The potential of detecting flaws in an experimental dam at Älvkarleby, Sweden, using P-wave traveltime tomography

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Outline

- Background and project goals
- Survey layout: hydrophones and boreholes
- What is P-wave traveltime tomography?
- Synthetic models:
  - Cavity
  - Horizontal permeable layer
- Summary & Outlook
- References

Background

- A large number of earth embankment dams were built in the second half of 20th century in Sweden
- Defects (e.g., seepages and internal erosion) inside the dams can be detected but not located with precision using indirect methods
- Vattenfall initiated a research project for detecting damages in this type of dams, using blind testing through continuous seismic, resistivity, and temperature measurements

Goals of this work

- Test and, if possible, detect built-in flaws of unknown position and size within the core of an experimental dam using synthetic and real P-wave traveltime tomographic data
- Support the interpretation of P-wave reflection seismic data

Experimental dam design

- 20 m long and 4 m high, composed of four parts: A (impermeable core), B (fine filter), C (coarse filter), and D (support filling)
- Seismic data recorded with 5 lines of hydrophones and one 3C-geophone in the deep boreholes, using a P-wave sparker as seismic source in every borehole

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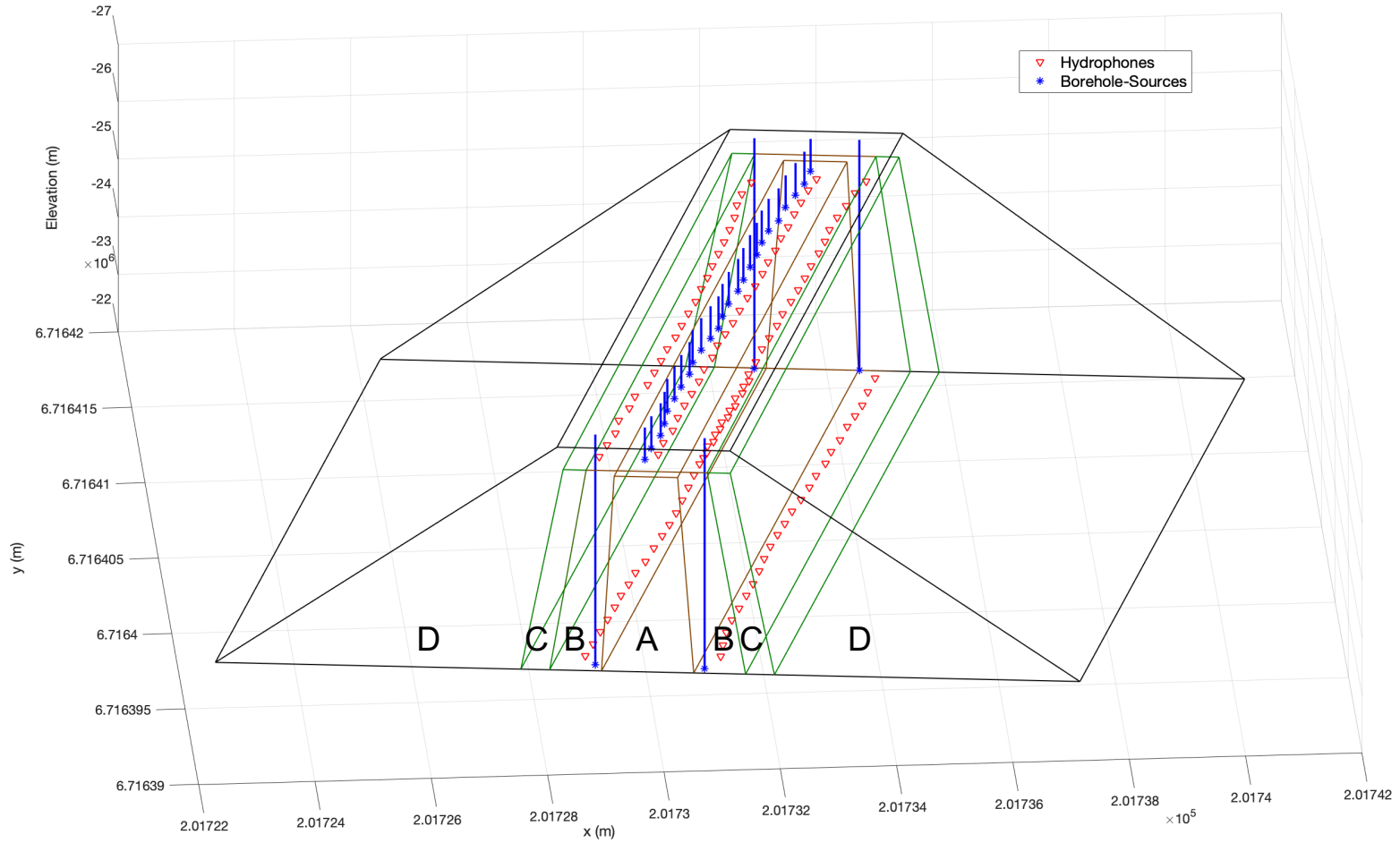
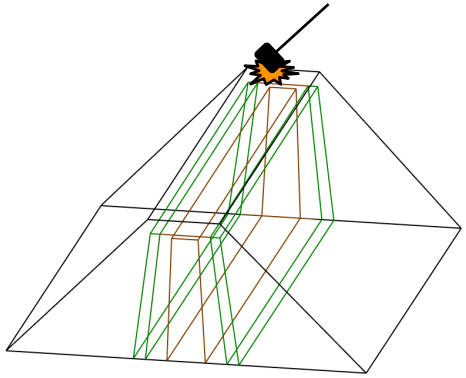
Survey layout

