



# GEOPHYSICAL INVESTIGATIONS AT THE LSBB

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## **GEOPHYSICAL INVESTIGATIONS AT THE LSBB**

I - Seismic/ERT investigations - anisotropy

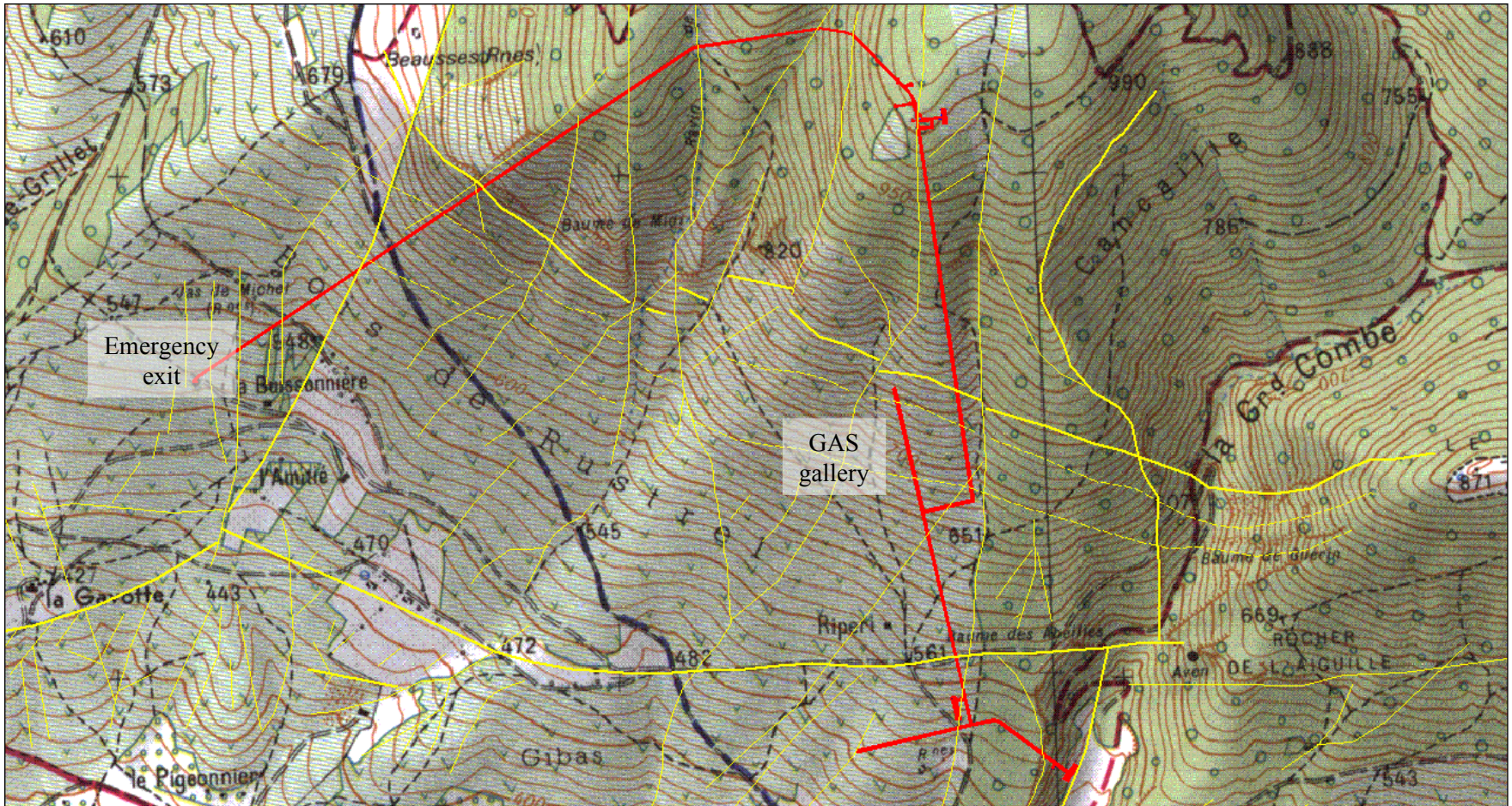
II - GPR investigations – multi-offset acquisition

