

Development of Non-intrusive Monitoring Using Cross-hole Seismic Tomography Techniques

Objectives

To investigate the use of cross-hole seismic tomography technique as a potential method to non-intrusively monitor changes within a sealed deposition cell.

Non Intrusive Monitoring of the NAGRA HG-A Experiment at Mont Terri URL Switzerland

- Experiment designed to mimic the evolution of a sealed disposal tunnel, replicating the phases of buffer saturation and gas generation (from canister corrosion).
- Aim is to identify gas migration paths and measure gas migration through the Opalinus Clay and along the engineered seals.
- 1m diameter micro-tunnel backfilled with a sand and sealed with a hydraulic mega-packer
- Several measurement phases conducted to represent backfill emplacement and saturation of the micro-tunnel and gas generation.

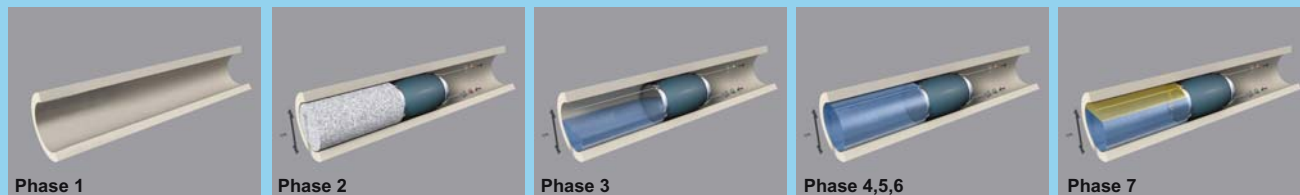
Conclusions

- Inspection of the seismograms revealed that the HG-A micro-tunnel seems to affect waveforms – this can be exploited with full waveform inversions.
- Geophones located within the HG-A micro-tunnel are capable of resolving the changes in experimental conditions (changes in the EDZ following saturation are observable).
- Travel-time inversions of the seismic data allow the main structural features of the Opalinus Clay to be delineated.