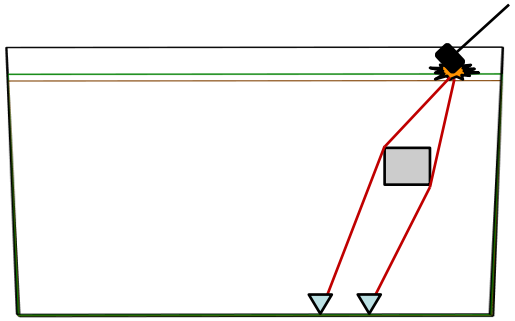


P-wave traveltime tomography

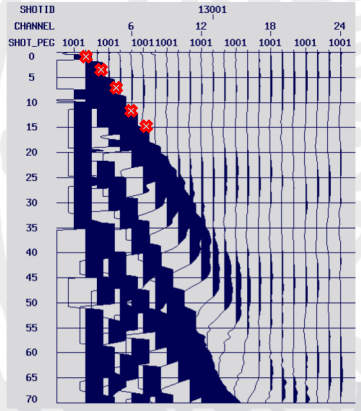
1. Shooting seismic source



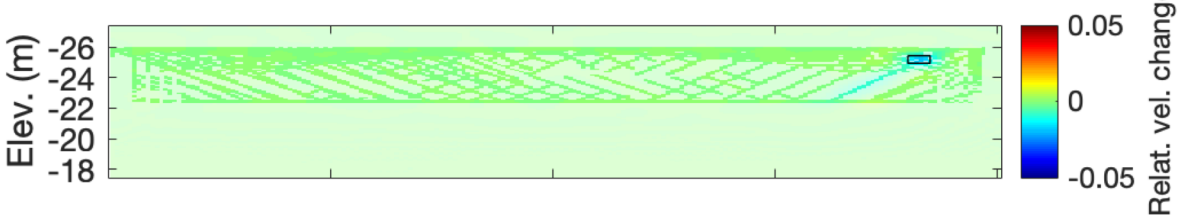
2. Raypath affected by cavity



3. Picking traveltimes (first arrivals) from shot records



4. Traveltime inversion for P-wave velocities (V_p)



Inversion parameters

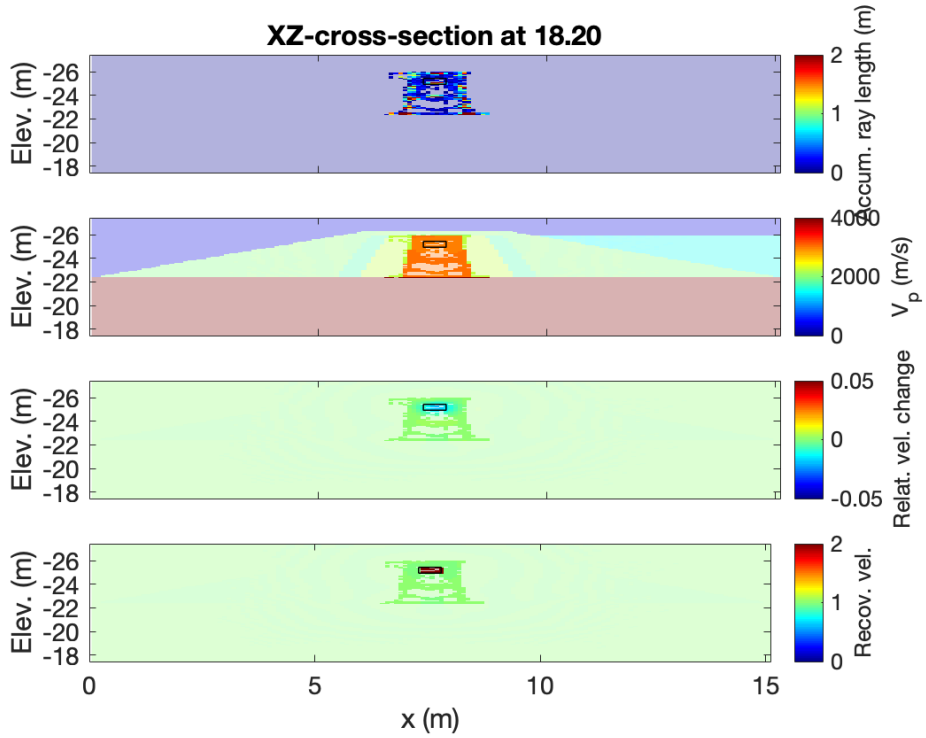
- Program: PStomo_eq (Tryggvason et al., 2002)
- Cell size (x,y,z): 0.1 x 0.1 x 0.1 m
- Number of iterations: 9