III - GPR and ERT investigations from the surface



# The LSBB : an analogue of “horizontal borehole”

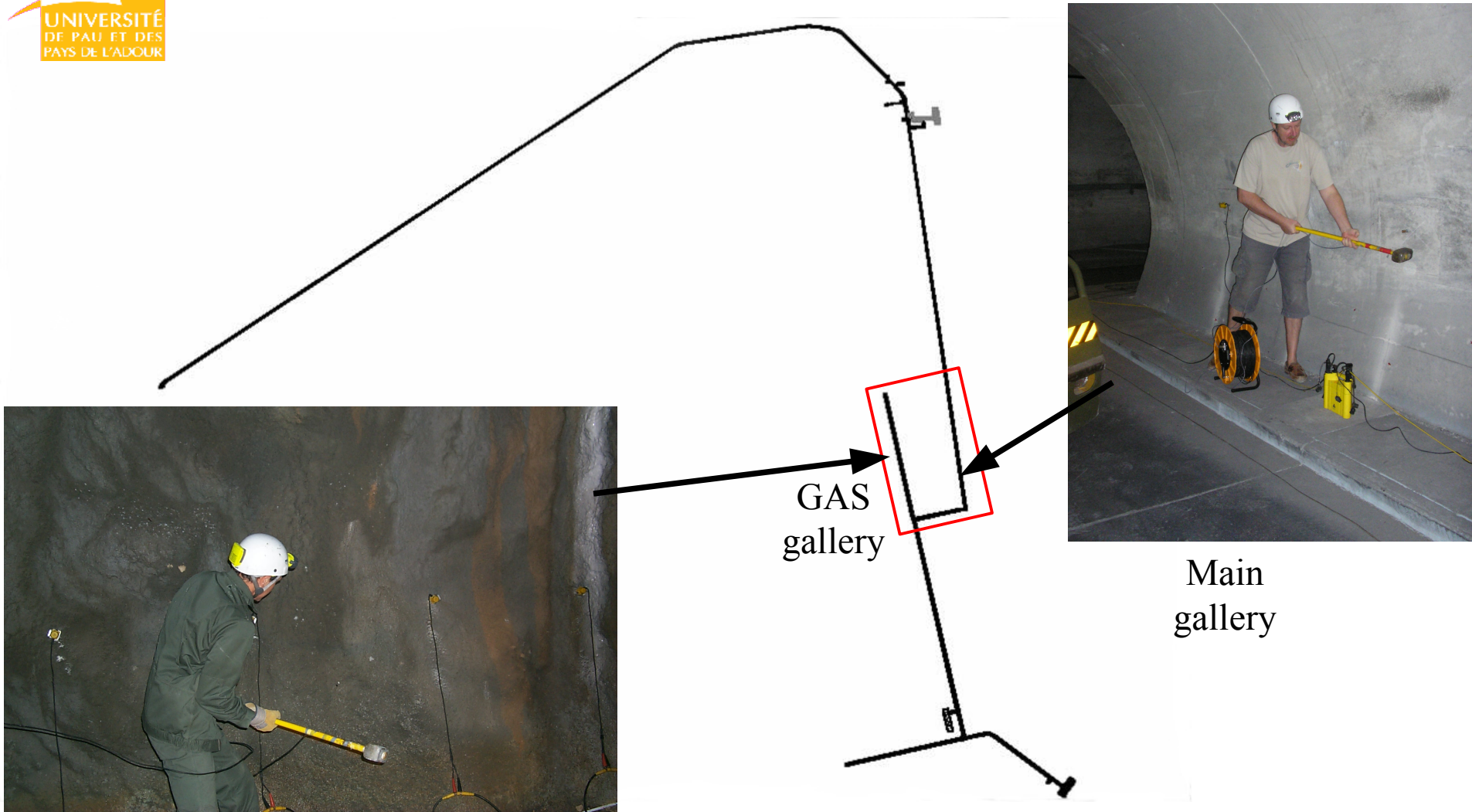
Can be considered « only » as an experimental site  
or as a water reservoir / oil reservoir analogue



