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Multi-purposing of passive seismic acquisition for characterisation and monitoring of tailings dam performance

Informing & connecting Tailings dam data

T. Kremer[2], W. Pettit[2], T. Gaubert-Bastide[2], J.M Ars[2], K. Khazraj[2], C. Voisin[2], SRK Consulting team[1]

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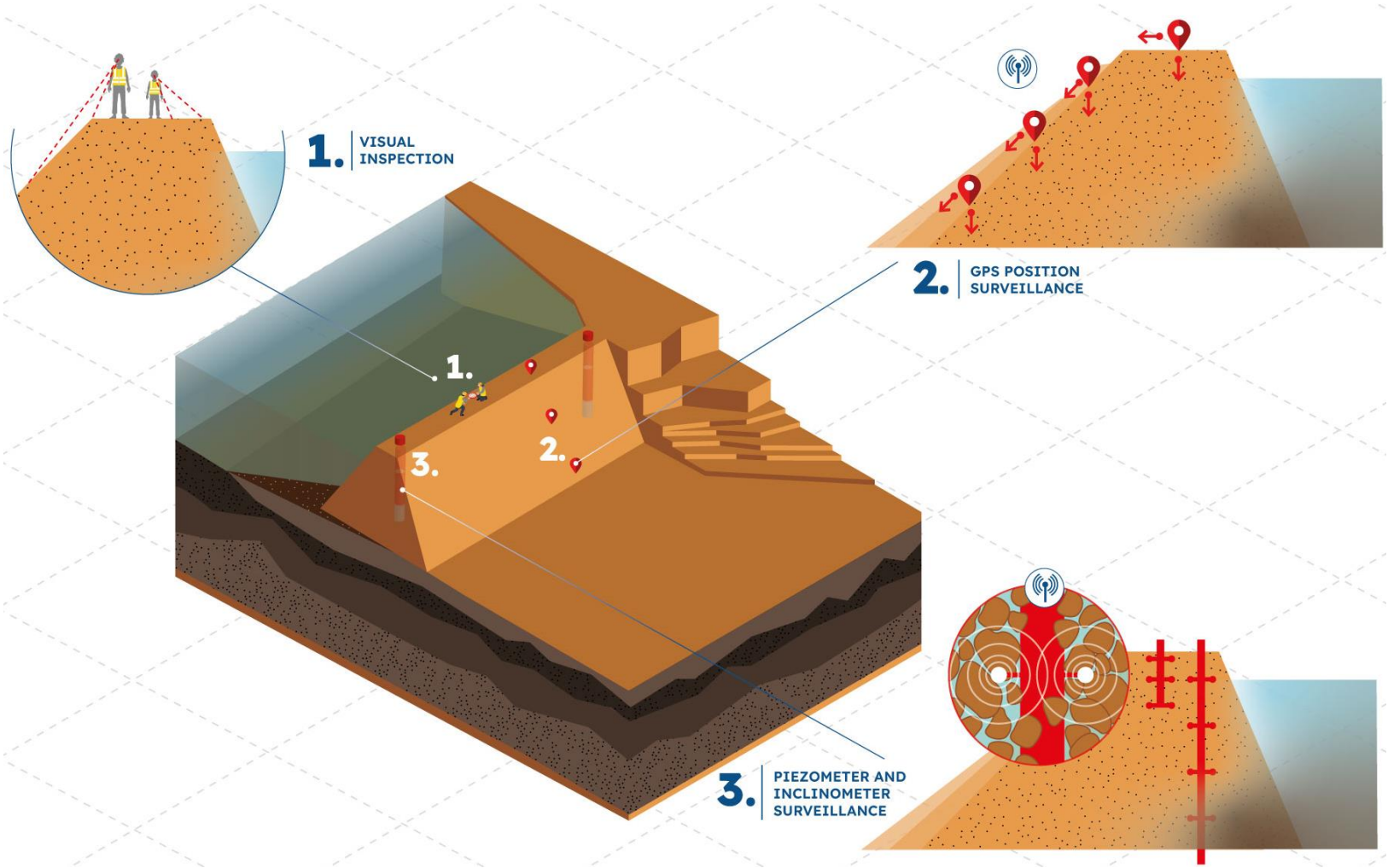
Passive seismic methods

Why the interest?



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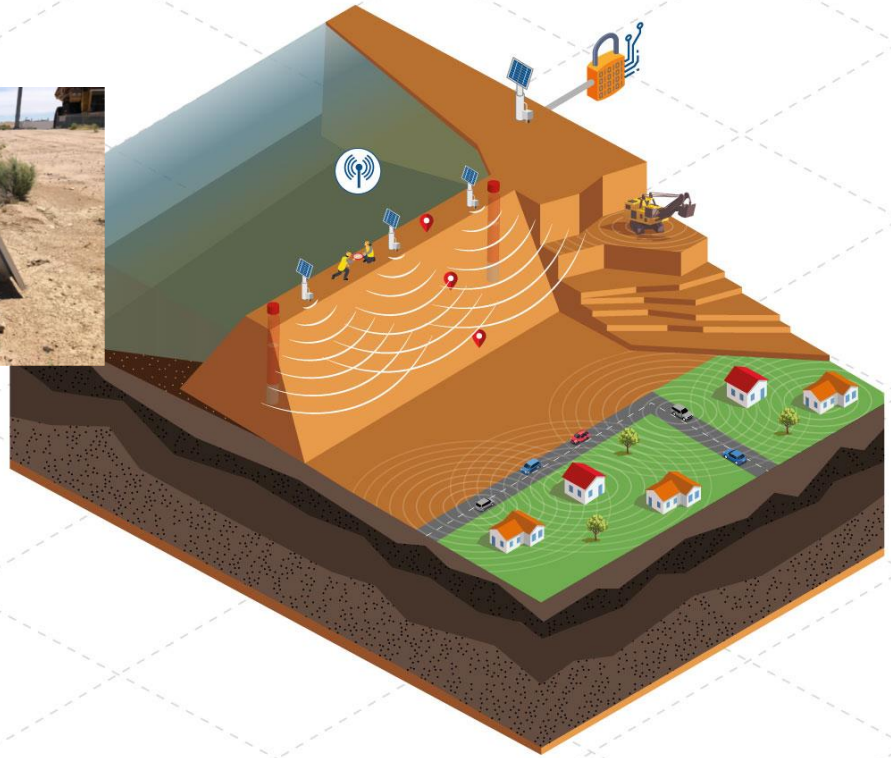
Passive seismic methods

Why the interest?

Based on seismic noise recordings

« One man’s trash is another man’s treasure »



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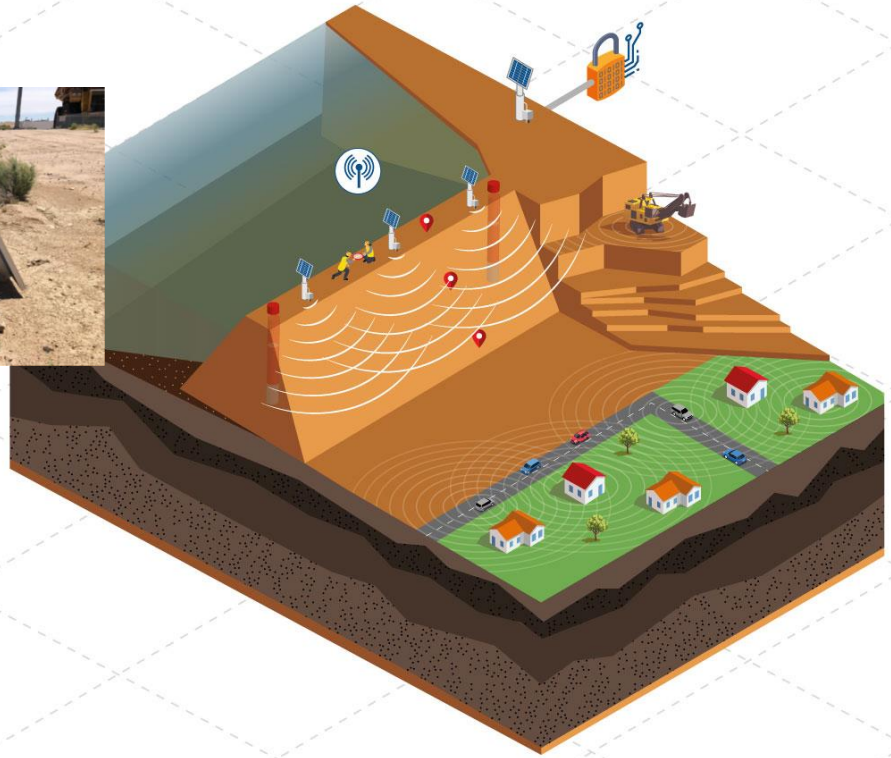

Complementarity - interoperability

Non-invasive

Access to internal structure
➔ *Depth localization*

Volumetric information
➔ *Full coverage*

Continuous monitoring

Flexible deployment

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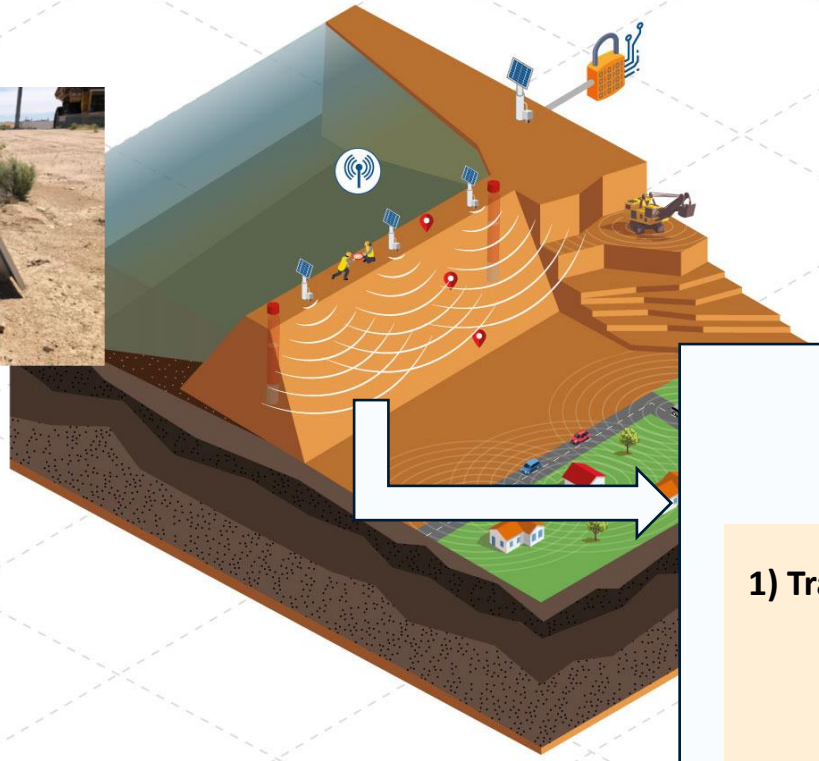