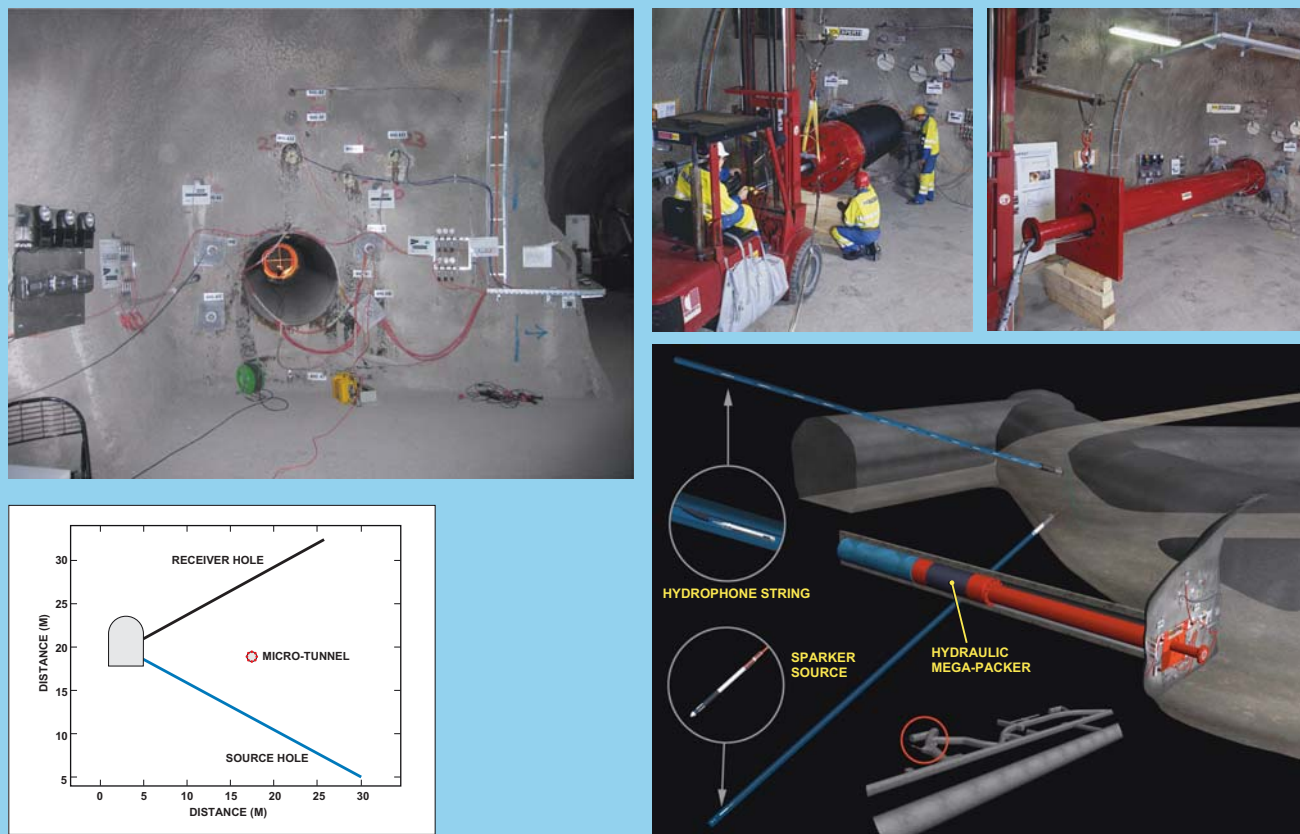
Further Work

- Continue measurement campaigns (gas injection phase).
- Development of transverse anisotropic full waveform inversion code.
- Application of waveform inversion code to collected data sets from Mont Terri.

Experiment Phases

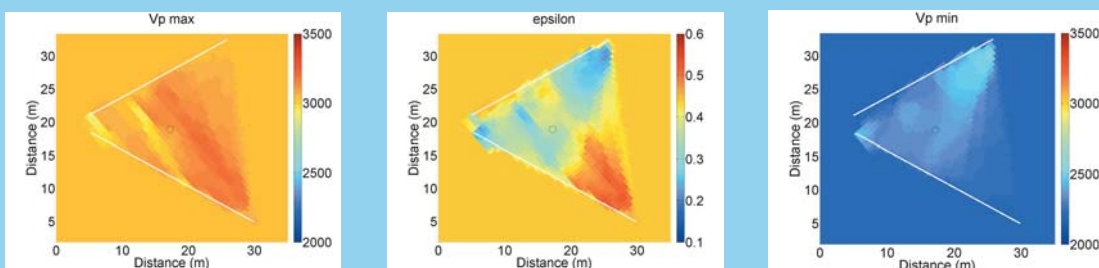


HG-A Test Setup and Construction



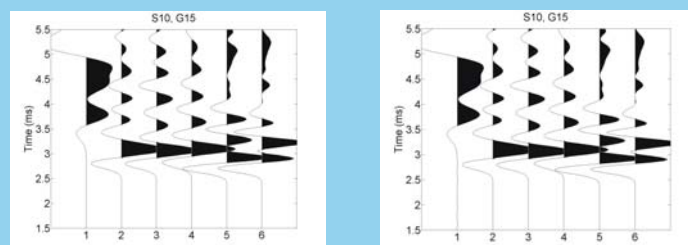
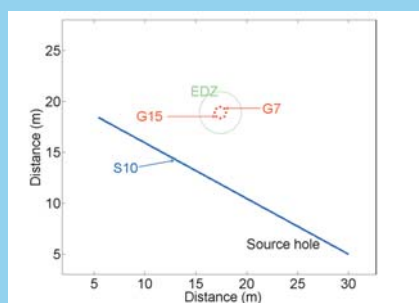
Results and Analysis

Anisotropic Travel-time Inversion



2D anisotropic travel-time inversions reveal a pronounced anisotropy of up to 50% (epsilon tomogram). Velocity tomograms for the fast (Vp max) and slow direction (Vp min) indicate layering of the Opalinus Clay. Micro-tunnel cannot be resolved with travel-time tomography.

Effects of Changes within the Micro-tunnel & its Excavation Damage Zone on the Seismic Waveforms



Seismograms from a shot at position S10 observed at locations G15 and G7 (see left) during the different phases of the experiment (see above).

Project TEM (Test & Evaluation of Monitoring Techniques) at Grimsel URL Switzerland

- Utilises the full scale (3.5m diameter x 4 m long) low pH shotcrete plug experiment being constructed under ESDRED Module 4.
- Aim is to demonstrate the support capacity of the shotcrete plug under realistic conditions (resisting the swelling pressure of the bentonite buffer).
- Provided the opportunity for simultaneous comparison of non intrusive seismic tomography alongside wireless (using magneto-inductive) and conventional wired systems.
- Provided the opportunity to investigate the use of cross-hole seismic tomography technique in a granitic geology.
- Several measurement phases planned during construction and at varying degrees of buffer (bentonite) saturation.

Grimsel Test Setup and Construction