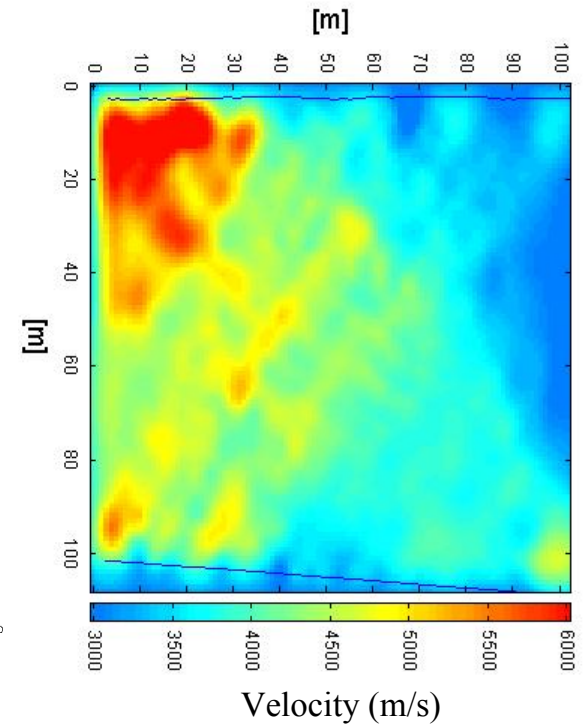
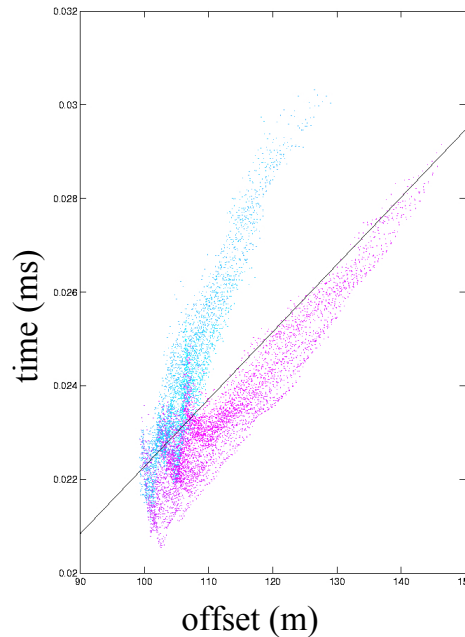
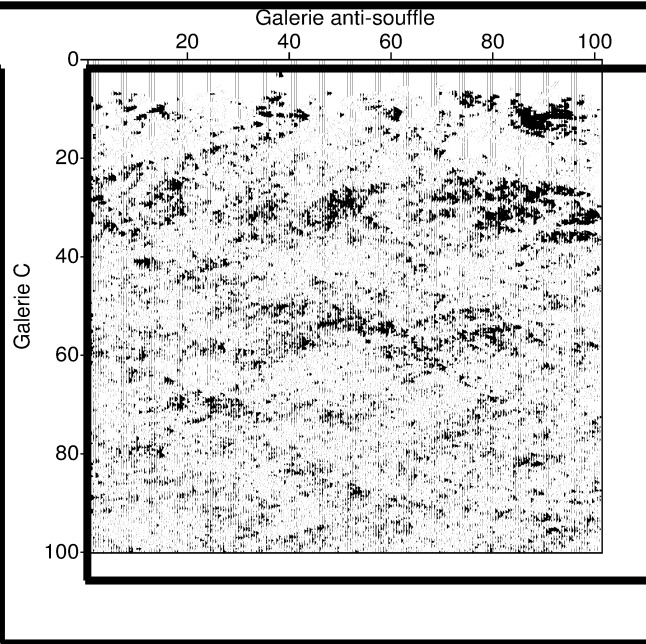
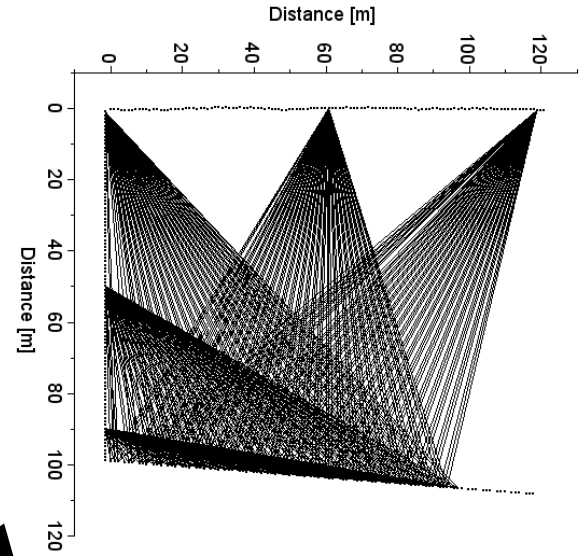
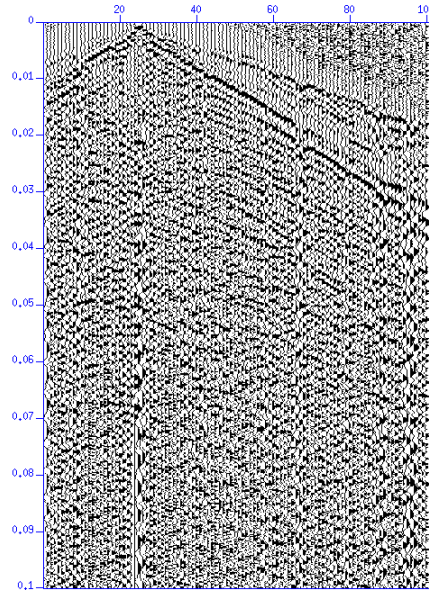