Complementarity - interoperability

Non-invasive

Access to internal structure
➔ *Depth localization*

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Continuous monitoring

Flexible deployment

Enhanced structural health monitoring

1) Tracking seismic velocity changes with ANSI (Interfrometry)

Pore pressure monitoring
Density/stiffness monitoring

2) Seismic predictive modelling parameters

Resonance frequency
Damping ratios
Response to seismicity

Outline

1. Passive seismic – why ?

2. **Monitoring seismic velocity changes with ANSI**

    a) The method
    b) Pilot demonstrator
    c) Use and applications

3. Seismic predictive modelling parameters

4. Conclusions

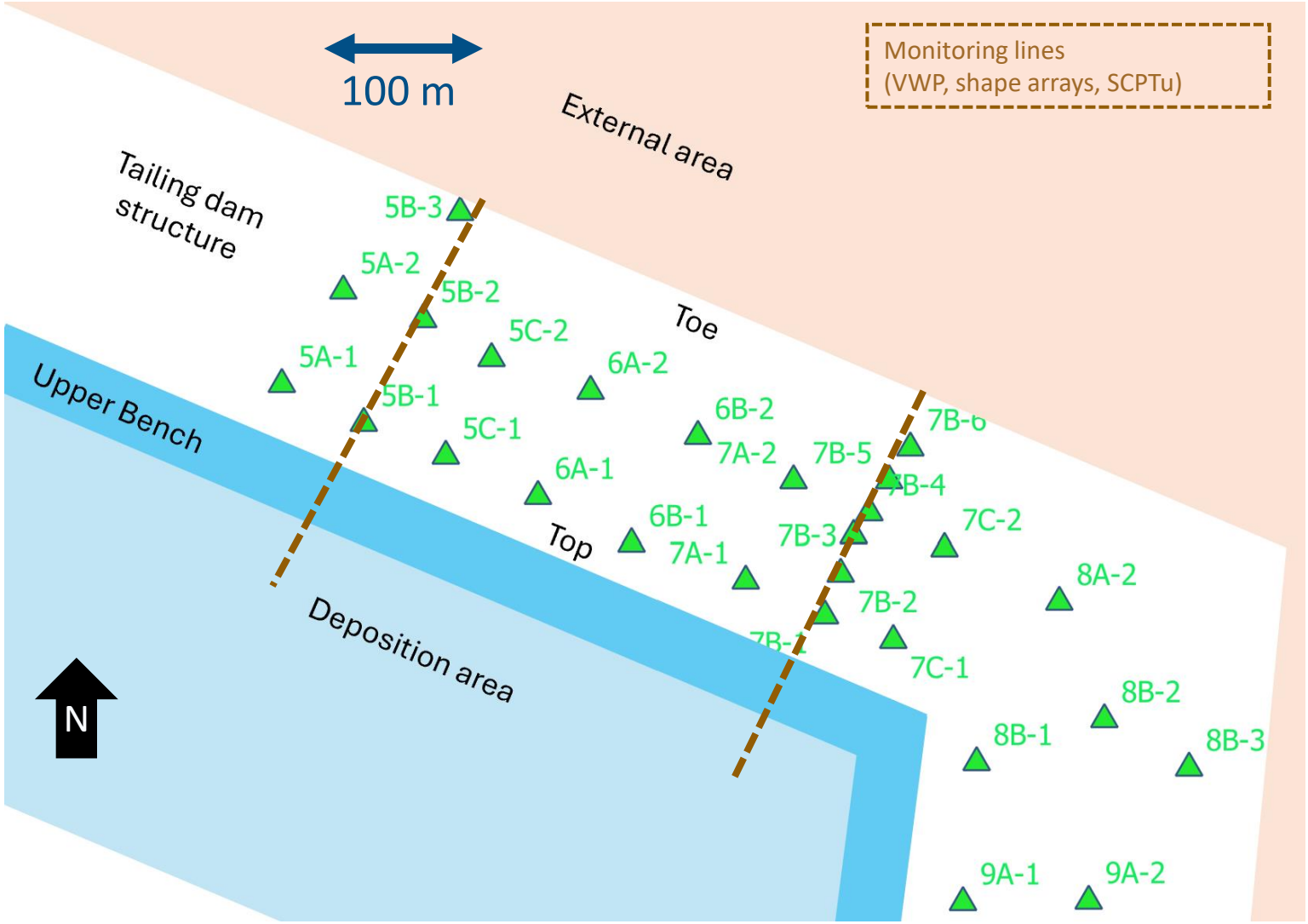
Pilot project

Context

10 months monitoring on tailing dam wall
33 sensors installed
2 phases

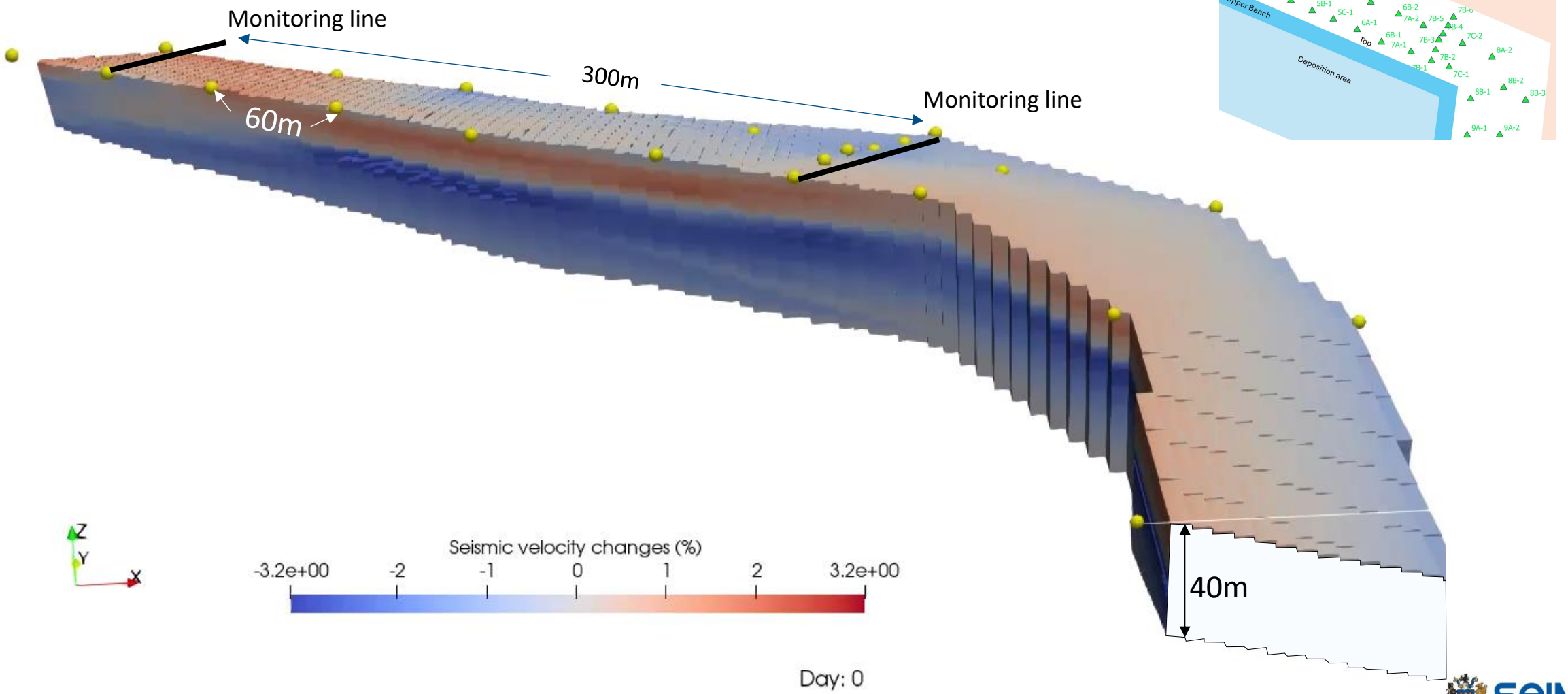
1) Feasibility & Calibration
2) Extension of monitoring array

Validation with geotechnical engineers.



