

Seismisk inversjon tilnærminger og usikkerhet



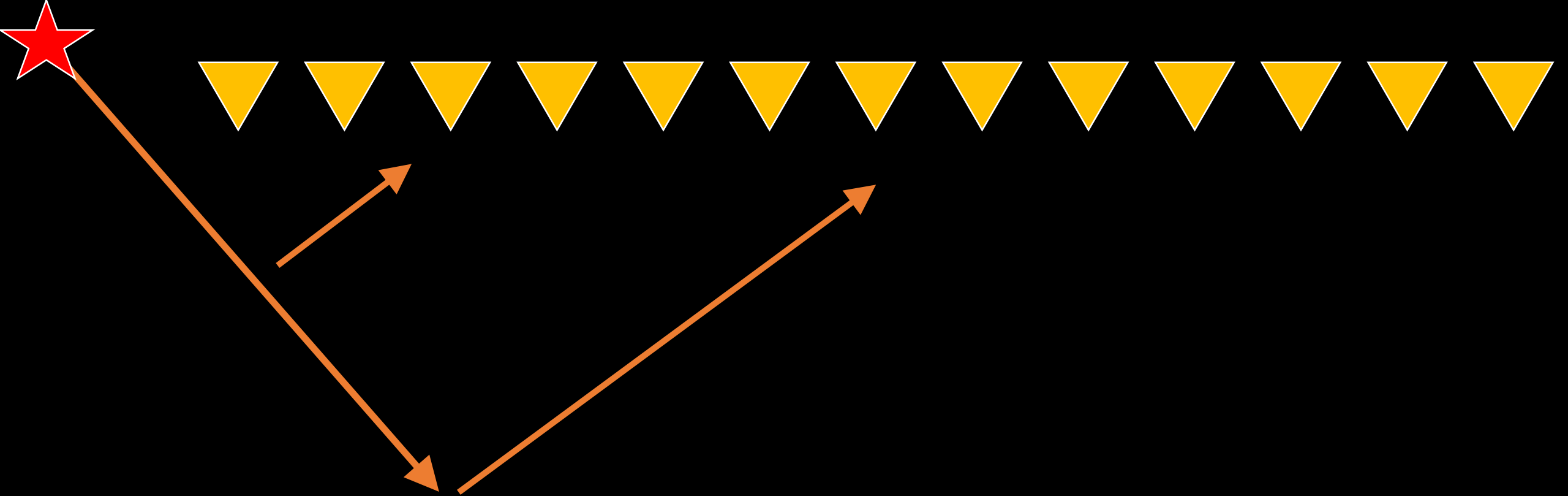
Handwritten notes on the left page of the notebook, including:

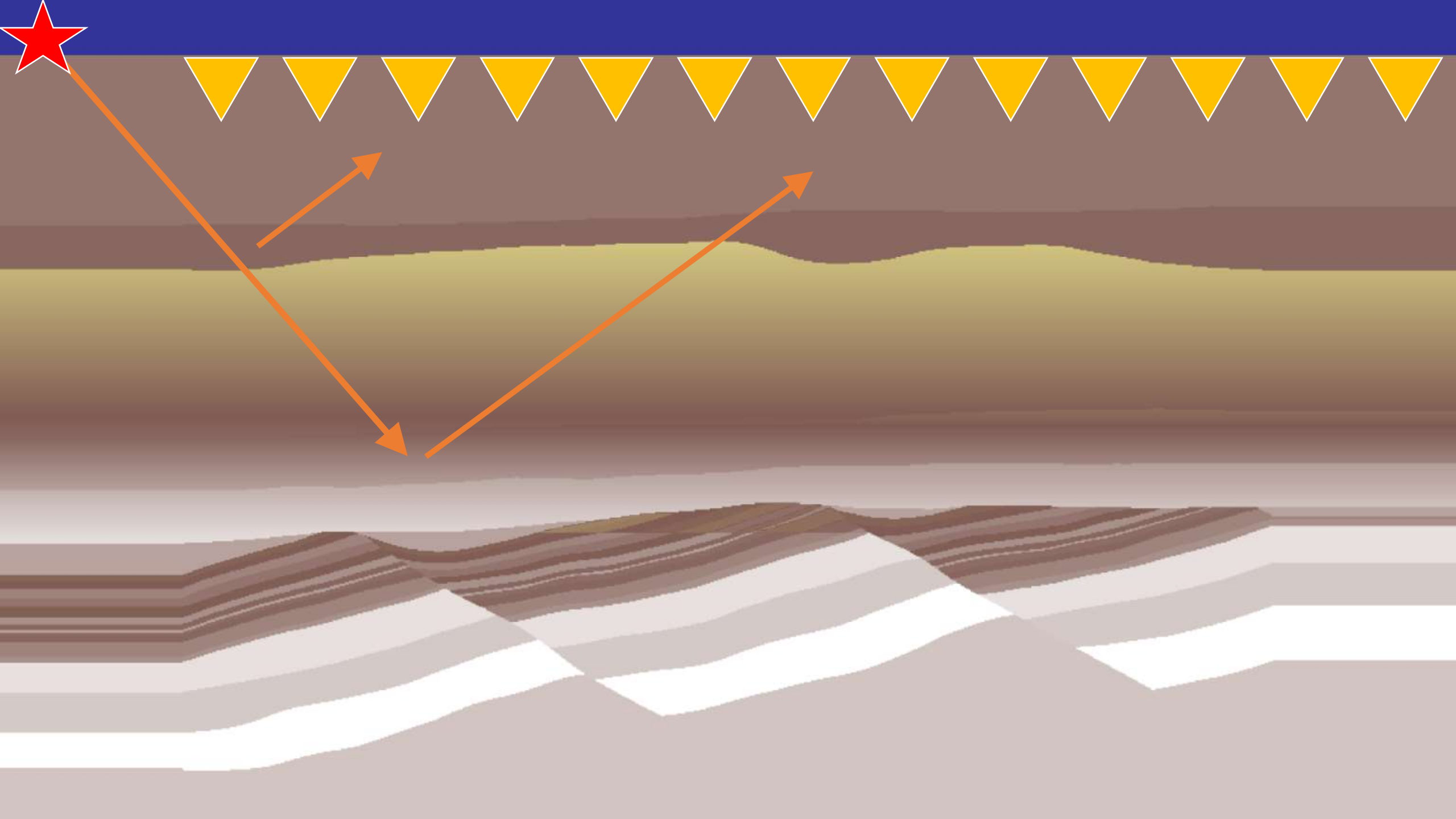
- $r(t) = \frac{1}{2} \cos(\omega t) - \frac{1}{2} \sin(\omega t)$
- Back to A_n
- $C_n = \begin{cases} C_n^{\text{real}}, & \text{even} \\ C_n^{\text{imag}}, & \text{odd} \end{cases}$
- $x = A_n \cos(\omega t + \phi_n) = C_n \cos(\omega t) + D_n \sin(\omega t)$
- $x_n = A_n e^{i\omega t} + i B_n e^{-i\omega t}$ (not sure how)
- And back to reality again:
- $r(t) = \frac{1}{2} \cos(\omega t) - \frac{1}{2} \sin(\omega t)$
- $\cos[2\omega t - \pi] = -\sin(\omega t)$
- $\sin[2\omega t - \pi] = \cos(\omega t)$
- $r(t) = \frac{1}{2} \cos(\omega t) - \frac{1}{2} \cos(\omega t) = 0$