# First investigations : seismic (2004/2005)



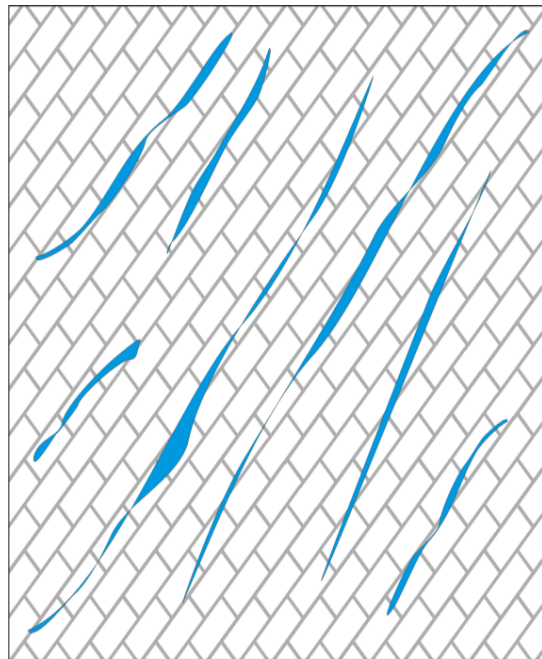
# Small scale seismic investigations



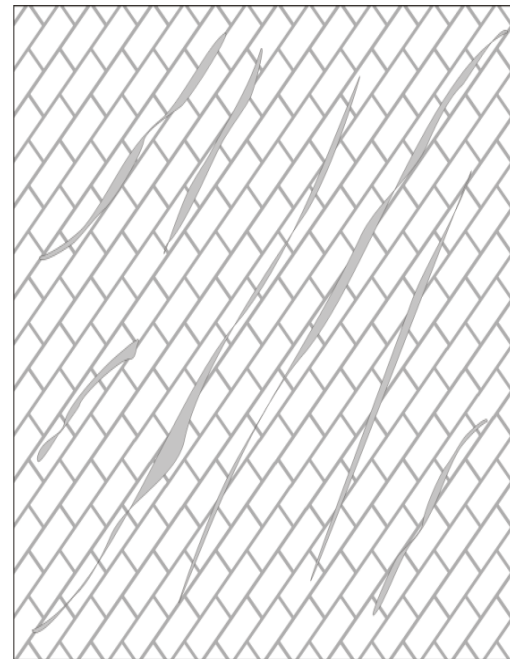


# Seismic/ERT anisotropy investigations ...

**Amount of anisotropy is dependent on the fractures and the saturation**



 Limestone  Water-filled fracture

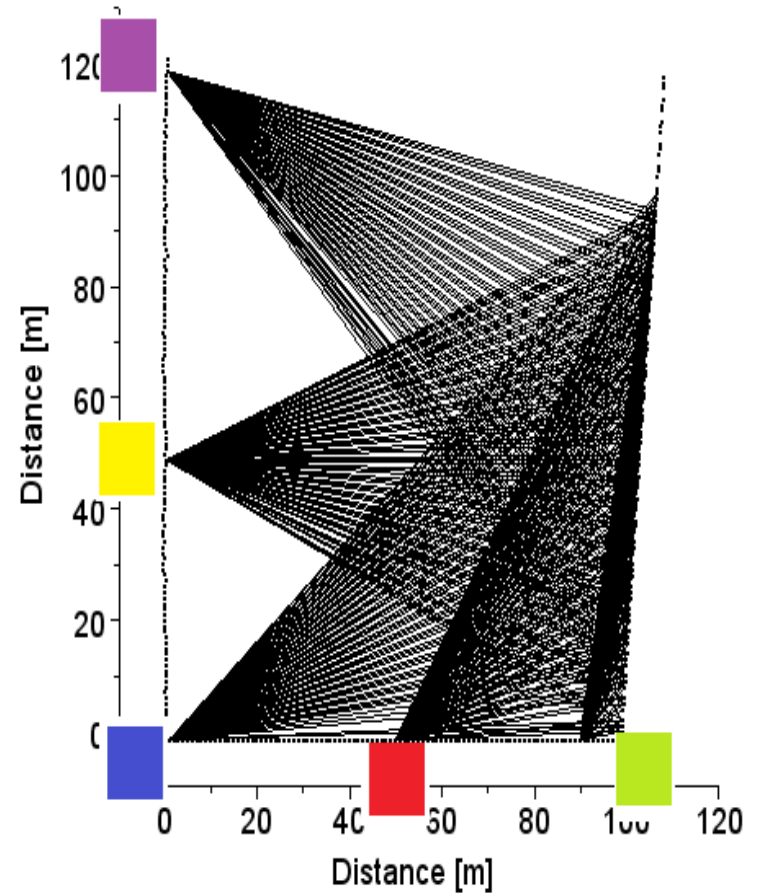
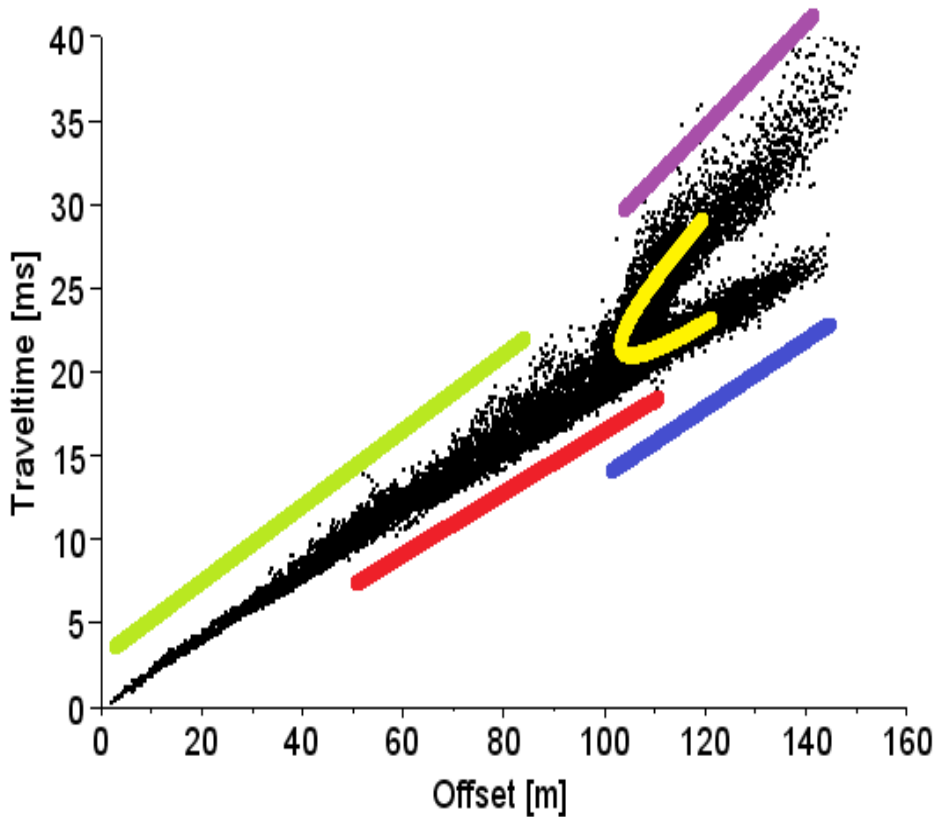