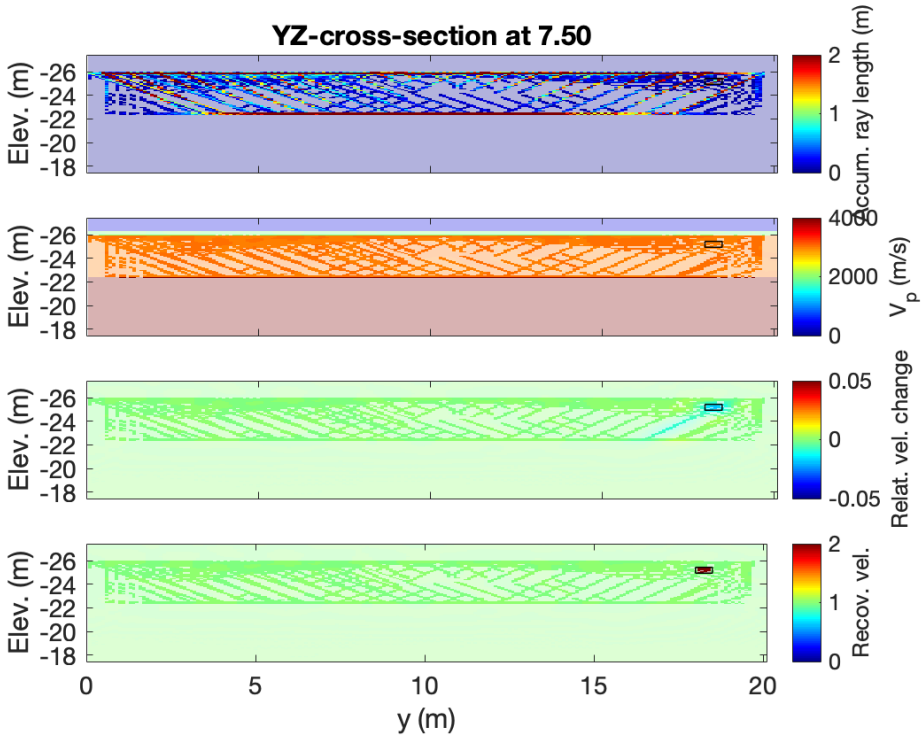
Starting model for inversion

V_p

- A: 3000 m/s
- B: 2200 m/s
- C: 1800 m/s
- D: 2000 m/s
- Bedrock: 5000 m/s
- Water: 1500 m/s
- Air: 340 m/s