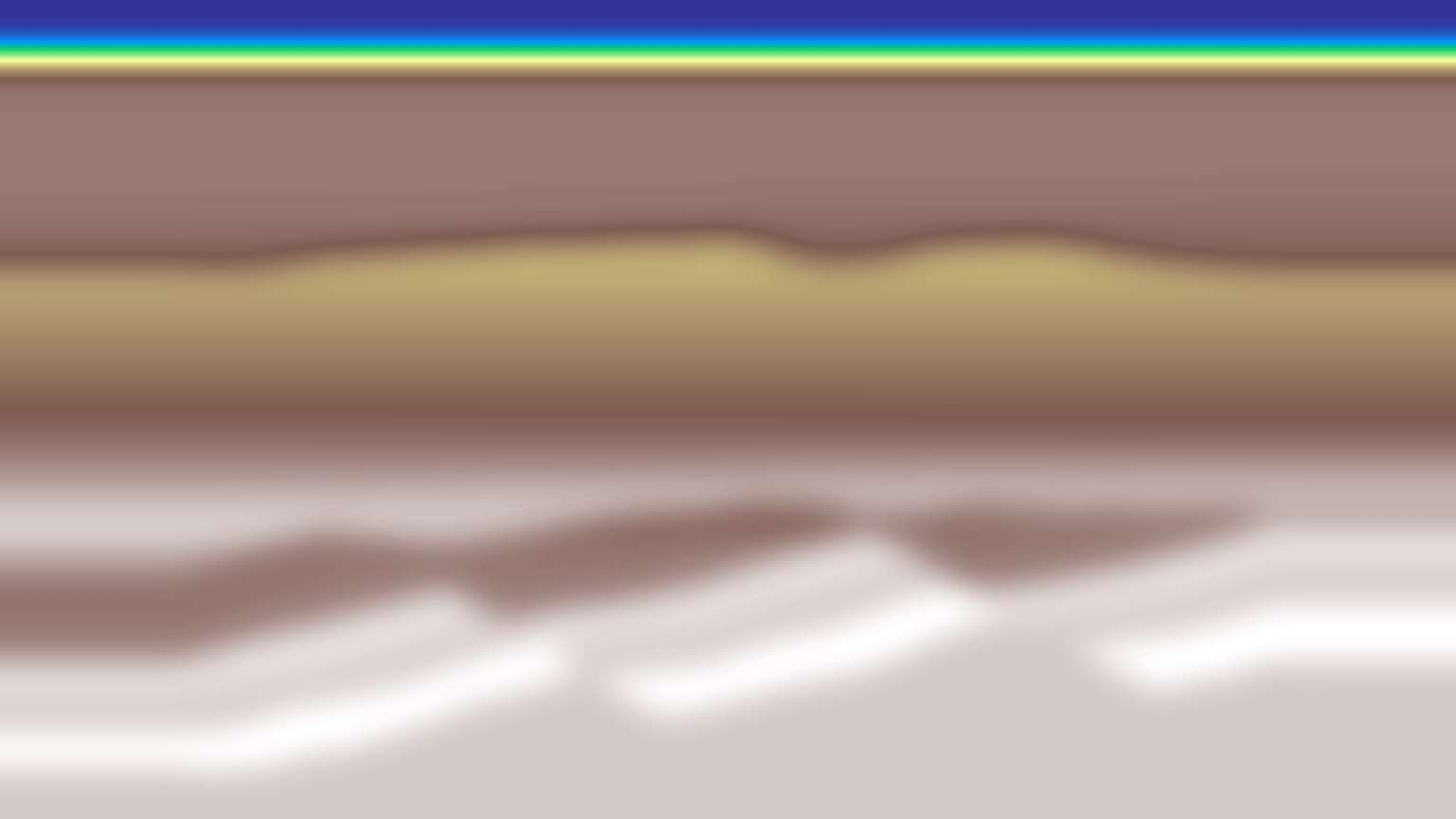
Handwritten notes on the right page of the notebook, including:

