Numerical modeling of seismic wave processes using grid-characteristic method

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Contents

- We will discuss shelf seismic exploration
- We will prove the following thesis

The use of elastic wave modeling is more better than the use of acoustic wave modeling for shelf seismic exploration independently on the source-receivers system type.

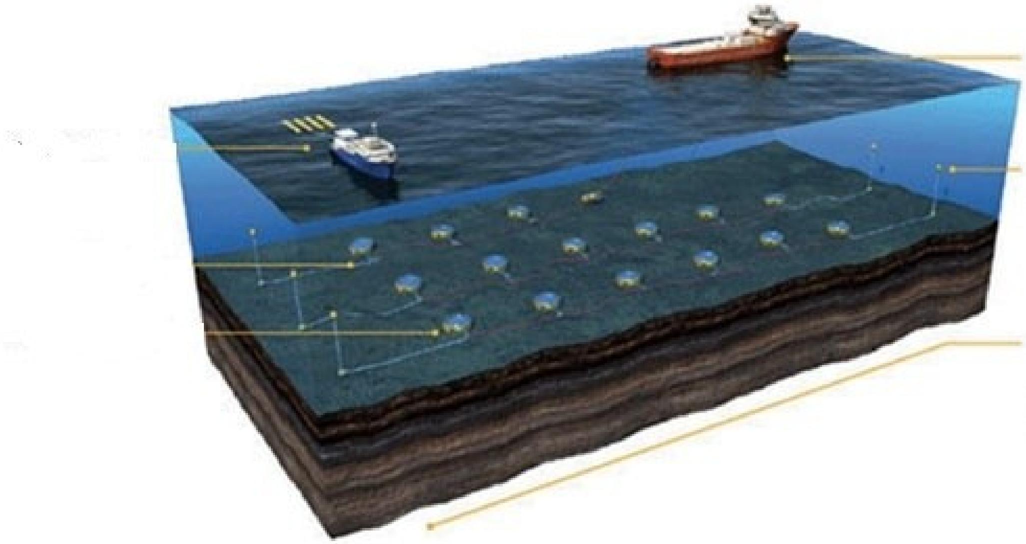
Also we will discuss another applications of elastic waves modeling:

- Numerical modeling of Arctic problems
- Numerical simulation in geology
- Numerical modeling of seismic stability