Results

4D seismic velocities



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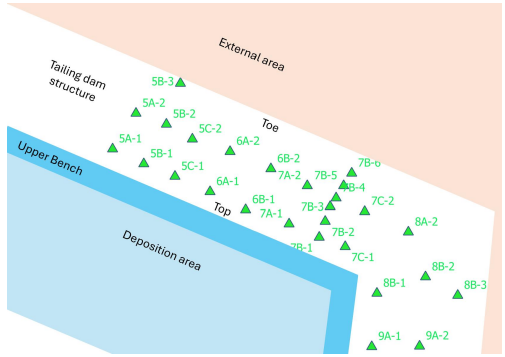
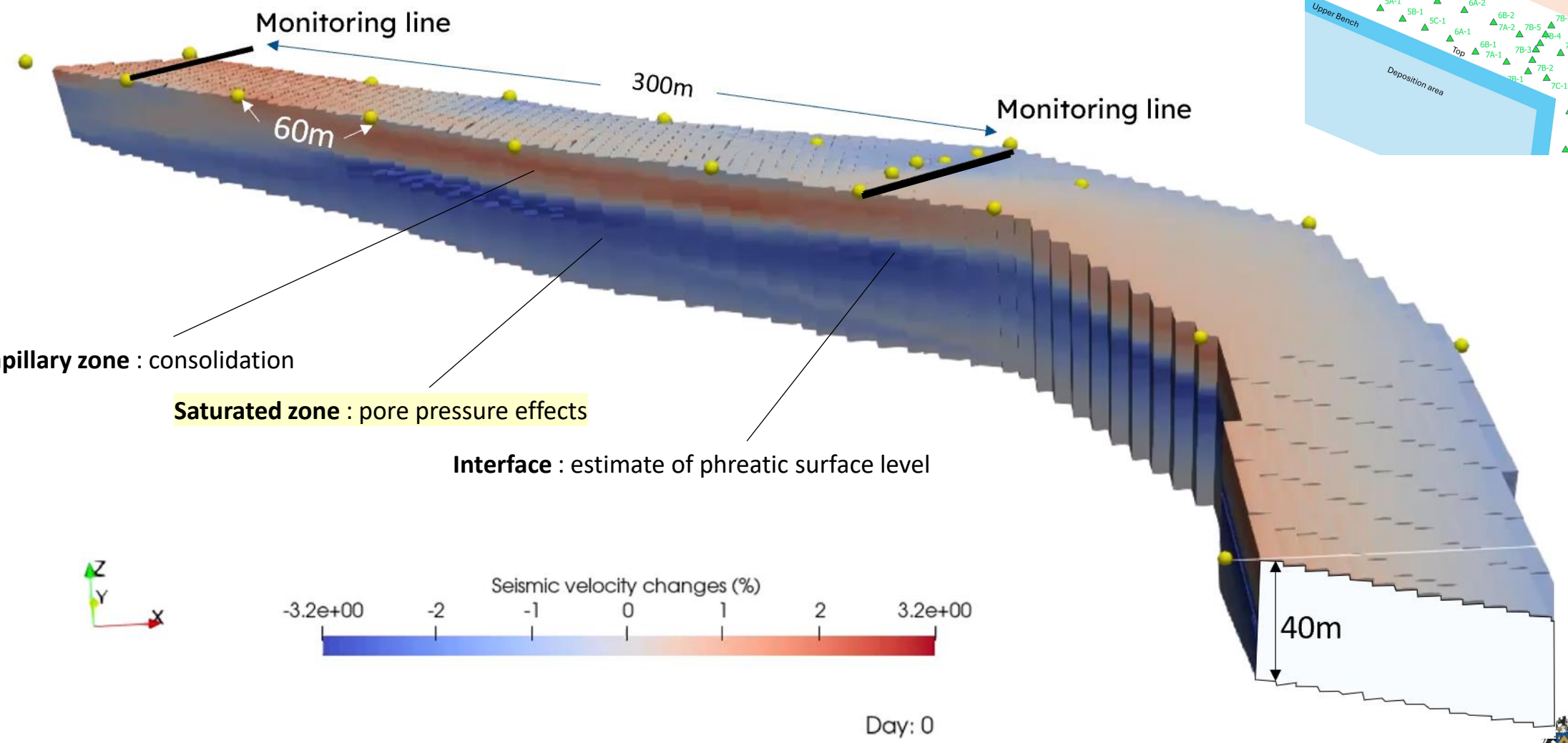
Interpretations

4D seismic velocities

Seismic velocity is sensitive to:
- **Pore pressure**
- **Density/stiffness**





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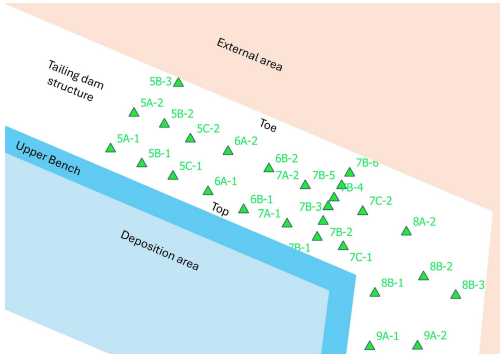

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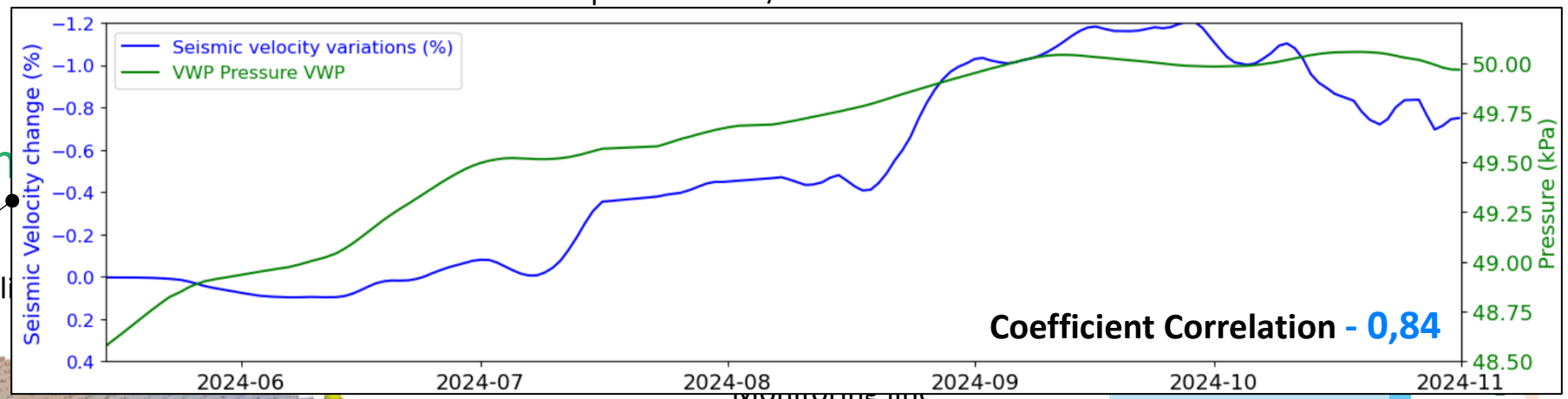
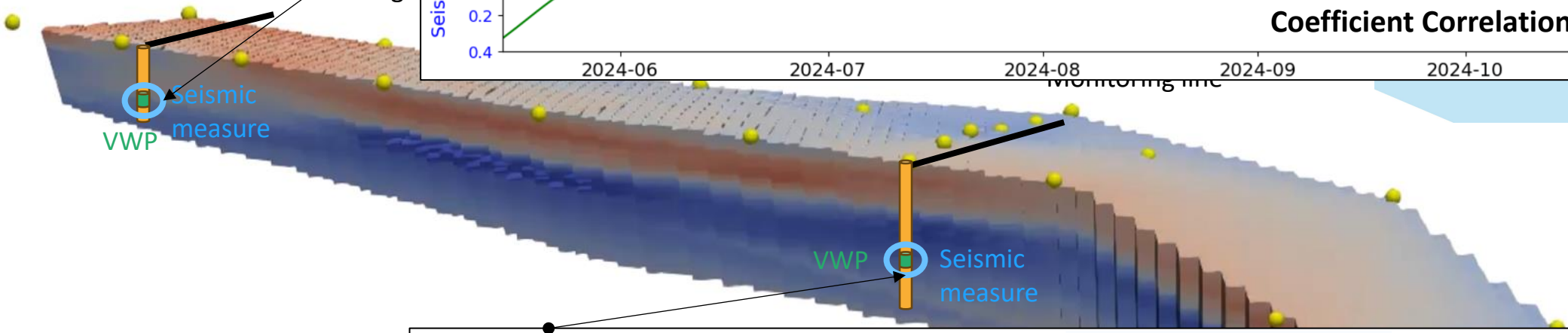
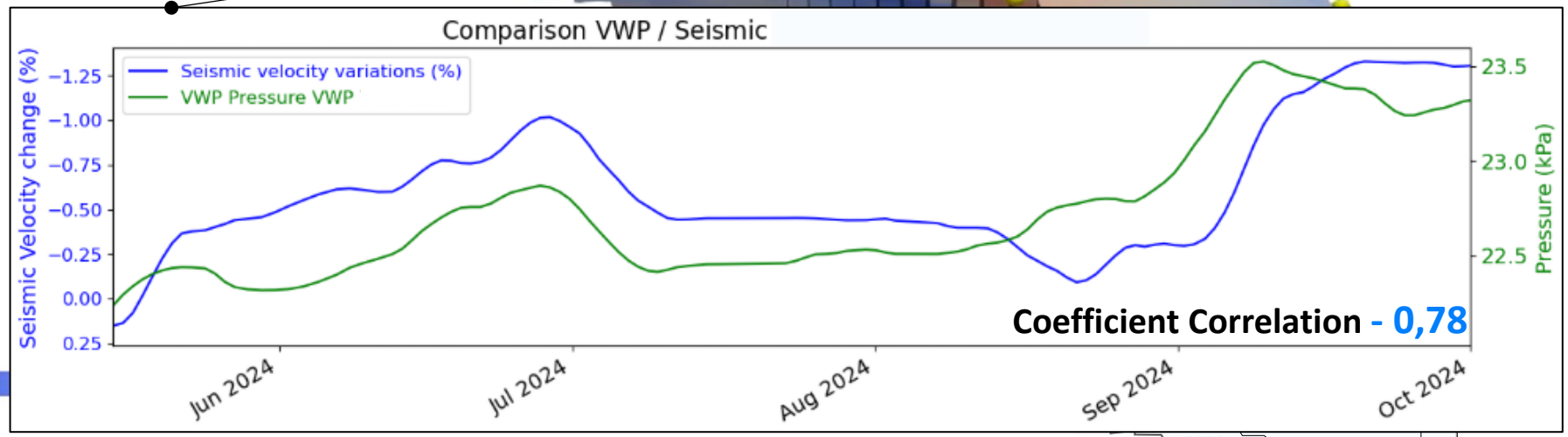
Interpretations