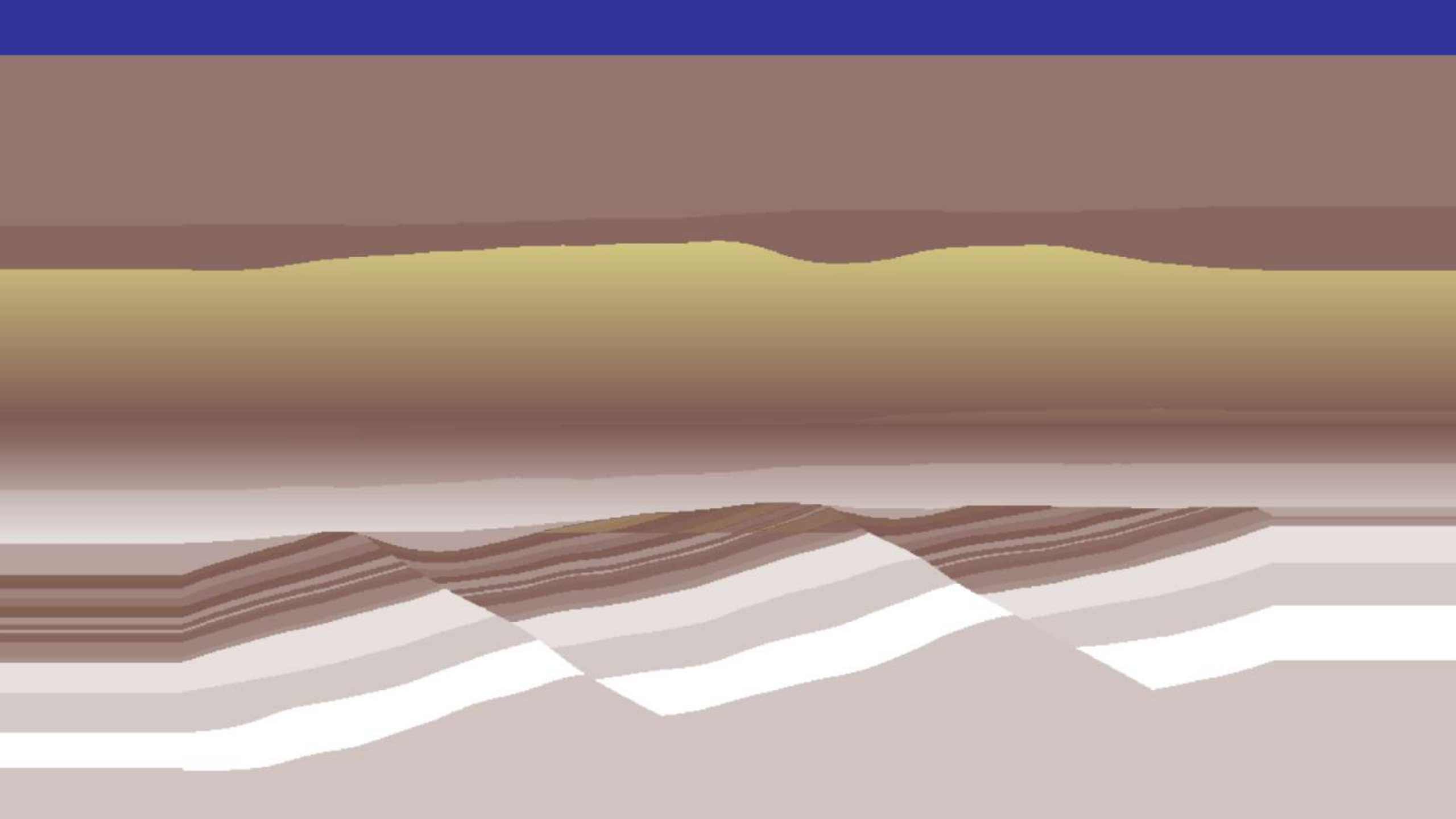
- 7.6: $f(x) = \begin{cases} x & \text{if } 0 \leq x < \pi \\ 0 & \text{if } \pi \leq x < 2\pi \end{cases}$
- $p = 2\pi$
- $a_n = \frac{2}{\pi} \int_0^{\pi} f(x) \cos\left(\frac{n\pi x}{\pi}\right) dx = \frac{2}{\pi} \int_0^{\pi} x \cos(nx) dx$
- $a_n = \frac{2}{\pi} \left[\frac{x \sin(nx)}{n} + \frac{\cos(nx)}{n^2} \right]_0^{\pi} = \frac{2}{\pi} \left[\frac{\pi \sin(n\pi)}{n} + \frac{\cos(n\pi)}{n^2} - \frac{0 \sin(0)}{n} - \frac{\cos(0)}{n^2} \right]$
- $a_n = \frac{2}{\pi} \left[\frac{\cos(n\pi)}{n^2} - \frac{1}{n^2} \right] = \frac{2}{\pi} \frac{(-1)^n - 1}{n^2}$
- $a_n = \frac{2}{\pi} \frac{(-1)^n - 1}{n^2}$











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?

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

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

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

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

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

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

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

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

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

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

$$\mathbf{F}_\rho^0(\mathbf{x}) = - \int_T \dot{u}_i^\dagger \dot{u}_i dt,$$

$$\mathbf{F}_\lambda^0(\mathbf{x}) = + \int_T \partial_i u_i^\dagger \partial_j u_j dt,$$

$$\mathbf{F}_\mu^0(\mathbf{x}) = \frac{1}{2} \int_T (\partial_j u_i^\dagger + \partial_i u_j^\dagger) (\partial_j u_i + \partial_i u_j) dt,$$

$$\Psi = \int_T \int_G \chi [\mathbf{u}(\mathbf{m}; \mathbf{x}_r, t), \mathbf{d}_0] dt dG,$$

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

$$\delta \mathbf{u}^\dagger = \nabla_m \mathbf{u}^\dagger \delta \mathbf{m} = \lim_{\nu \rightarrow 0} \frac{1}{\nu} [\mathbf{u}^\dagger(\mathbf{m} + \nu \delta \mathbf{m}) - \mathbf{u}^\dagger(\mathbf{m})].$$

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

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

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

$$(\mathbf{r} + \delta \mathbf{r}) \approx \mathbf{J}(\mathbf{m}) \mathbf{m} \quad \nabla_m \mathbf{J}(\mathbf{m}) = \mathbf{0}$$

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

$$C_{ijkl} = \kappa u_{l,j}$$

$$\mathbf{u}|_{t=0} = \mathbf{u}|_{t=1} = \mathbf{0}$$

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

$$\sigma \mathbf{n}|_{x \in \partial G} \in \mathcal{C} = \left\{ \alpha \left| \min \Psi(\mathbf{u}(\mathbf{m} + \alpha \delta \mathbf{m}, \mathbf{x}_r), \mathbf{d}_0) \right. \right\}.$$

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

$$\mathbf{r}^0(\mathbf{x}) = \int_T \dot{\mathbf{u}}_i^* \rho \, dt$$

$$\mathbf{r}^0(\mathbf{x}) = \int_T \partial_i \dot{\mathbf{u}}^* \partial u \, dt$$

$$\Psi = \int_T \int \chi[\mathbf{u}(\mathbf{m}; \mathbf{x}_r, t), \mathbf{d}_0] \, dt \, dG,$$