Shelf seismic exploration

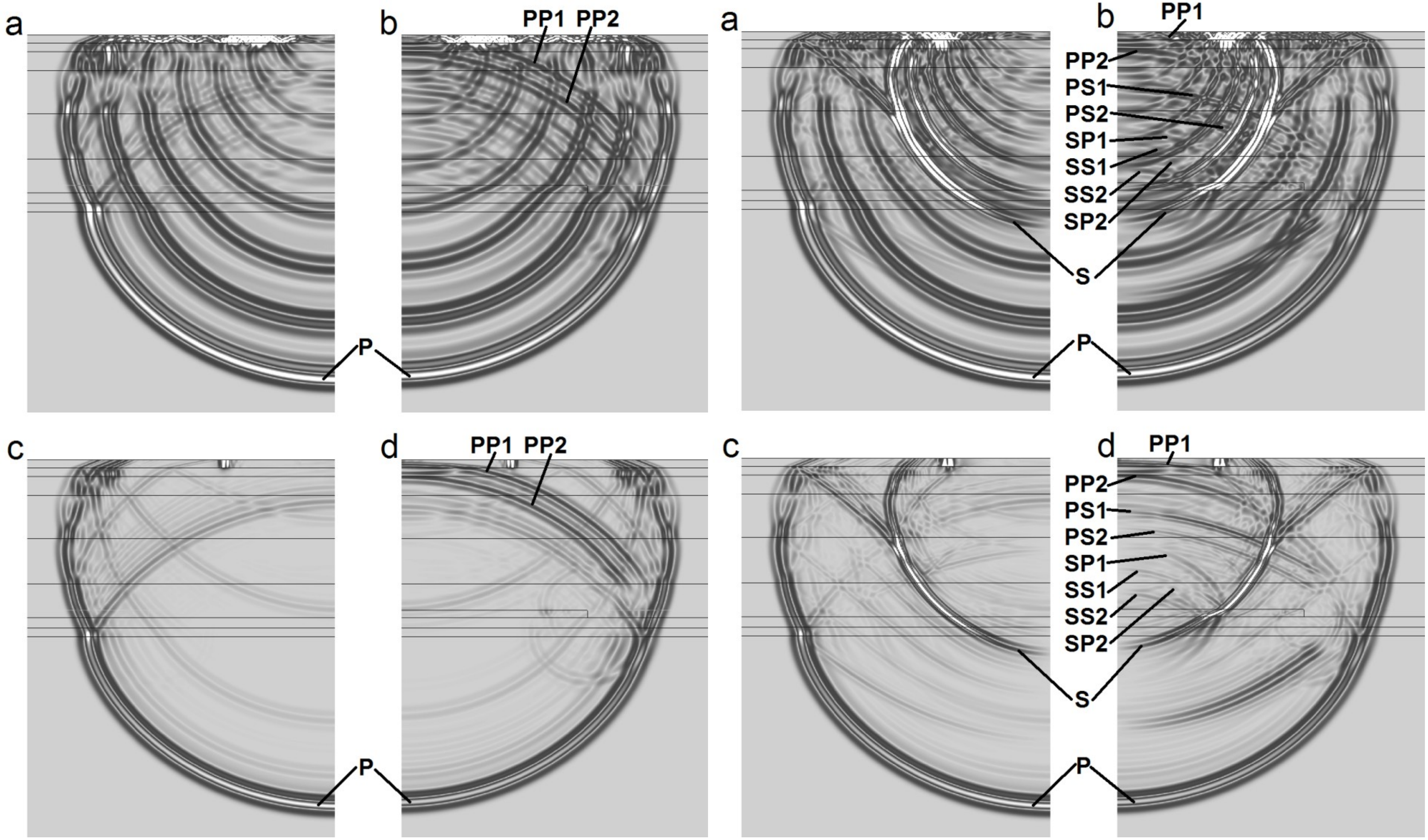
Types of source-receivers systems

Streamer
- P-waves
- Low price
- High performance
- Use of acoustic wave modeling?