Pore pressure mon







Day: 0

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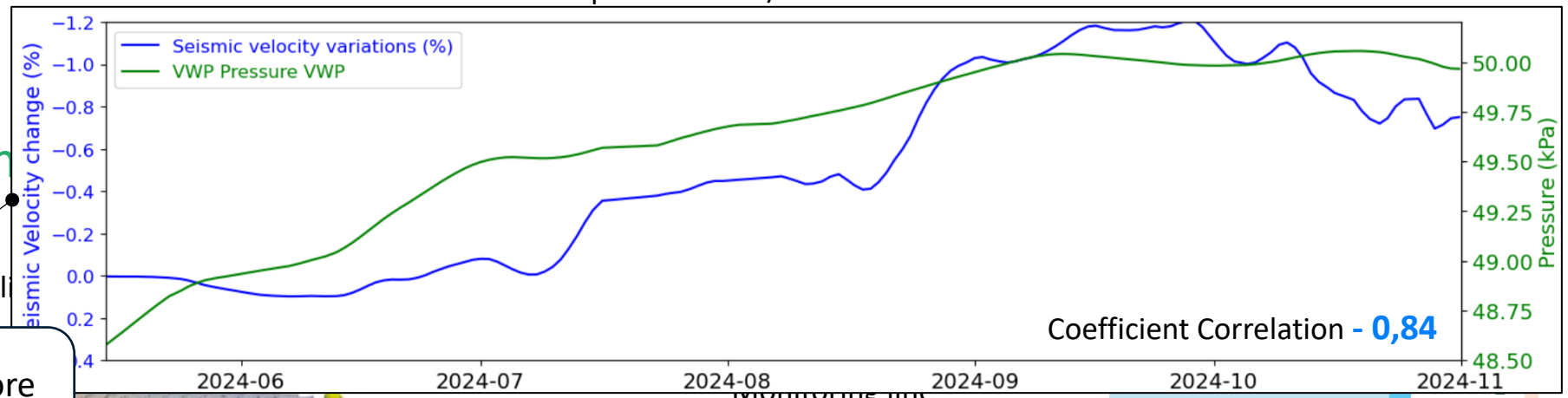
Interpretations

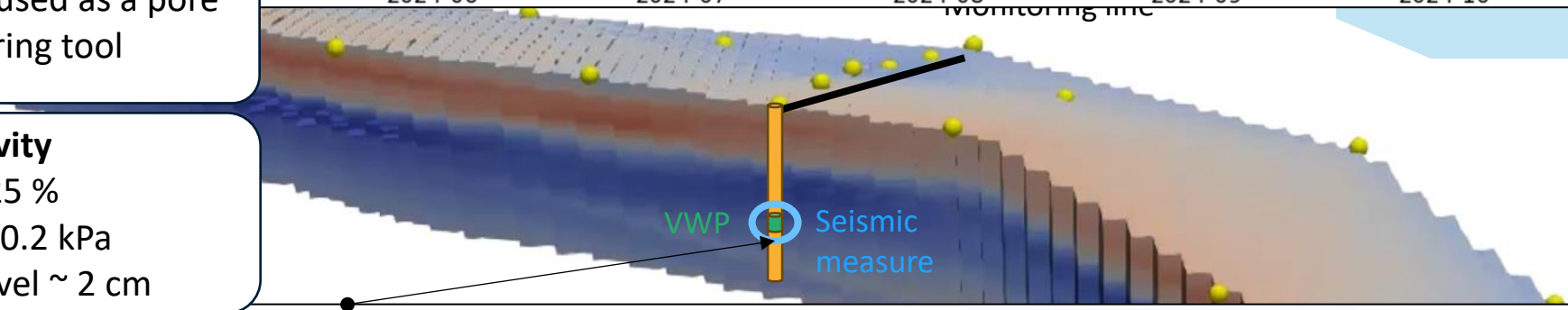
Pore pressure mon

Passive seismic can be used as a pore pressure monitoring tool

High sensitivity
Seismic ~ 0.25 %
Pore pressure ~ 0.2 kPa
Phreatic surface level ~ 2 cm

Comparison VWP /seismic





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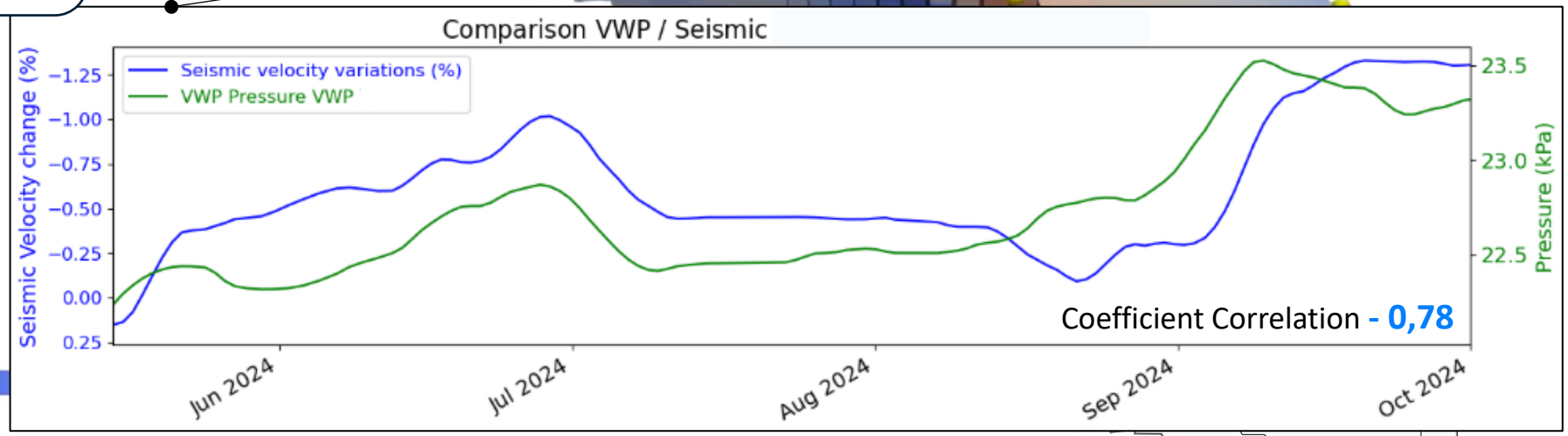

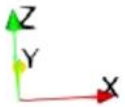

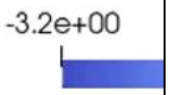

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Use and applications

Seismic velocity is sensitive to:
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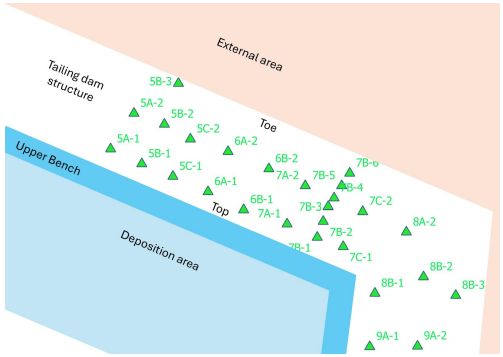
- **Density/stiffness**



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The method allows for complementing VWP

- **Hydrogeological information in between boreholes**
- **Cross-validation** (redundancy, reduce false alarms)

The method allows for monitoring

- **Deposition cycles influence**
- **Meteorological effects**
- **Construction activities effects**

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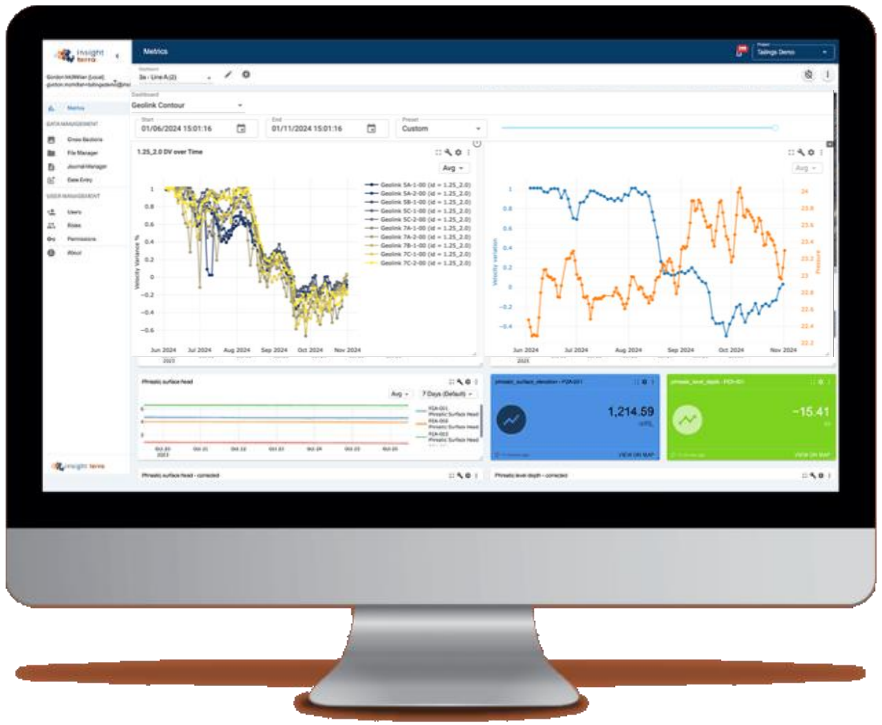