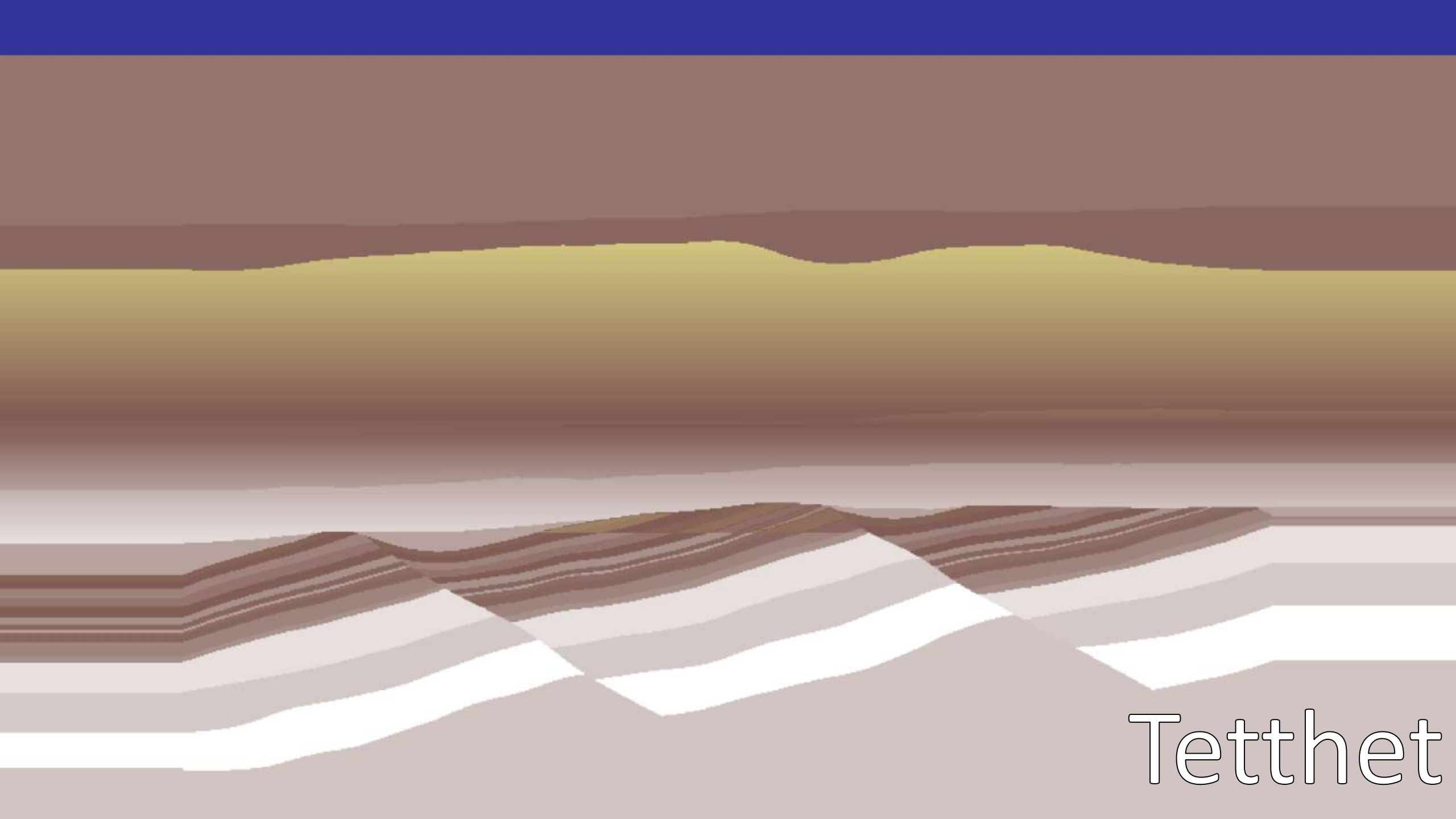
$$\mathbf{0} = \int_T \left(\partial_j \dot{\mathbf{u}}^* \partial u - \partial_i \dot{\mathbf{u}}^* \partial u \right) \, d$$

$$\mathbf{u} = \nabla_m \mathbf{u} = \frac{1}{\nu} \left[\mathbf{u}(\mathbf{m} + \nu \delta \mathbf{m}) - \mathbf{u}(\mathbf{m}) \right]$$

$$\delta \mathbf{u}^\dagger = \nabla_m \mathbf{u}^\dagger \delta \mathbf{m} = \lim_{\nu \rightarrow 0} \frac{1}{\nu} \left[\mathbf{u}^\dagger(\mathbf{m} + \nu \delta \mathbf{m}) - \mathbf{u}^\dagger(\mathbf{m}) \right].$$

Hvor mye fysikk skal vi inkludere?

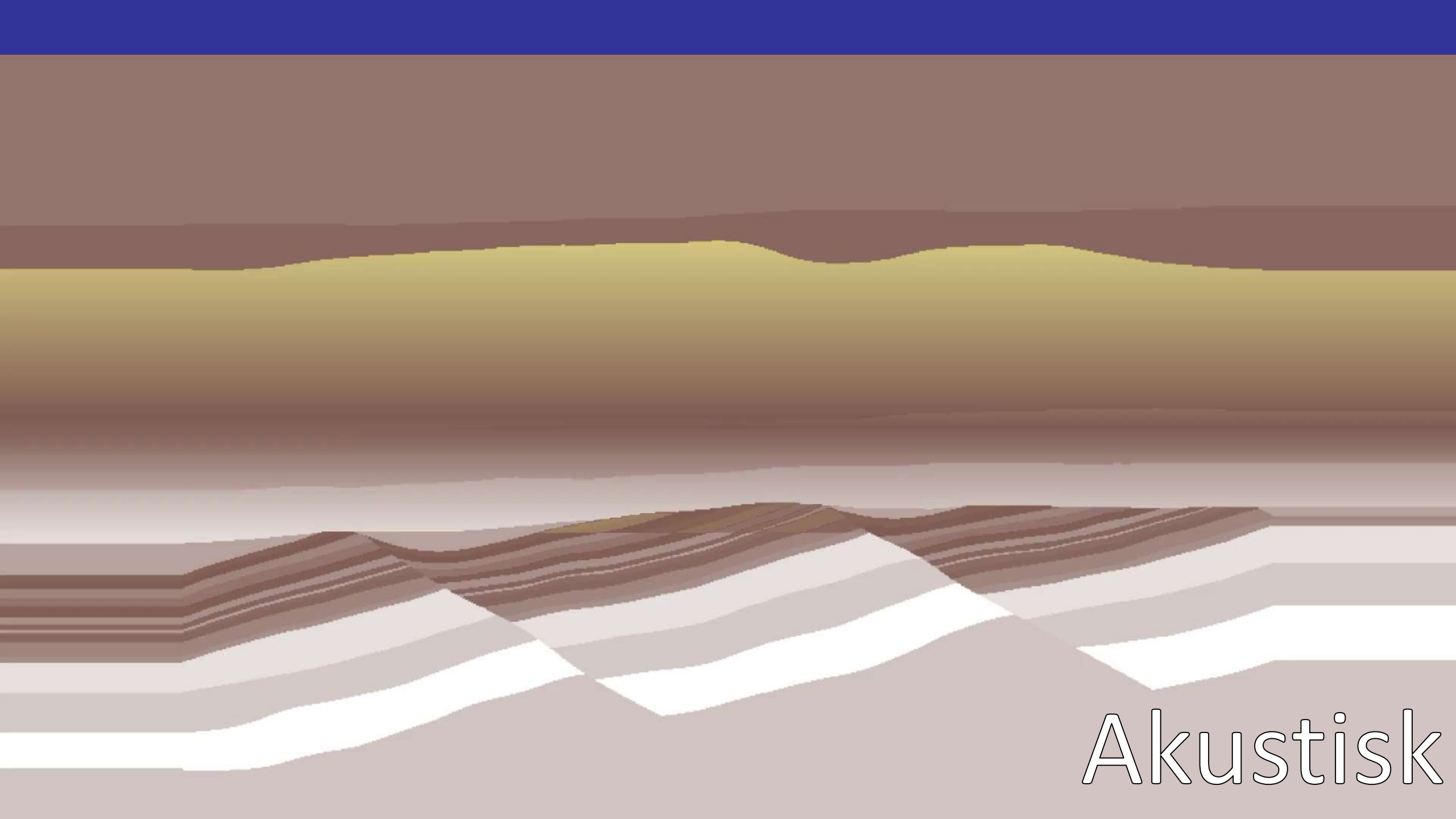
- Akustisk (sann for væske og gass)
- Elastisk (sann for isotropt fast stoff)
- Anisotropi (litt mer sann for fast stoff)