 Limestone  Air-filled fracture

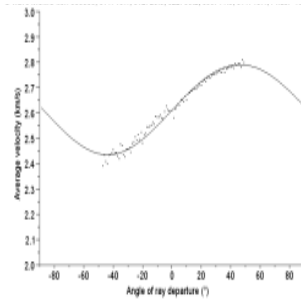
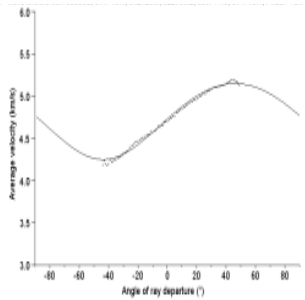
Electric  
conductivity

Seismic  
velocities

# Seismic anisotropy investigations ...



# Seismic anisotropy investigations ...



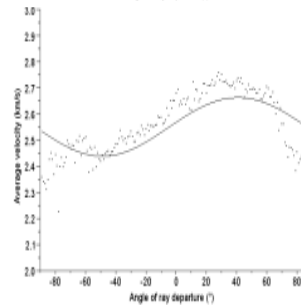
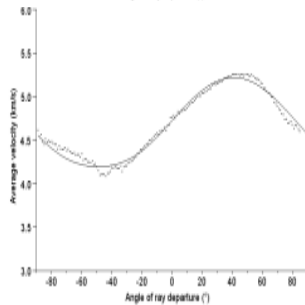
## May 2005

VPmin = 4.25 km/s

VSmin = 2.43 km/s

VPmax = 5.15 km/s

VSmax = 2.79 km/s



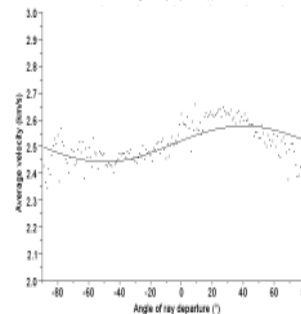
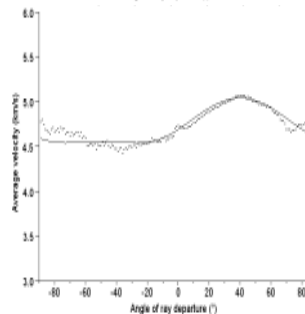
## June 2011

VPmin = 4.19 km/s

VSmin = 2.43 km/s

VPmax = 5.22 km/s

VSmax = 2.66 km/s



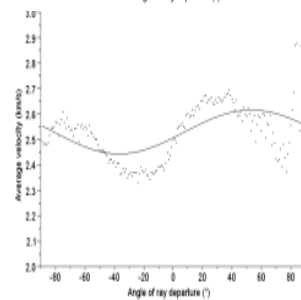
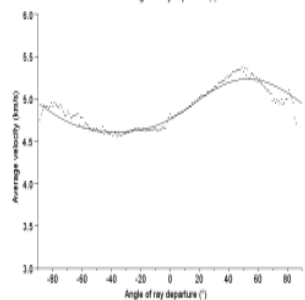
## July 2012