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Interoperability

- **Integration in client data environment**
- **Integration in TARP**

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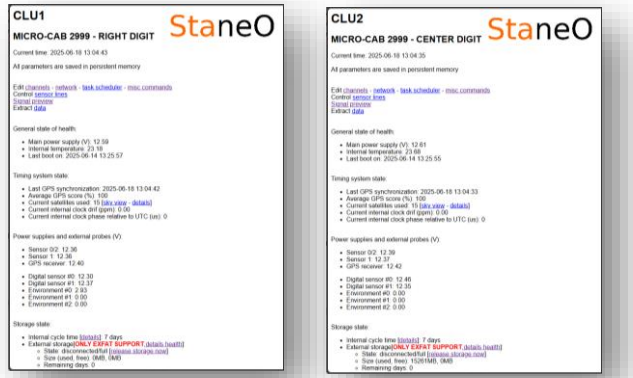
Use and applications

Real-time data transfer & processing

Autonomous
No site intervention
Robust (meantime failure 2/3 years)

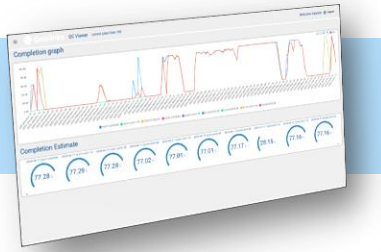
real-time plot (raw)

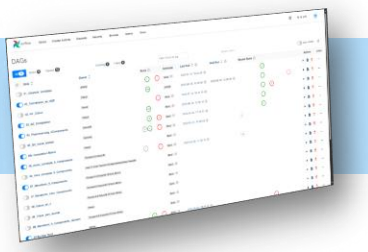


digitizers status

Data Logger
Can be monitored/configured remotely
Collects and stores raw data at high resolution (2,000Hz)
Streams data in real-time in standard format (miniSEED) at chosen resolution (100~200Hz) to cloud (AWS buckets)

Processing specifications
Processed & interpreted data available at t+2h
Temporal resolution – hourly to daily





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Outline

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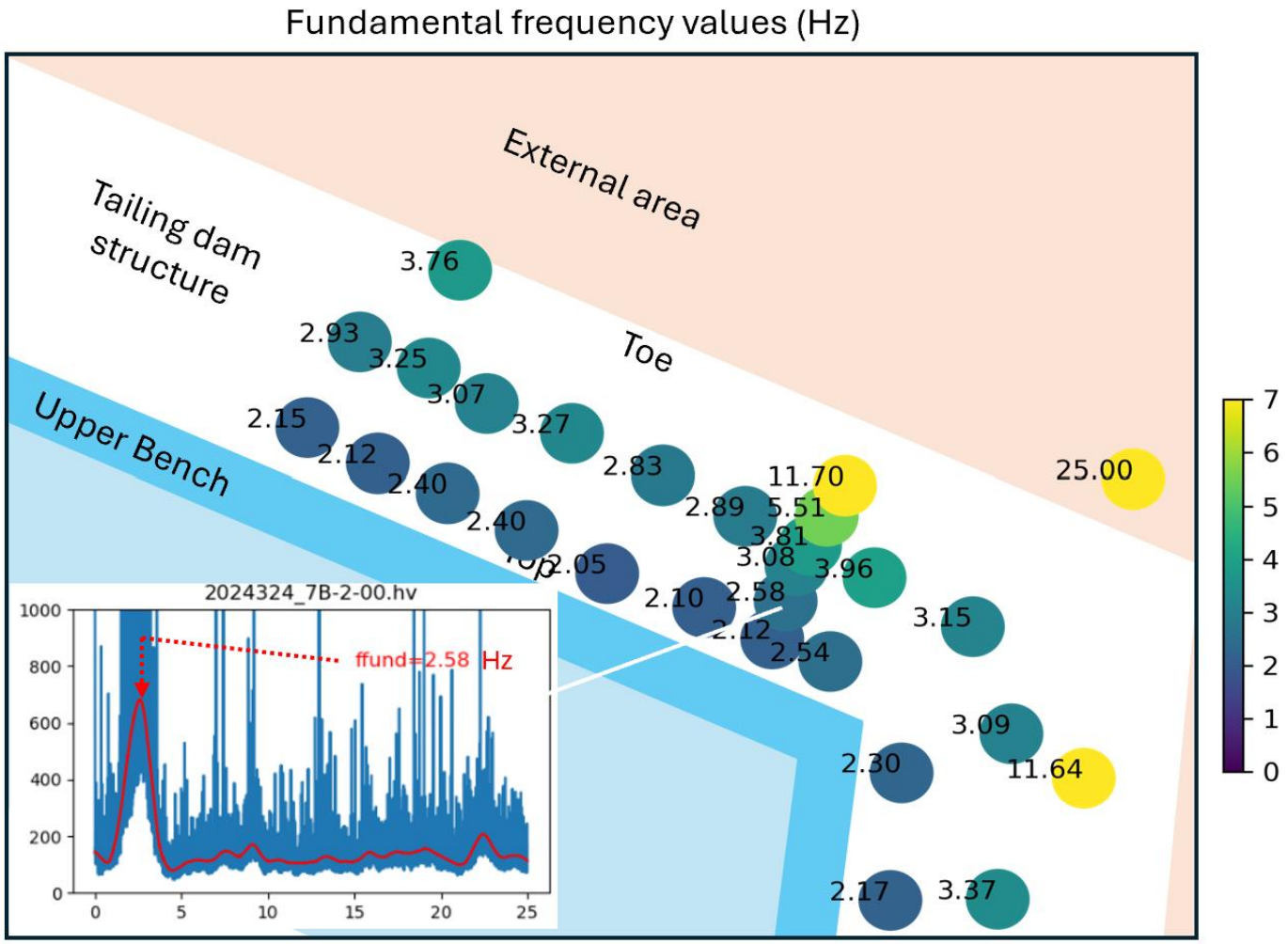
3. **Seismic predictive modelling parameters**

4. Conclusions

Multi-purposing

Resonance frequency



Inform seismic resonance risks
Reveals structural heterogeneity

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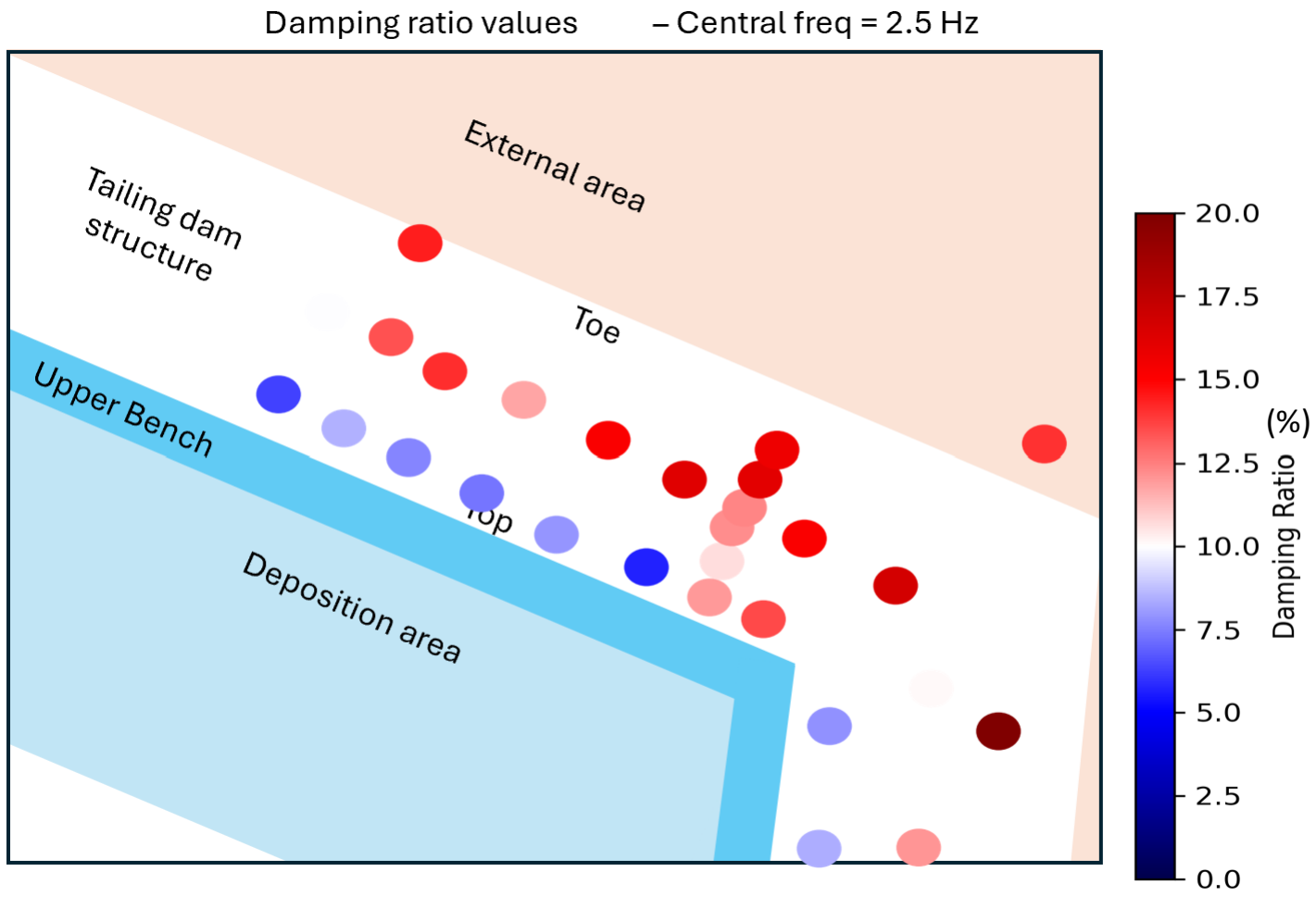
Multi-purposing