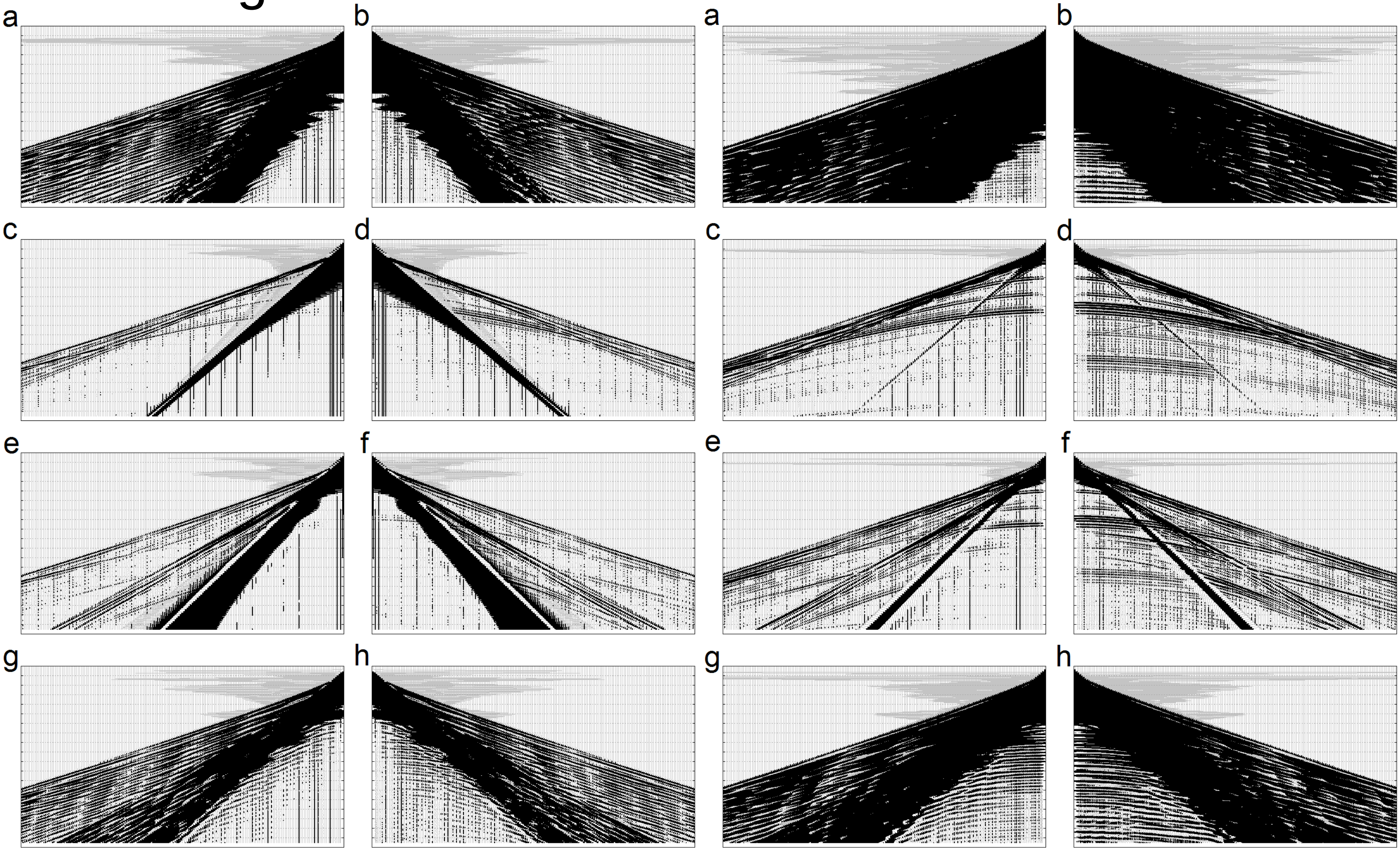


Seabed stations
- P-, S-, PS-, SP-waves
- High price
- High comprehension of obtained data
- Use of elastic wave modeling only

Comparison between acoustic and elastic waves modeling



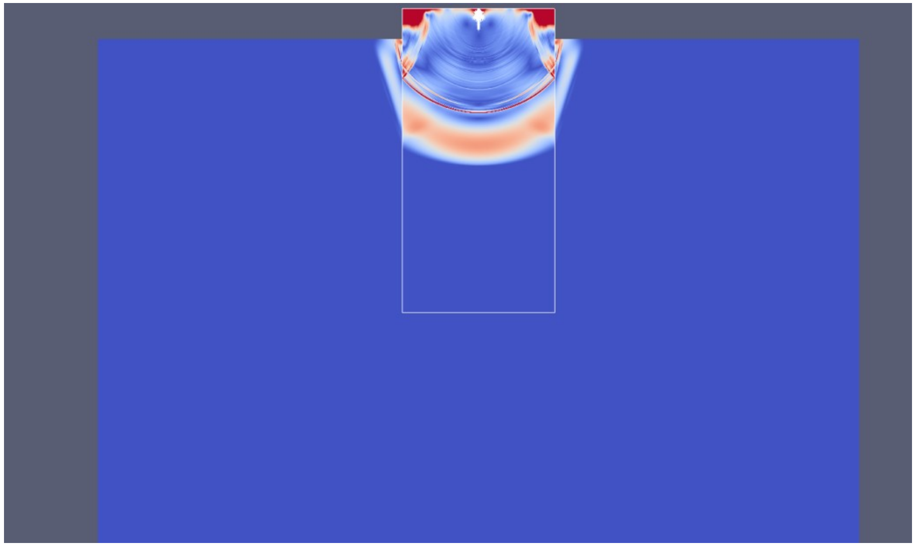
Comparison between acoustic and elastic waves modeling