Tetthet

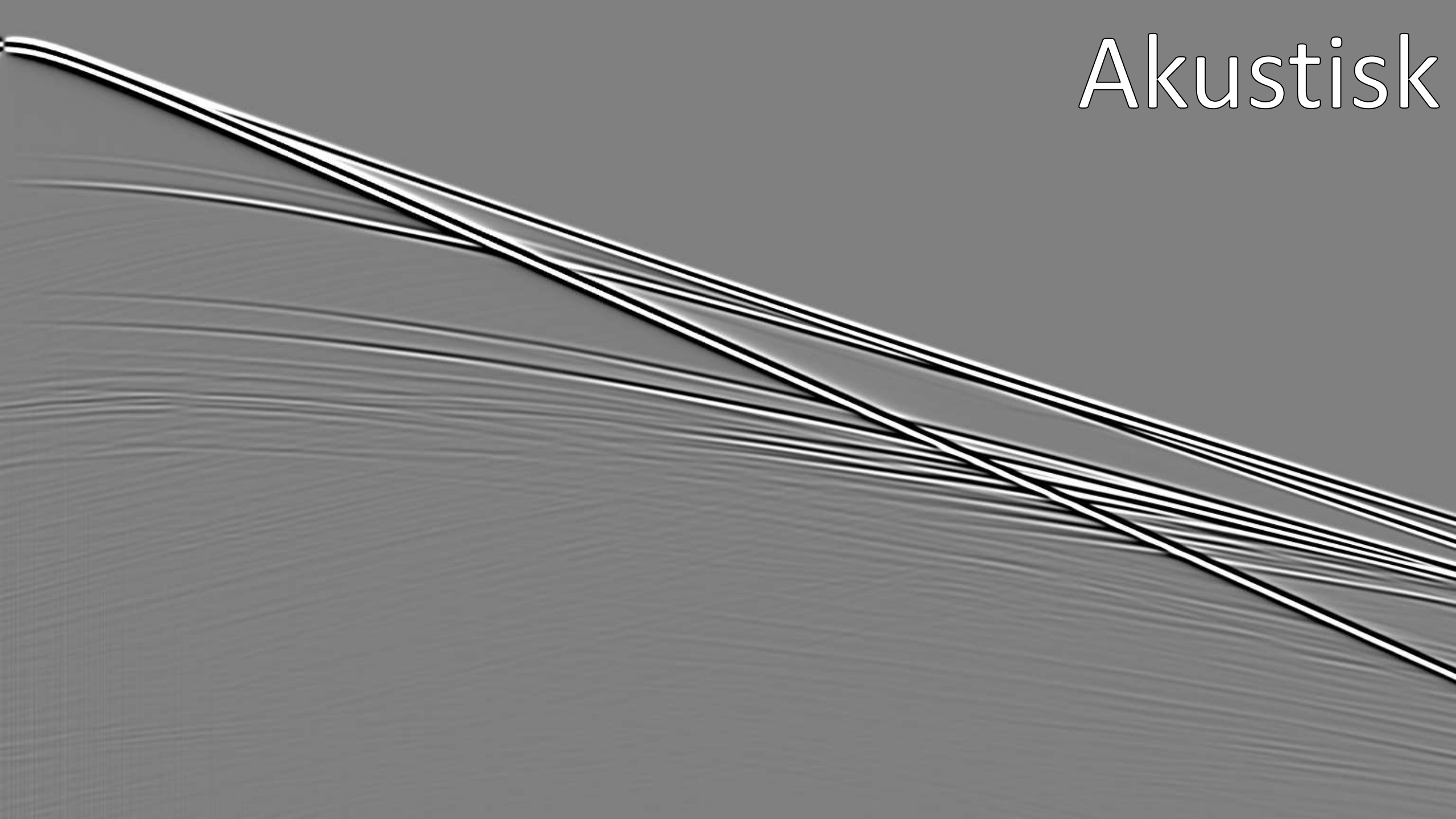


Trykkbølge-hastighet



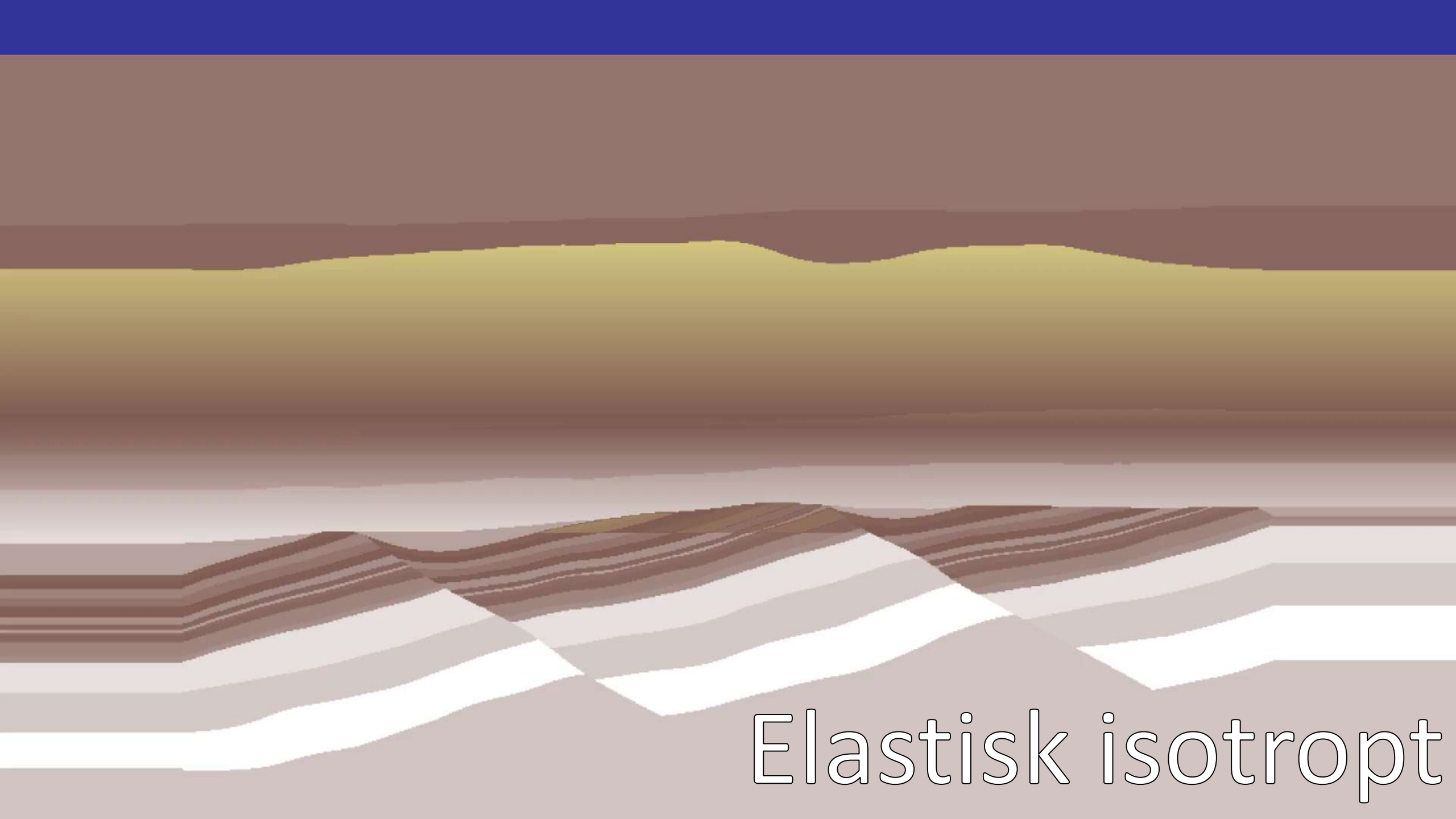
Akustisk

Akustisk