Damping ratios



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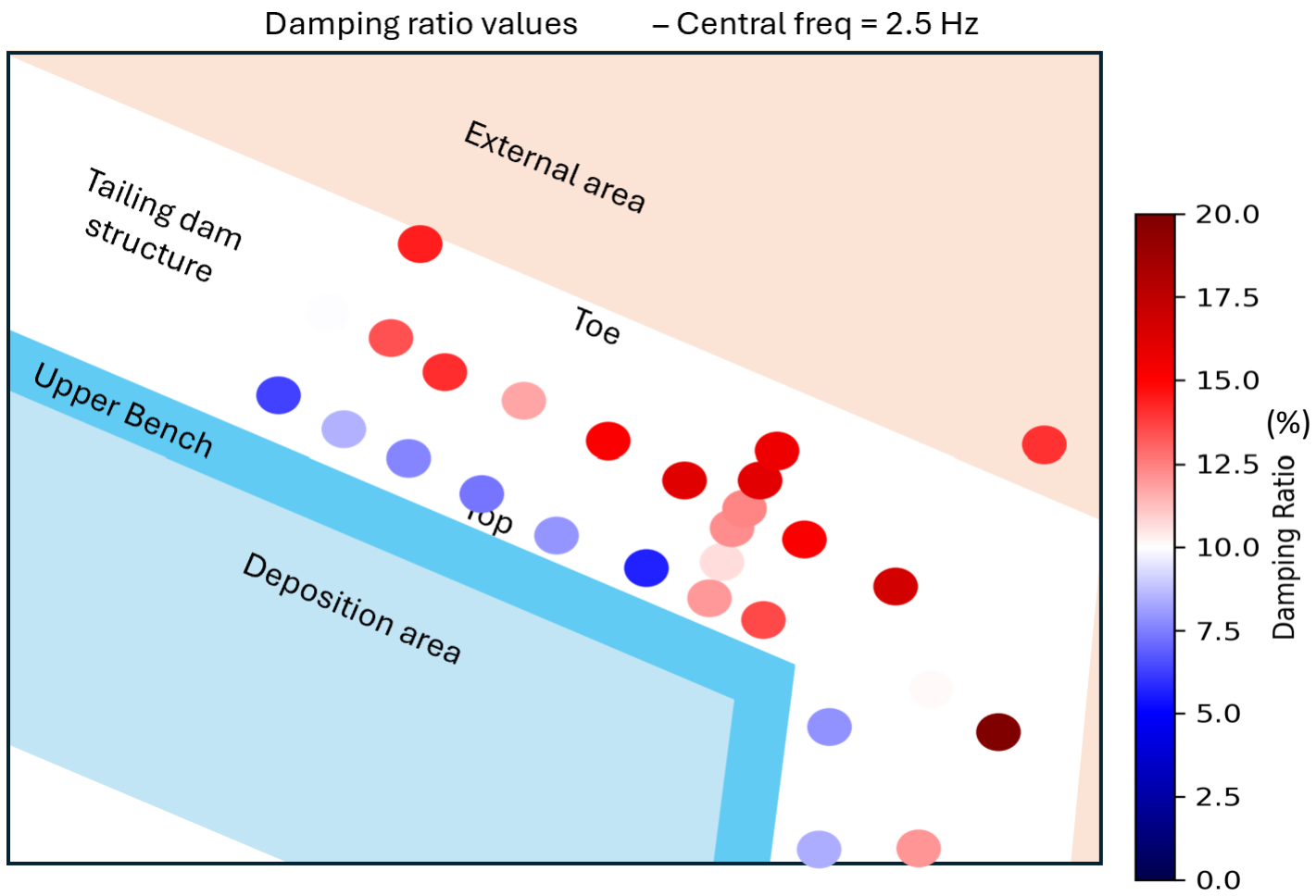

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Seismic risks predictive modelling

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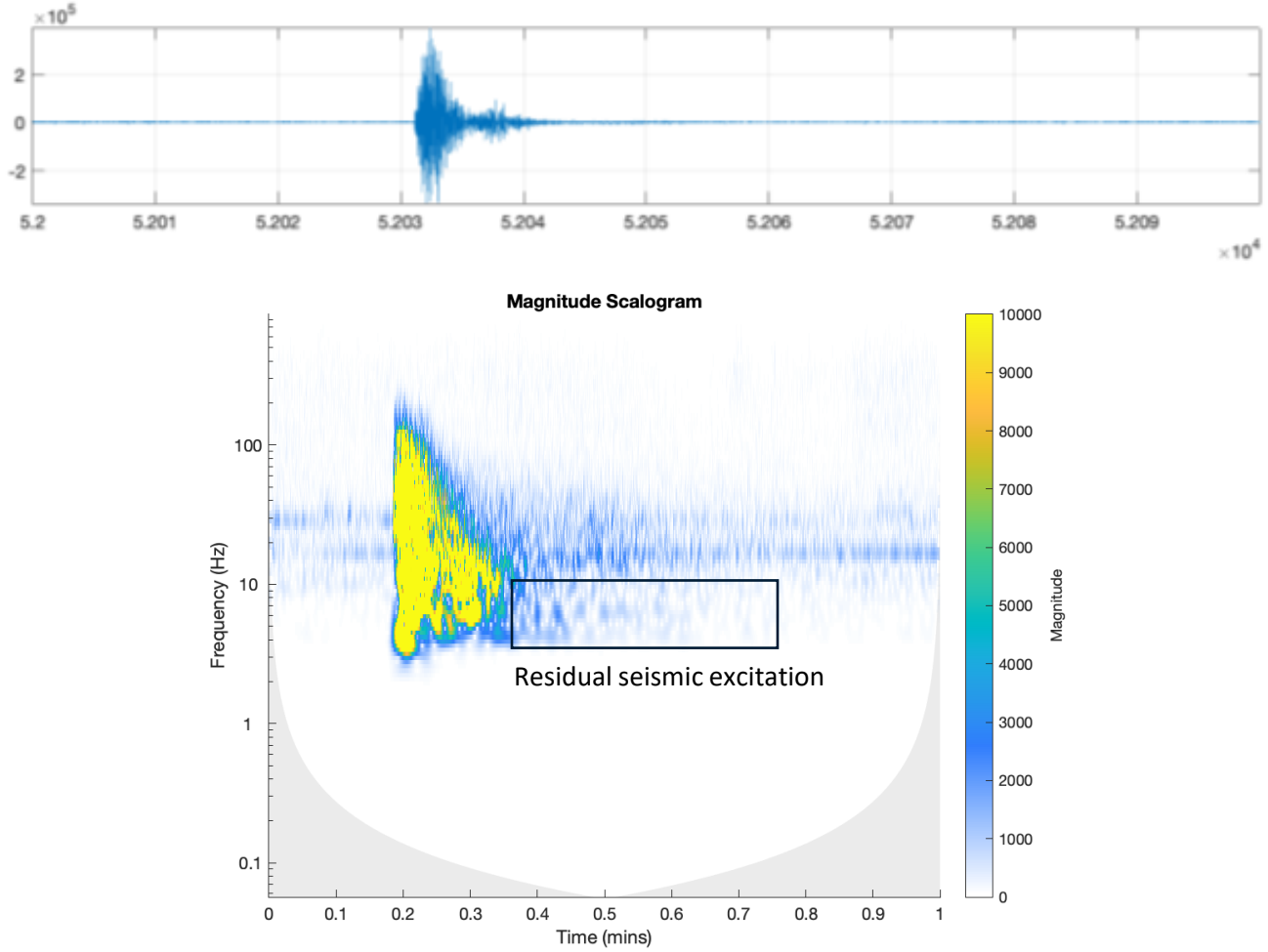
Multi-purposing

Seismic events monitoring

Microseismic assessment - single station measurement



Inform seismic resonance risks
Reveals structural heterogeneity

Inform seismic attenuation capacity of the TSF

Seismic risks predictive modelling

Inform on the TSF response to significant seismic events (microseismicity, blasts)

Seismic risks assesment

Key messages

Passive seismic data set can be multi-purposed and provide multiple levels of information.

- 4D health monitoring (pore pressure & stiffness)
- Seismic predictive modelling parameters.

Monitoring of pore pressures variations **at depth** and across **the entire structure** with **high sensitivity.**

Interoperability, **cross-validation**, can be integrated into TARP and surveillance platforms

Non-invasive deployment, **adaptable** throughout the entire TSF life cycle.