VPmin = 4.56 km/s

VSmin = 2.44 km/s

VPmax = 5.04 km/s

VSmax = 2.58 km/s



## December 2012

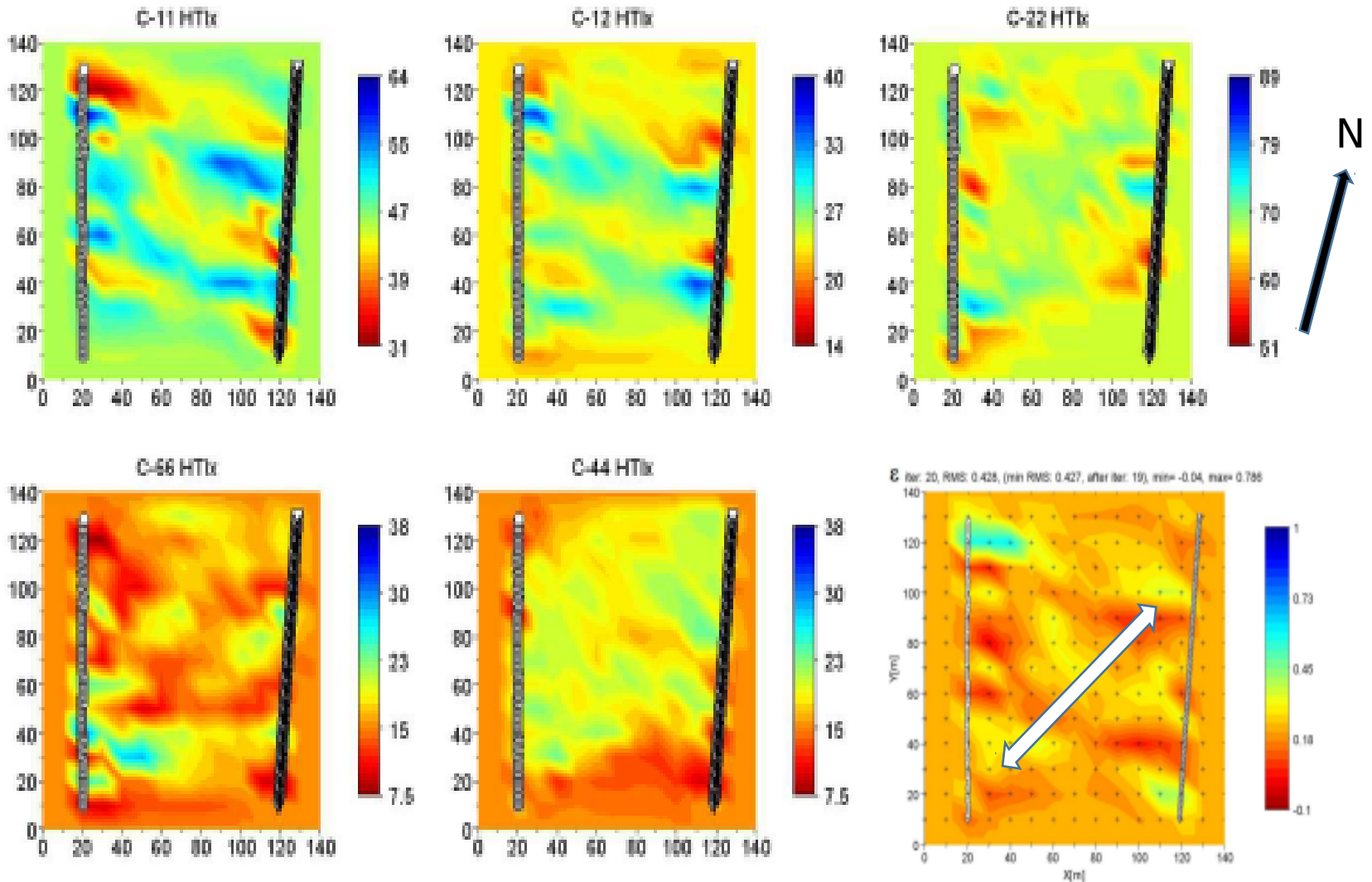
VPmin = 4.61 km/s