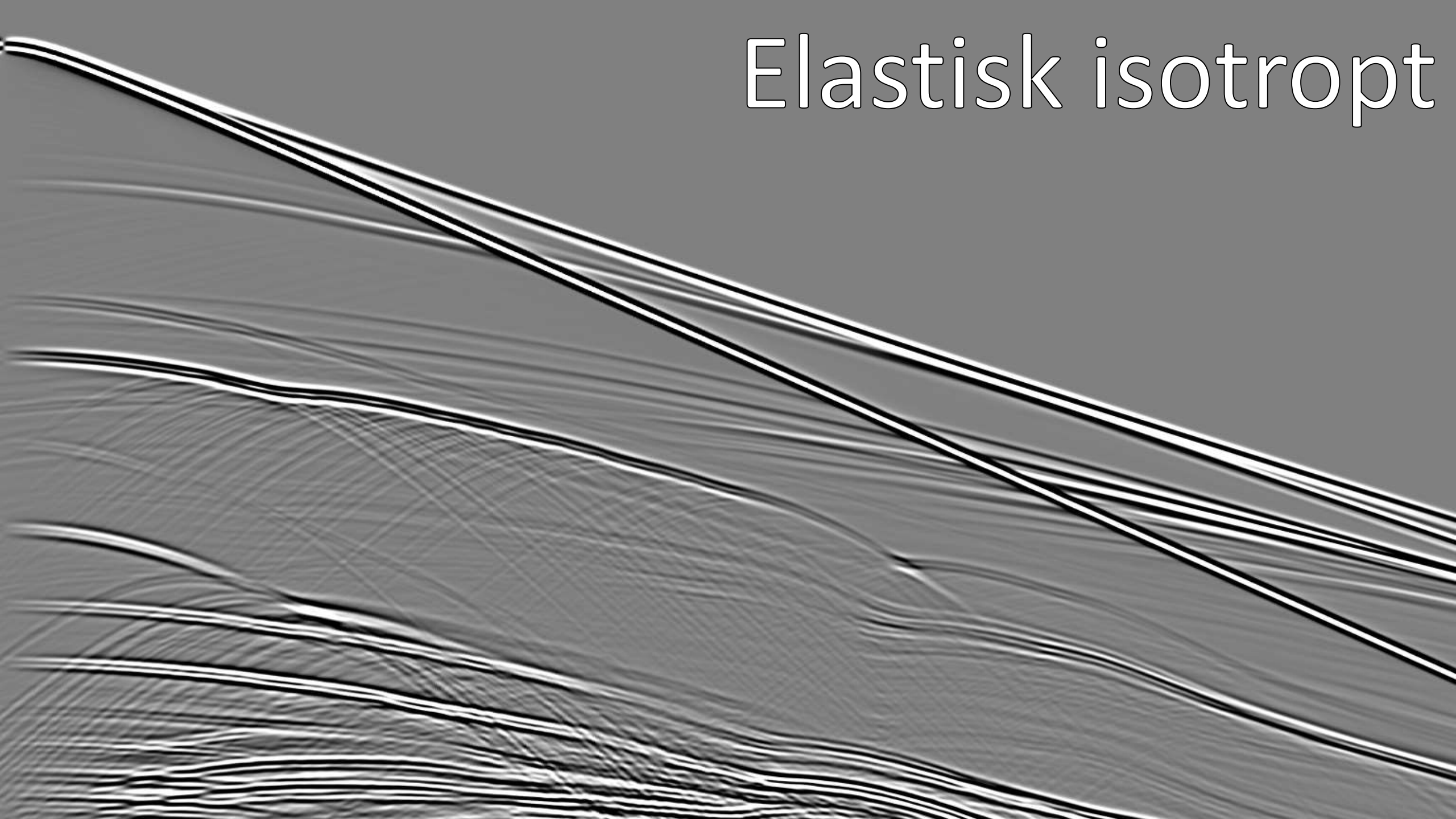


Skjærbølge-hastighet

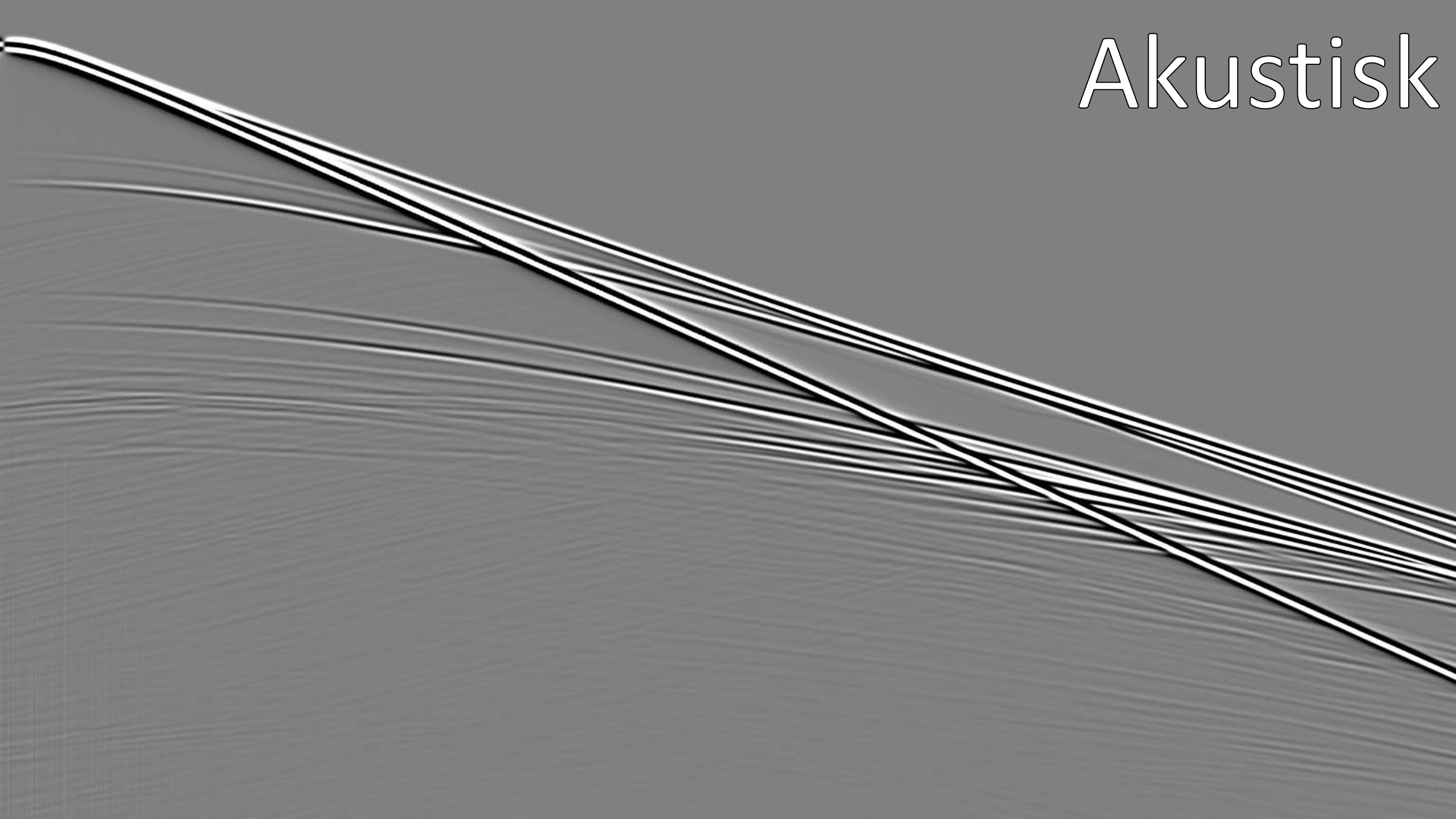


Elastisk isotropt


Elastisk isotropt




Akustisk