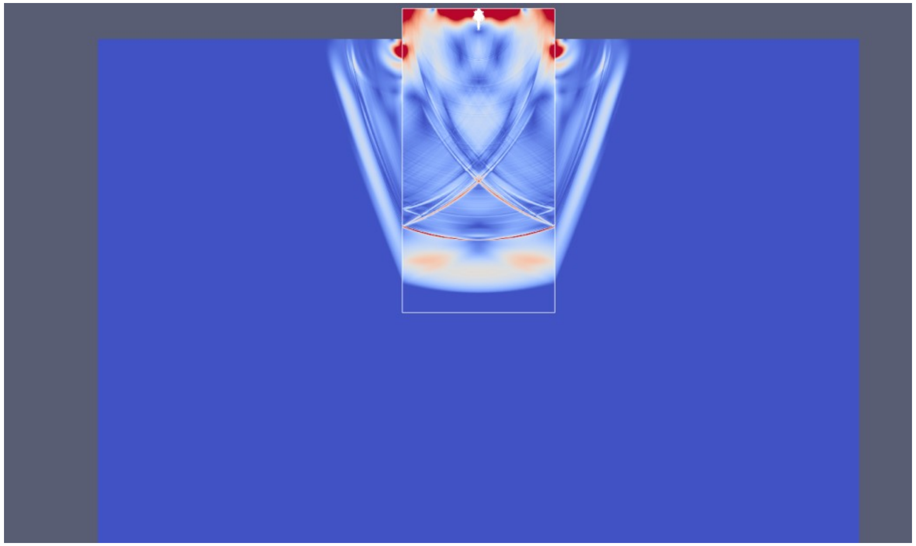


horizontal component vertical component

Numerical modeling of Arctic problems

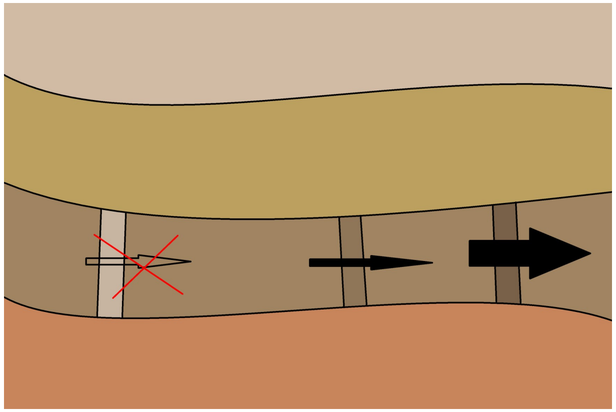
Destruction of the iceberg under intense dynamic impacts

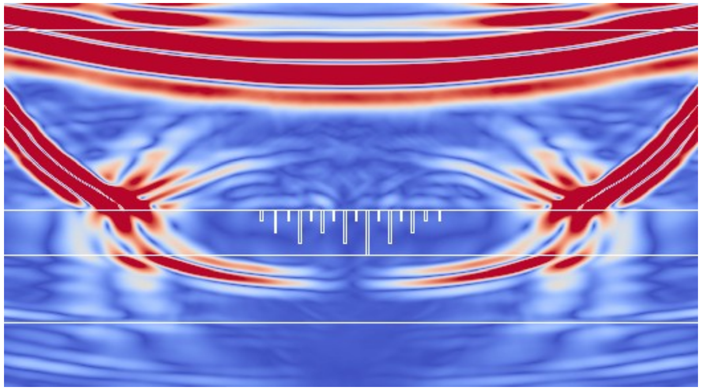




Numerical simulation in geology

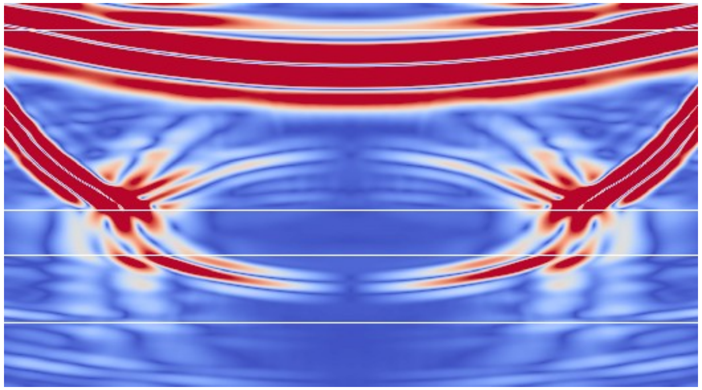
Types of cracks: barriers, conductors and neutral one

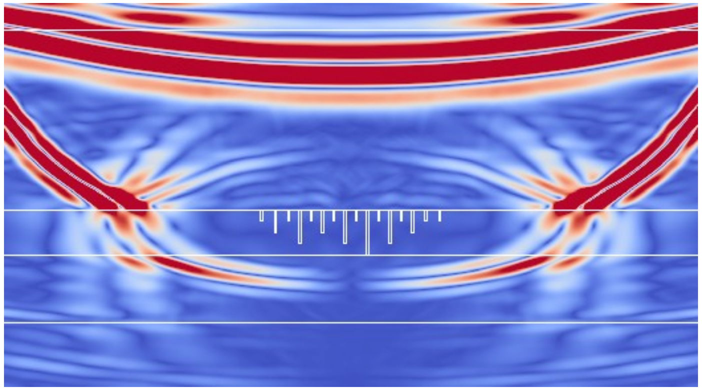




$K = 0.5$

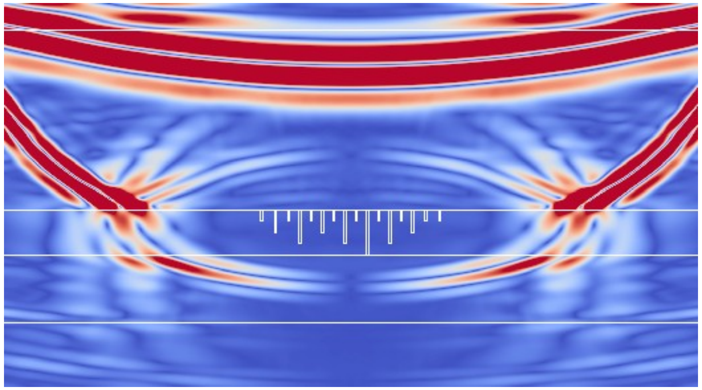
$K = 1.0$ (no cracks)