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Use and applications

Visualisations

Seismic velocity is sensitive to:
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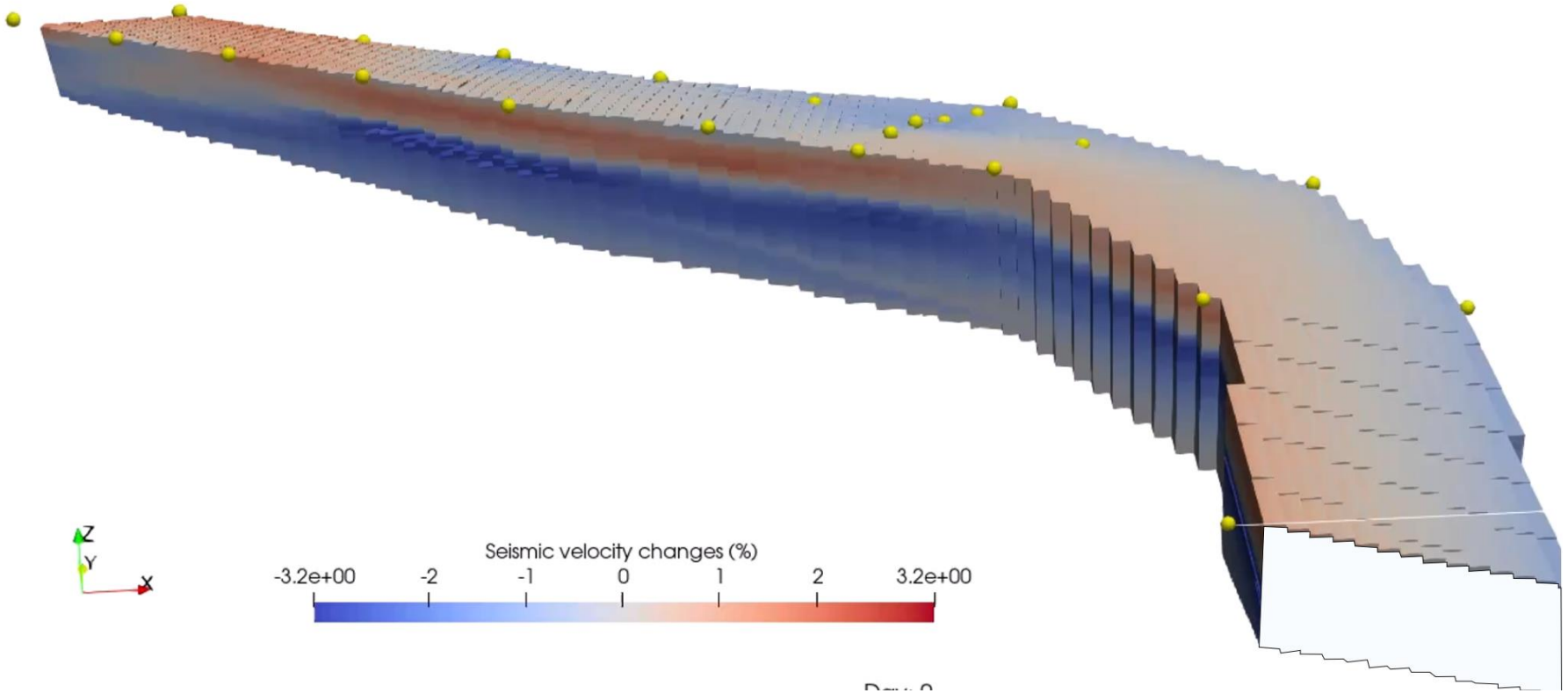
- **Density/stiffness**

Data can be visualized according to main target requirements

4D



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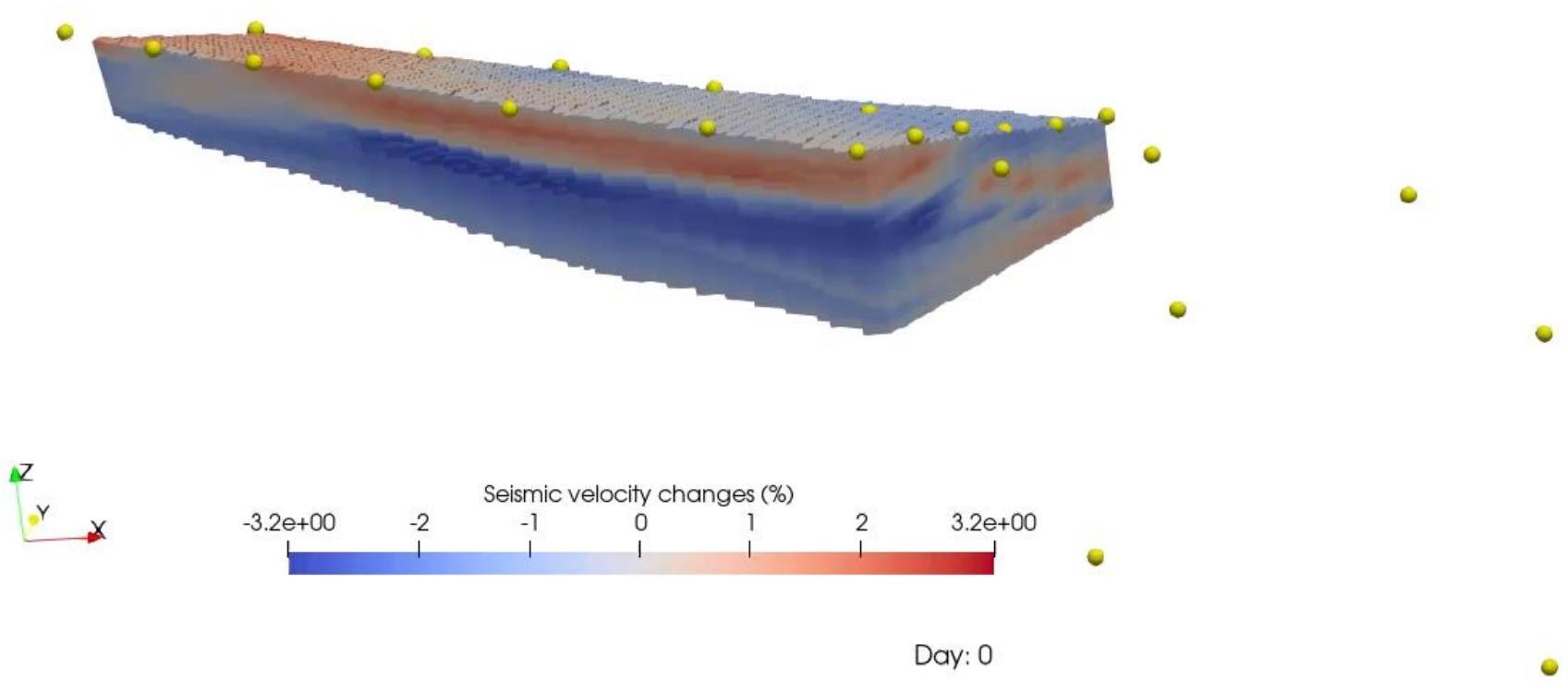

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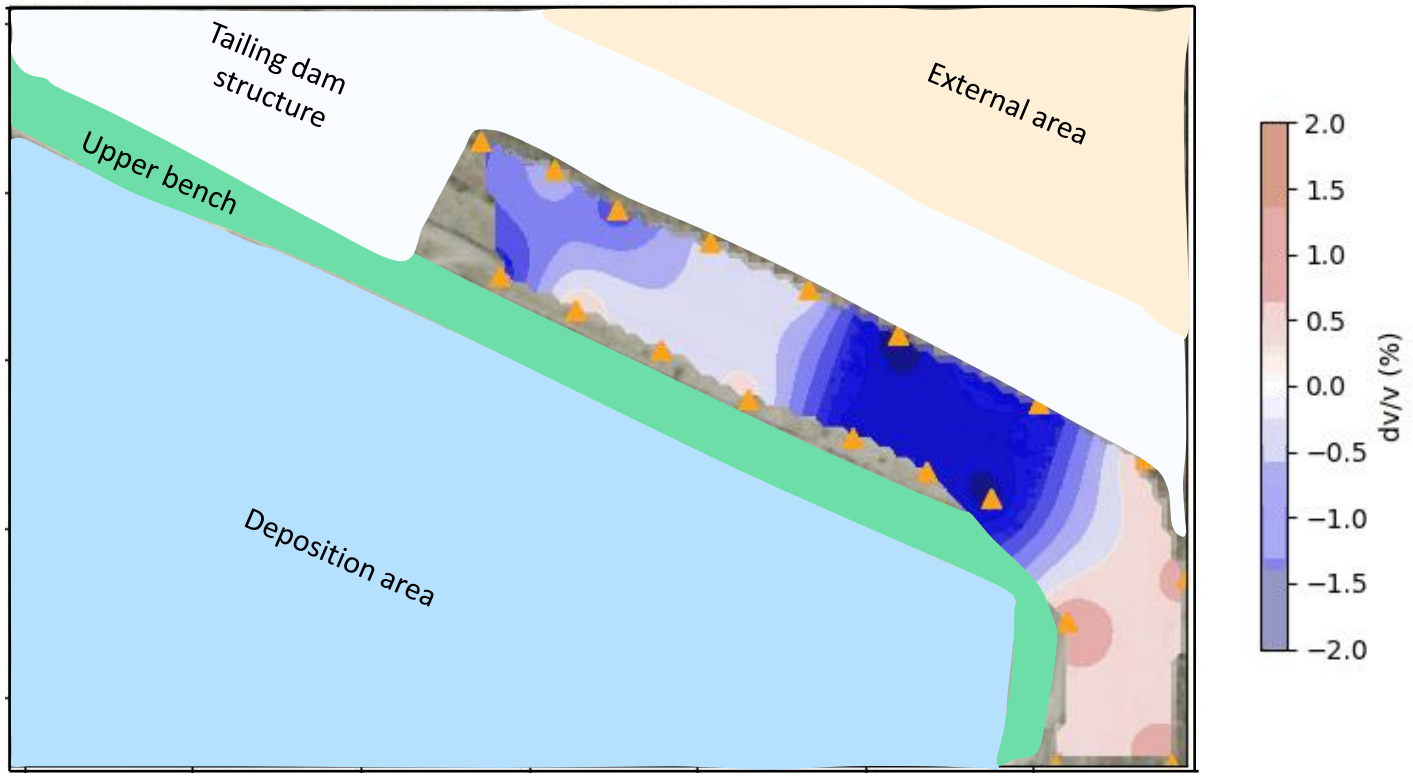
2D heat maps