VSmin = 2.44 km/s

VPmax = 5.23 km/s

VSmax = 2.62 km/s

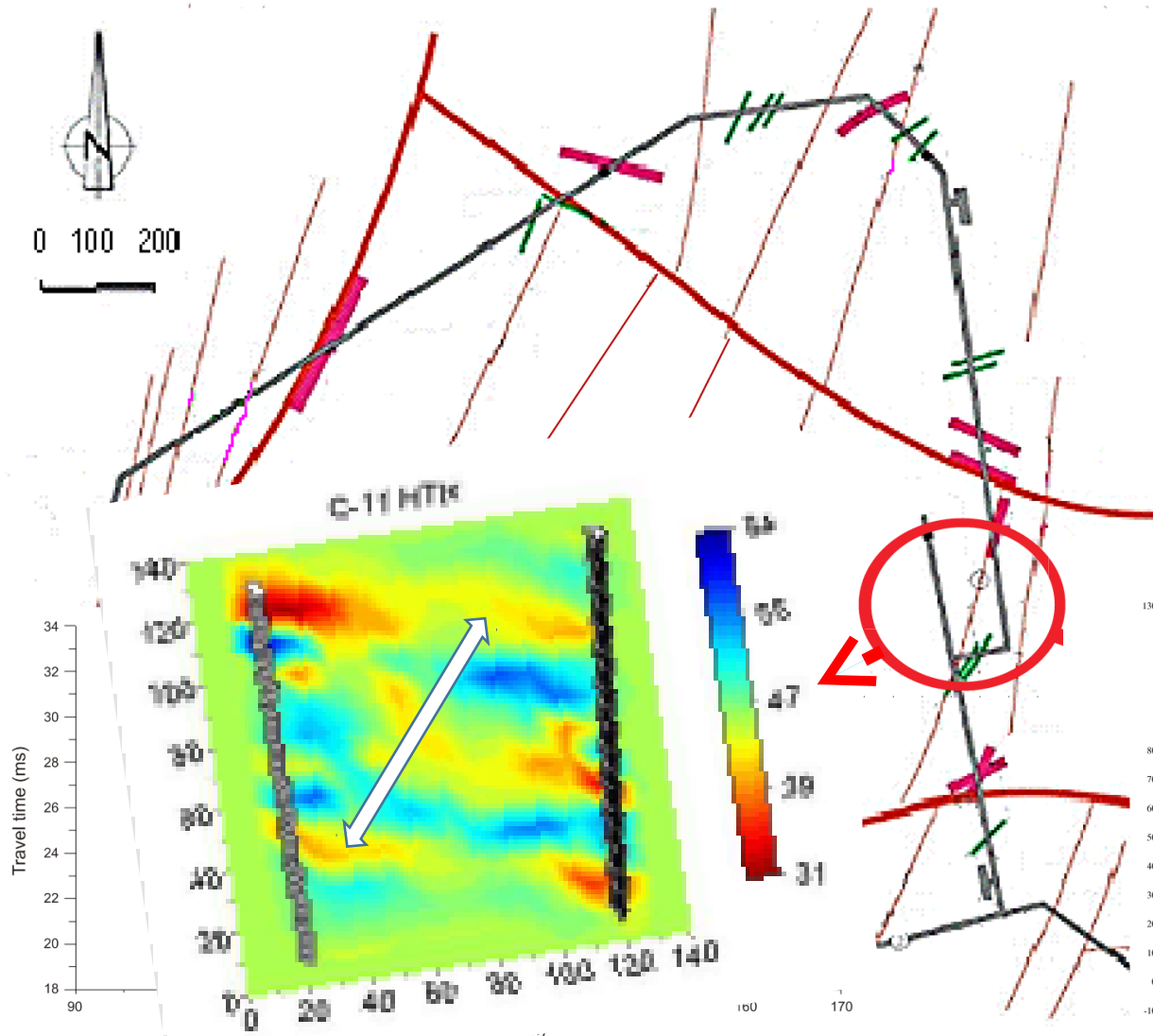
# Seismic anisotropy investigations ...