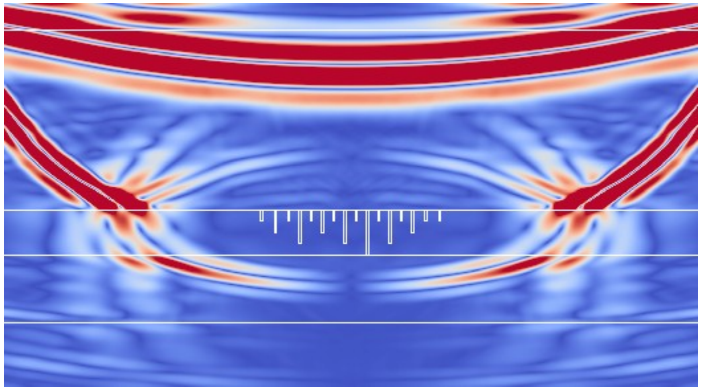




$K = 0.6$

$K = 0.9$

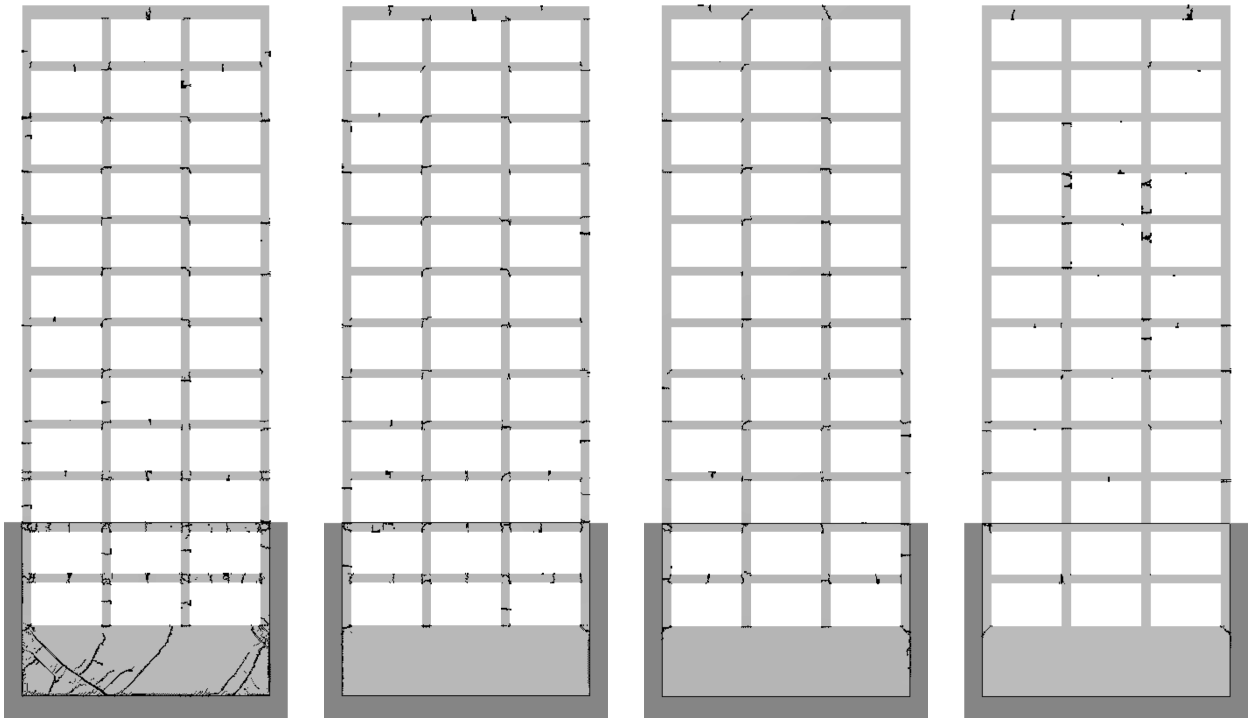




$K = 0.75$

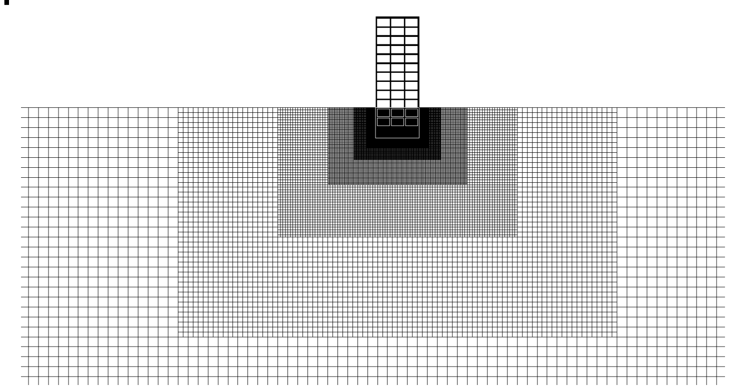
Numerical modeling of seismic stability

Seismic stability of the buildings



1000 m 2000 m 3000 m 4000 m

Different depth of earthquake hypocenter



Thank you for your attention!

We discussed:

- Shelf seismic exploration

The use of elastic wave modeling is more better than the use of acoustic wave modeling for shelf seismic exploration independently on the source-receivers system type.

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Appendix: Grid-characteristic method

System of equations describing elastic and acoustic waves

- Elastic waves: $$\rho \partial_t \vec{v} = (\nabla \cdot \boldsymbol{\sigma})^T$$

$$\partial_t \boldsymbol{\sigma} = \lambda (\nabla \cdot \vec{v}) \mathbf{I} + \mu \left(\nabla \otimes \vec{v} + (\nabla \otimes \vec{v})^T \right)$$

ρ density, $\vec{v}$ velocity in the elastic media, $\boldsymbol{\sigma}$ stress tension,

