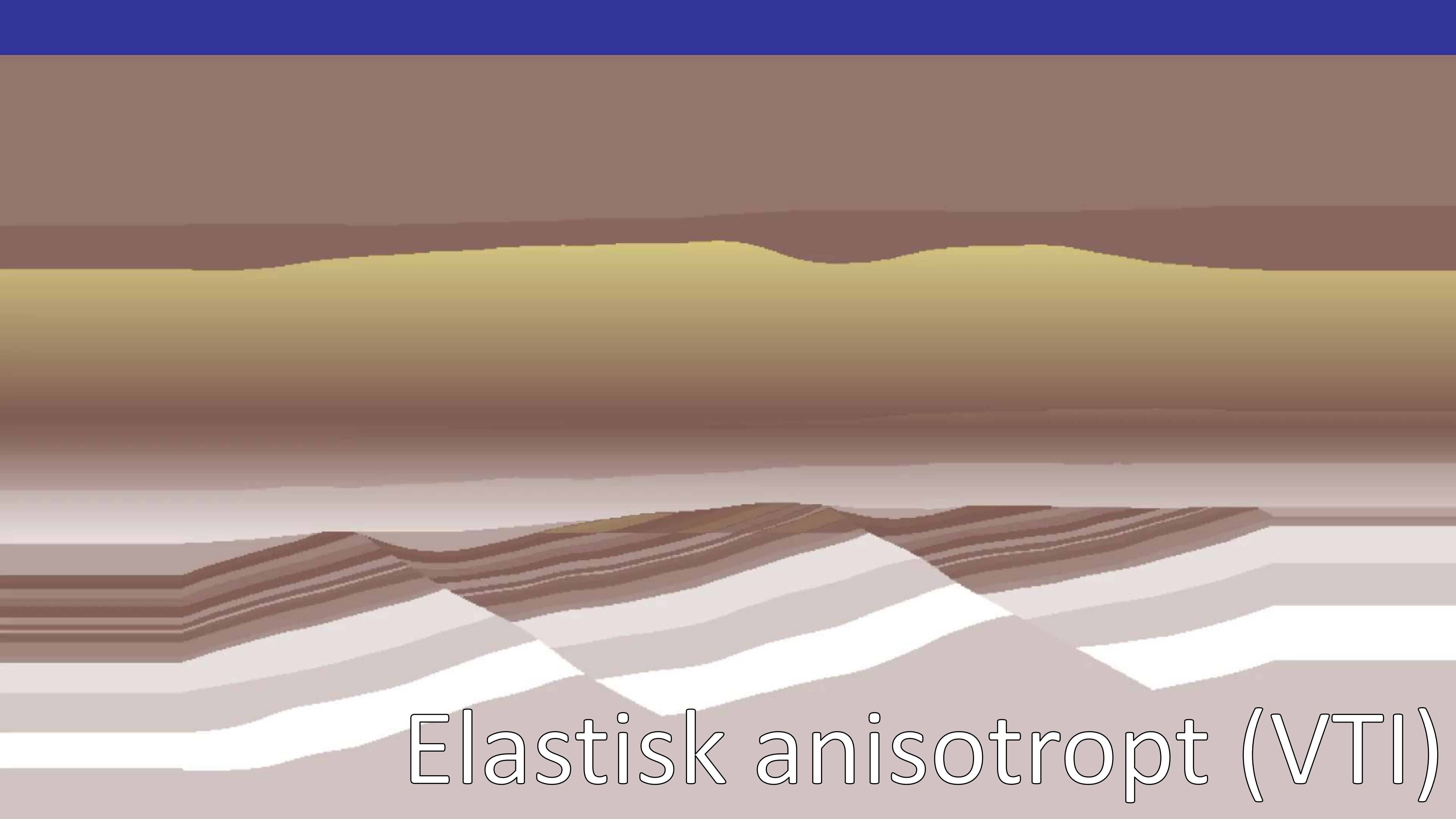


Akustisk



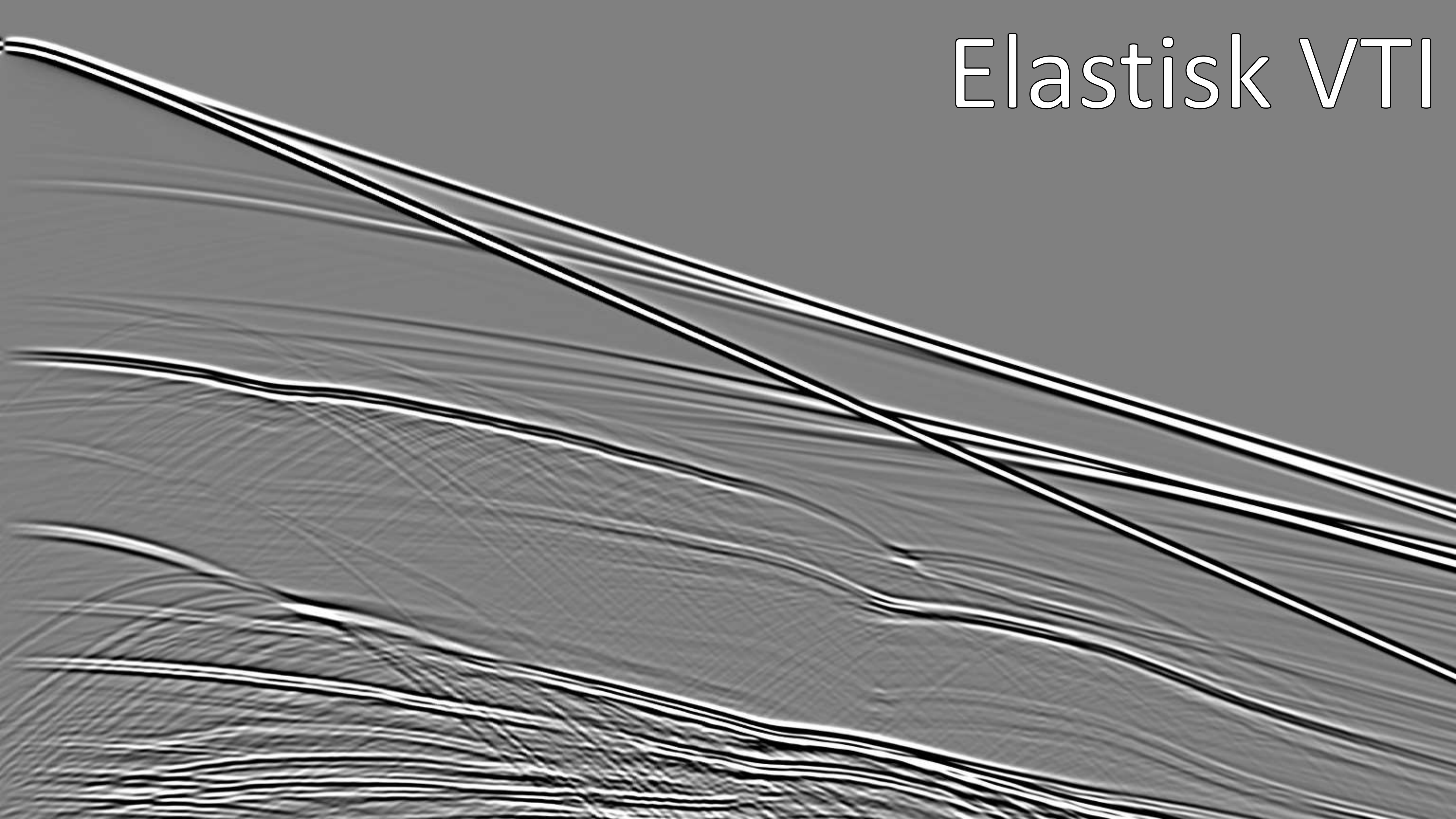
Trykkbølge-anisotropi

Skjærbølge-anisotropi