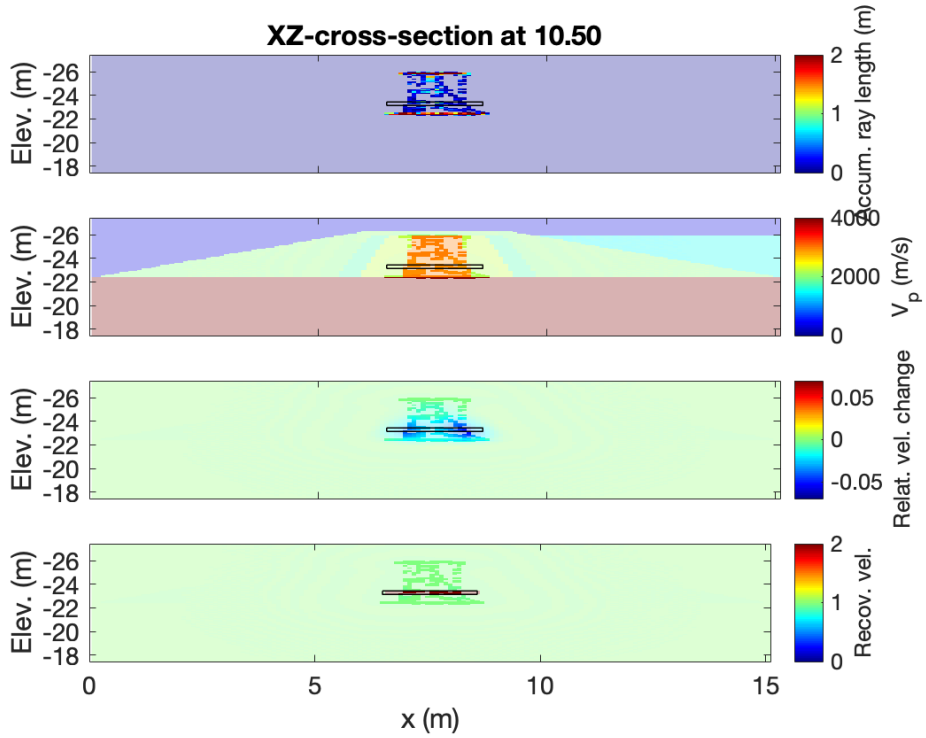
Synthetic model: cavity

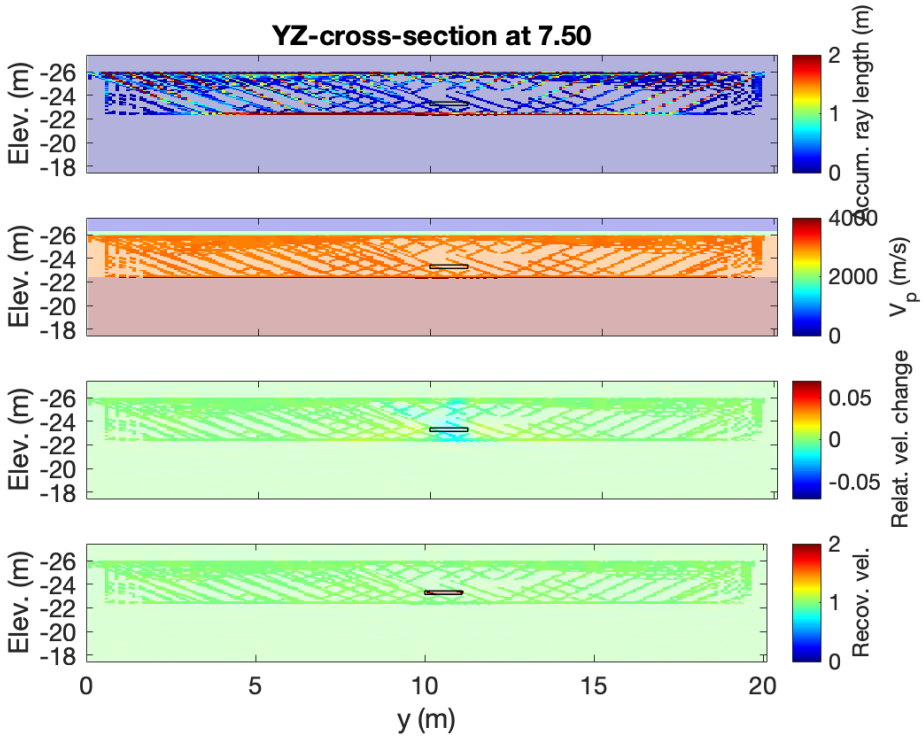




Cavity
- Size: 0.4 x 0.4 x 0.4 m
- V_p = 1000 m/s

Synthetic model: horizontal permeable layer





Horizontal permeable layer
- Size: 2 x 1 x 0.2 m
- V_p = 1000 m/s

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Summary

- Synthetic modelling results show, in general, that the defect position can be identified by tomography
- Velocity and size of the defects are not well recovered by the method (seismic ray coverage is limited in some areas)

Outlook

- Continue modelling synthetic and real traveltime data
- Reflection seismic surveys every 2 months (the reservoir will be operated at its max. water level for about 18 months)
- Interpretation of reflection seismic data together with P-wave traveltime tomography

References

- Tryggvason A, Rögnvaldsson S ður T, Flóvenz ÓG (2002) Three-dimensional imaging of the P- and S-wave velocity structure and earthquake locations beneath southwest Iceland. Geophys J Int 151: 848–866. doi:10.1046/j.1365-246X.2002.01812.x