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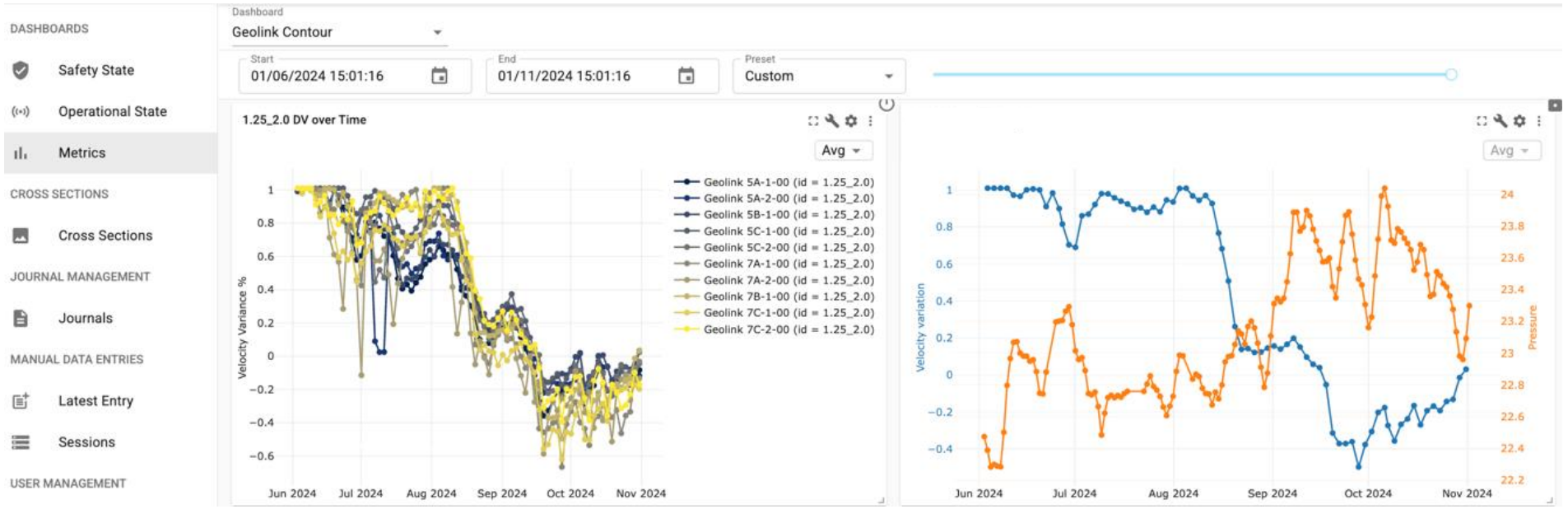
Time-series



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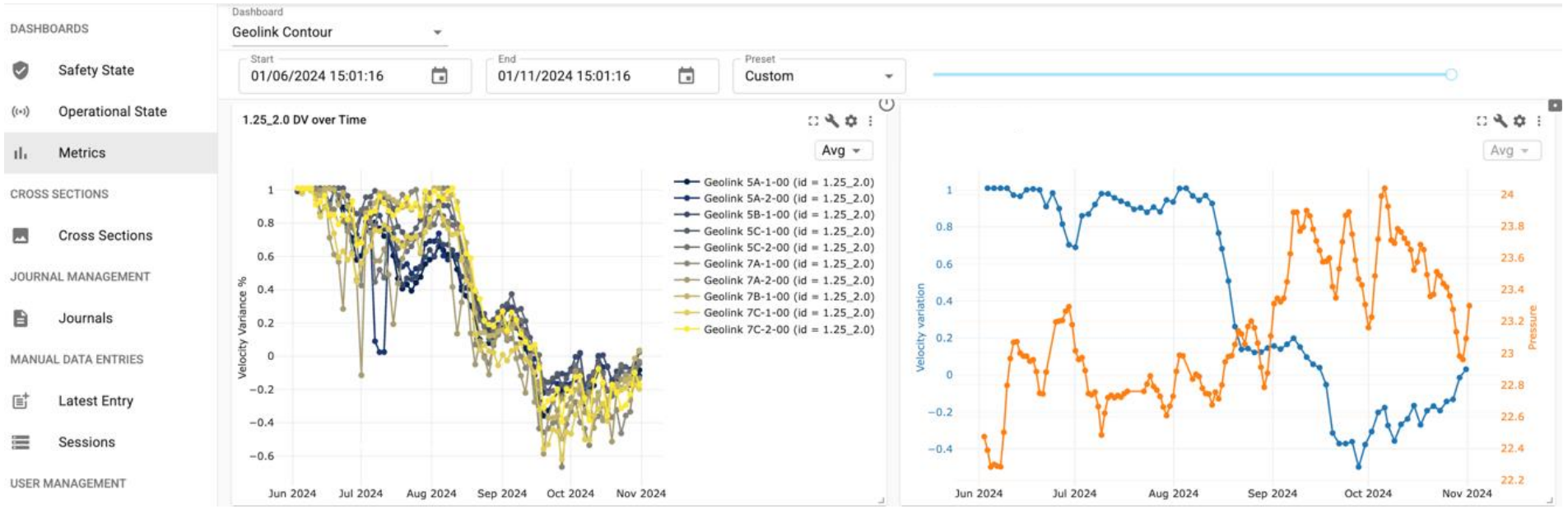

Functionalities can be integrated into the TARP

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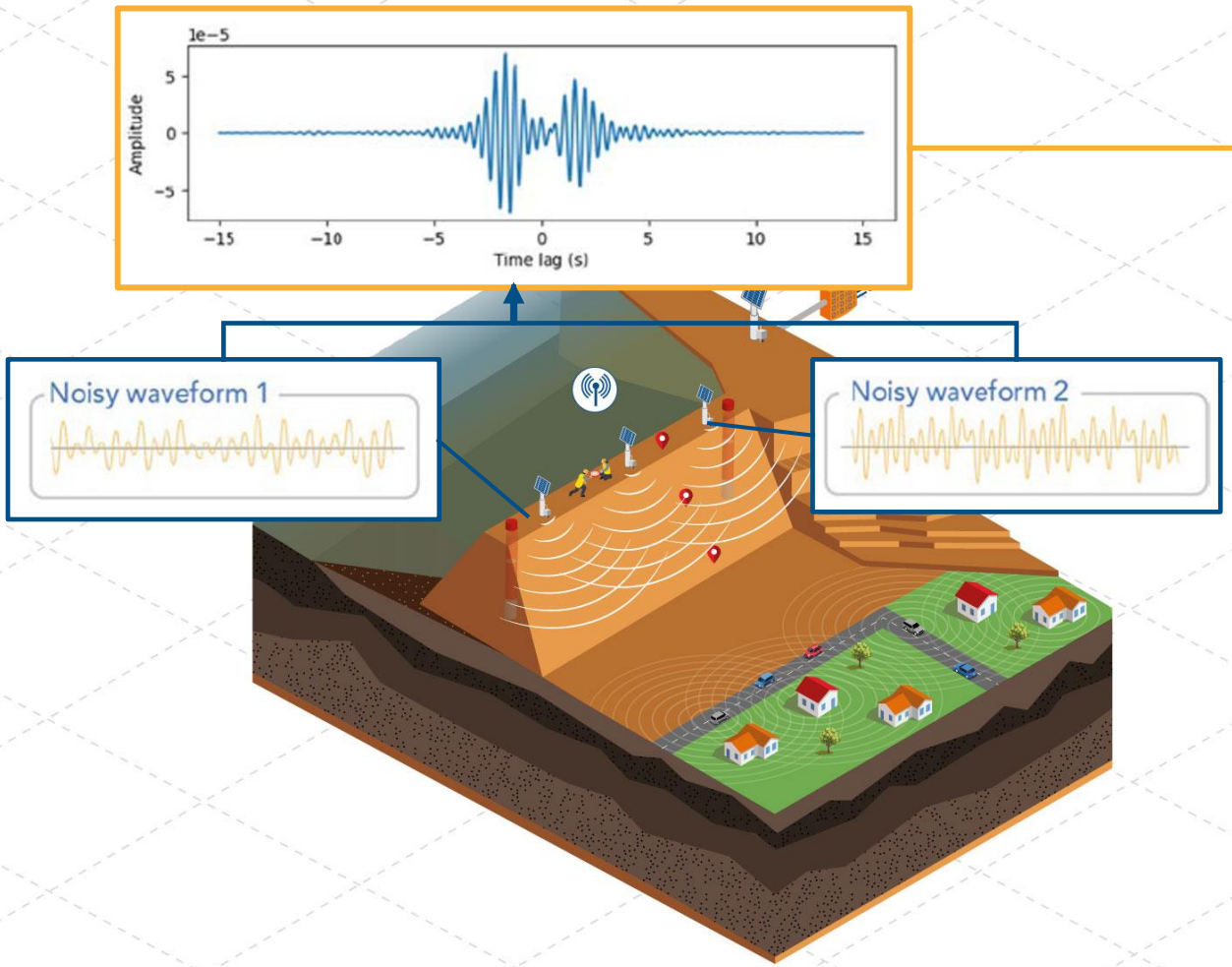
Seismic velocity variations

Ambient noise seismic interferometry (ANSI)

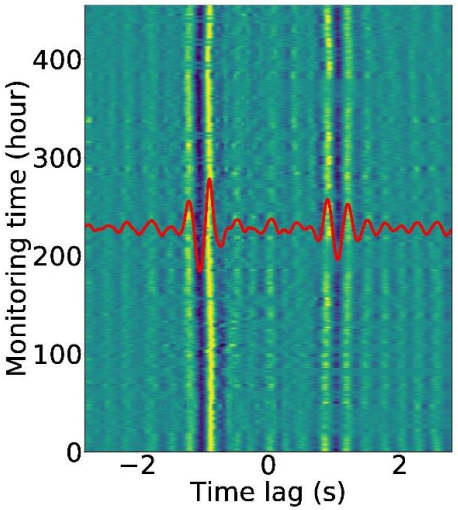


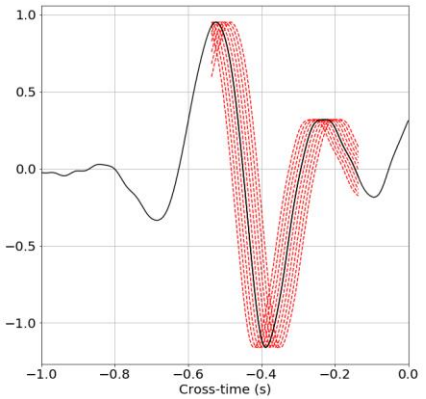
Reconstructing seismic waves

Repeat in time

Measure velocity variations

Sensitivity < 1%





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