λ, μ Lame's parameters,

$$c_p = \left((\lambda + 2\mu) / \rho \right)^{1/2}$$ speed of P-waves,

$$c_s = (\mu / \rho)^{1/2}$$ speed of S-waves.

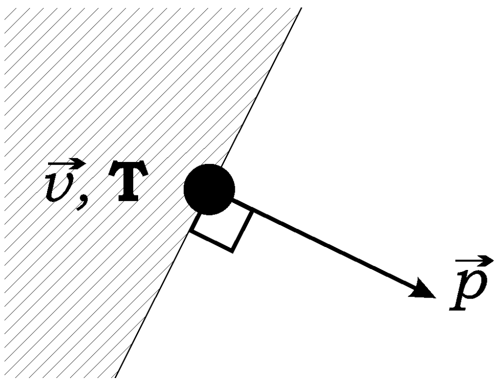
- Acoustic waves: $$\rho \partial_t \vec{v} = \nabla p$$

$$\partial_t p = c^2 \rho (\nabla \cdot \vec{v})$$

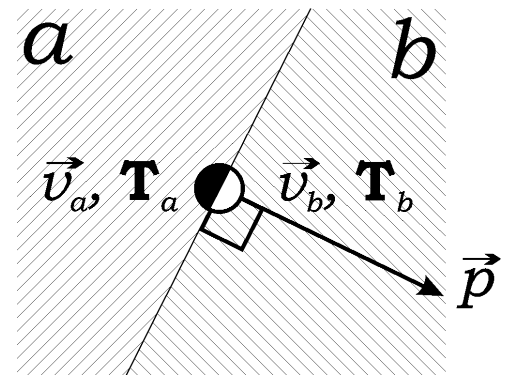
ρ density, $\vec{v}$ velocity in the acoustic media, p pressure, c speed of sound.

Boundary and interface conditions

Boundary



Interface



- Given traction

$$\boldsymbol{\sigma}\vec{p} = \vec{f}$$

- Given velocity of boundary

$$\vec{v} = \vec{V}$$

- Mixed boundary conditions
- Absorbing boundary contions

Continuity of the velocity and traction

$$\vec{v}_a = \vec{v}_b = \vec{V}, \vec{\sigma}_a = -\vec{\sigma}_b$$

Free sliding conditions

$$\vec{v}_a \cdot \vec{p} = \vec{v}_b \cdot \vec{p}, \sigma_p^a = \sigma_p^b, \sigma_\tau^a = \sigma_\tau^b = 0$$

The interface condition between acoustic and elastic bodies