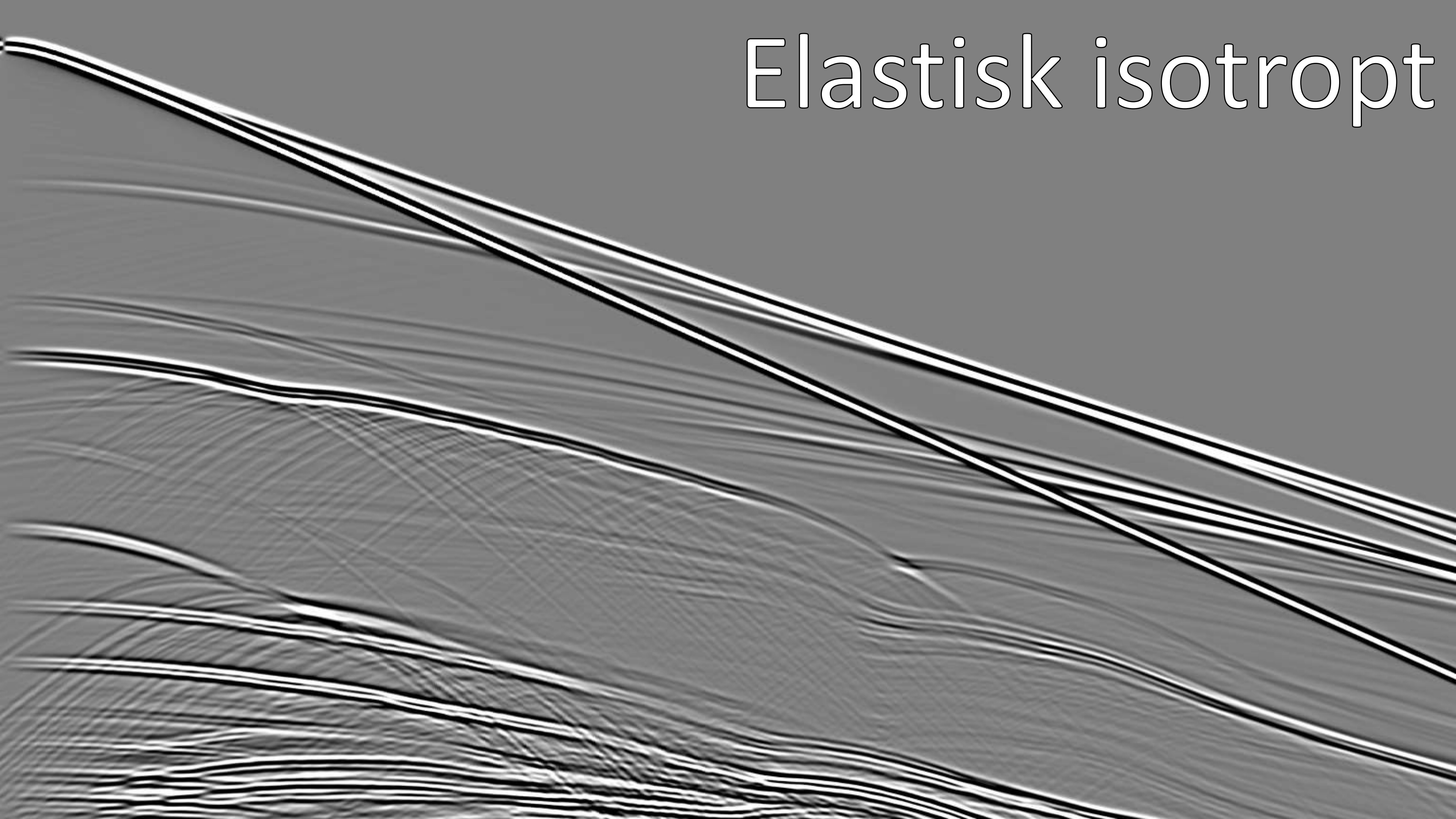


Elastisk anisotropt (VTI)

Elastisk VTI



Elastisk isotropt



Oppsummering

- Det er nødvendig å gjøre tilnærminger
  - For lite og det blir for komplisert
  - For mye og man går glipp av detaljer

- Viktig med tilgang til datakraft

NTNU

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