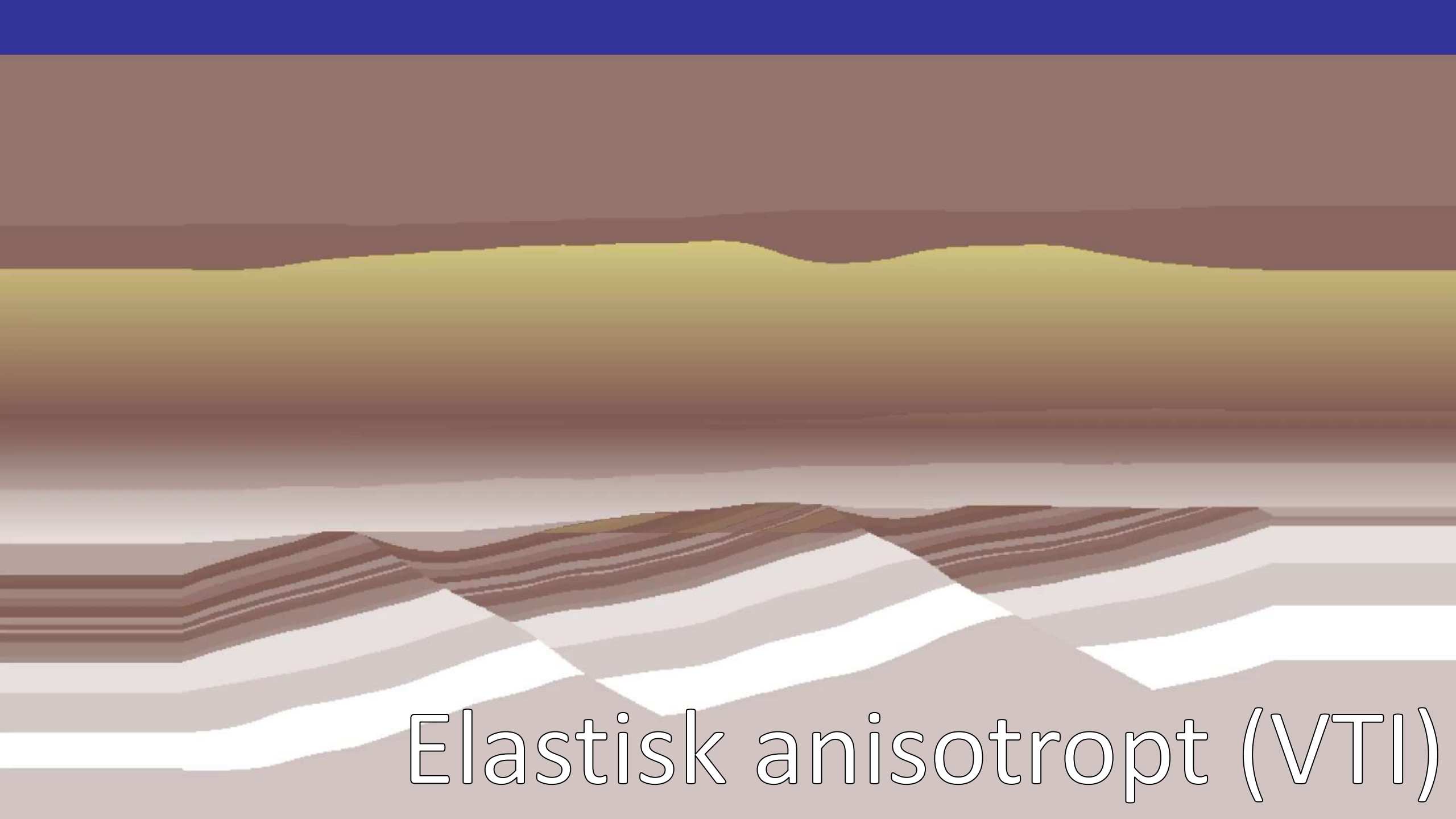




Trykkbølge-anisotropi

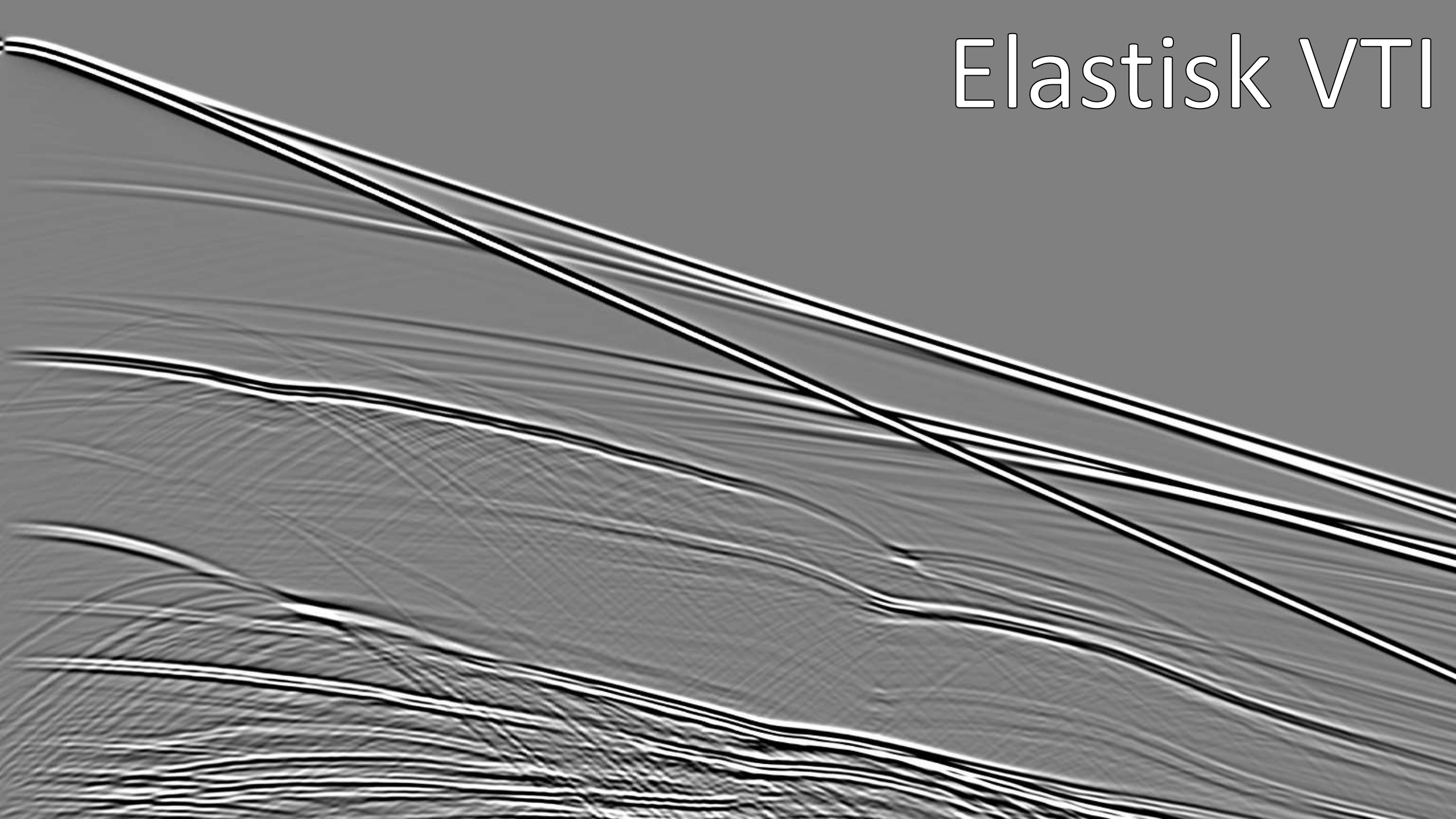


Skjærbølge-anisotropi

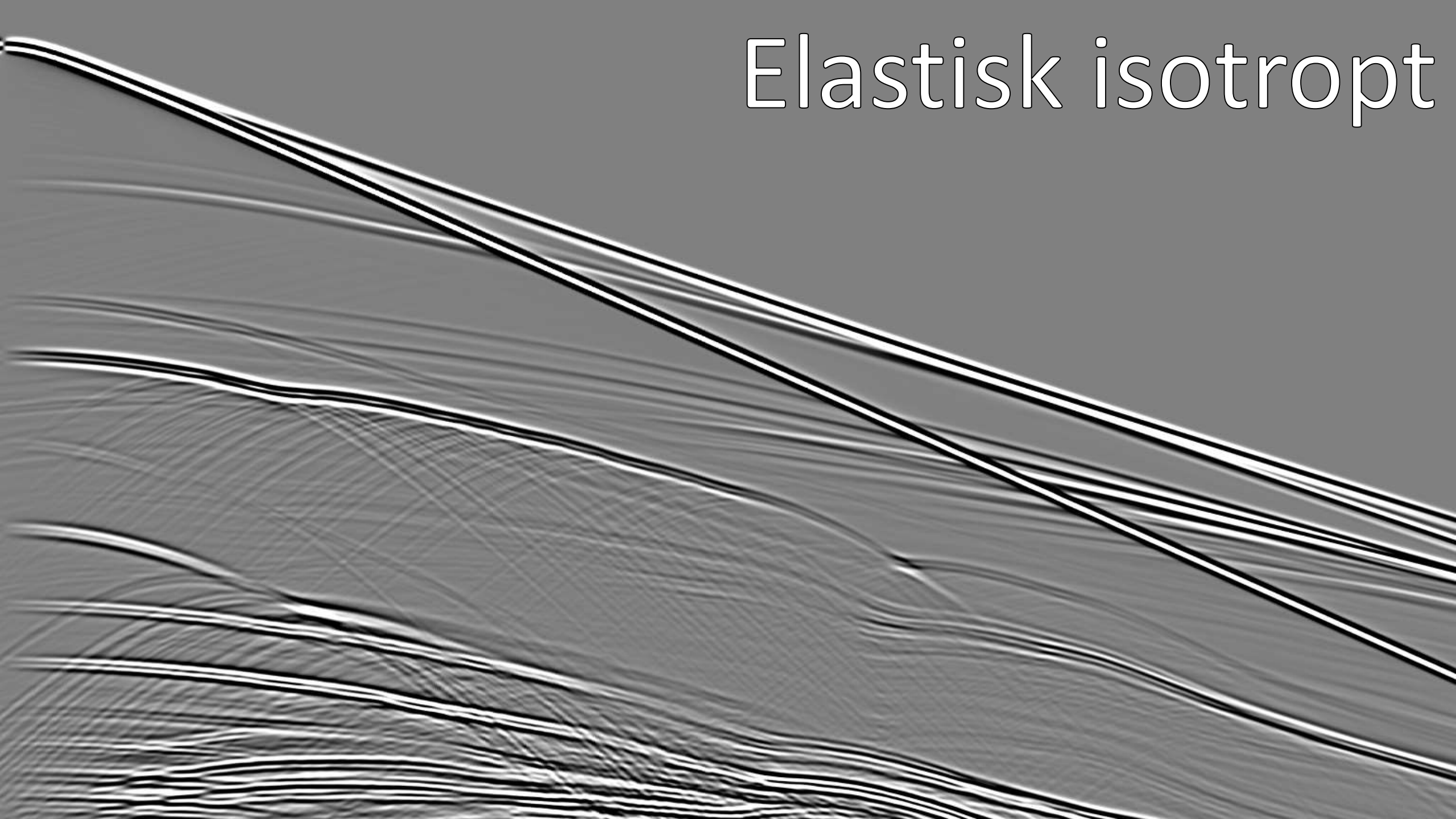


Elastisk anisotrop (VTI)

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



Norwegian University of
Science and Technology



AkerBP