Distribution of parameters of stiffness matrix after inverting the data

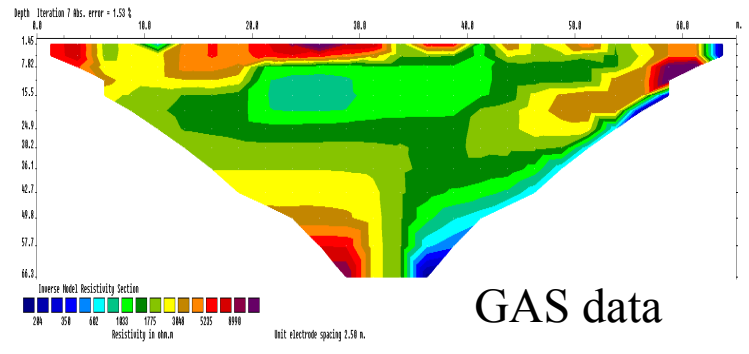
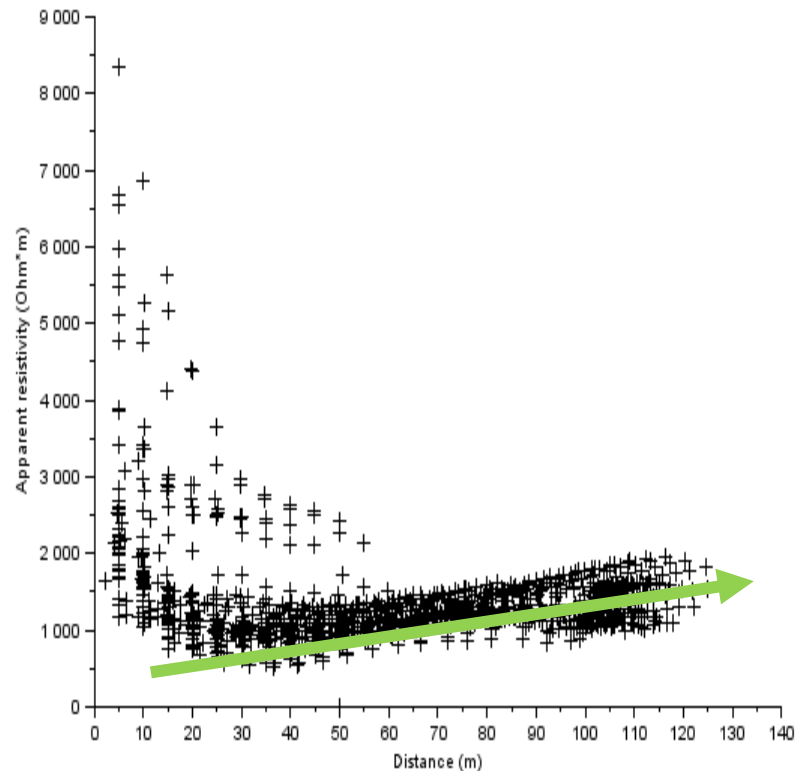
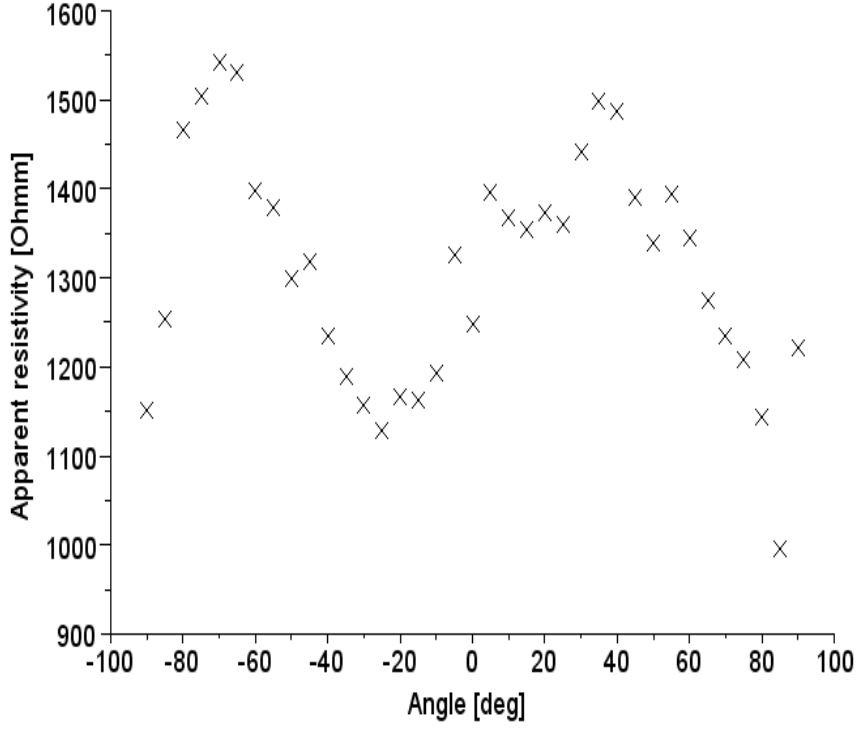


# Seismic anisotropy investigations ...

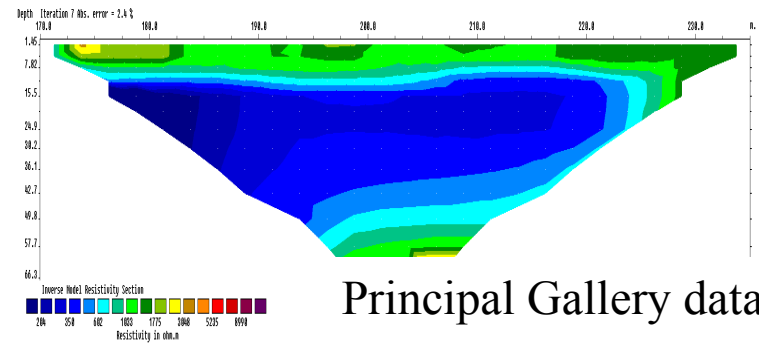


# Electric anisotropy investigations ...

Resistivity vs. azimuth variations

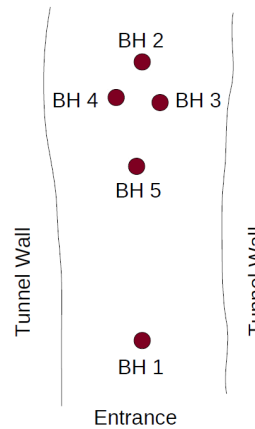
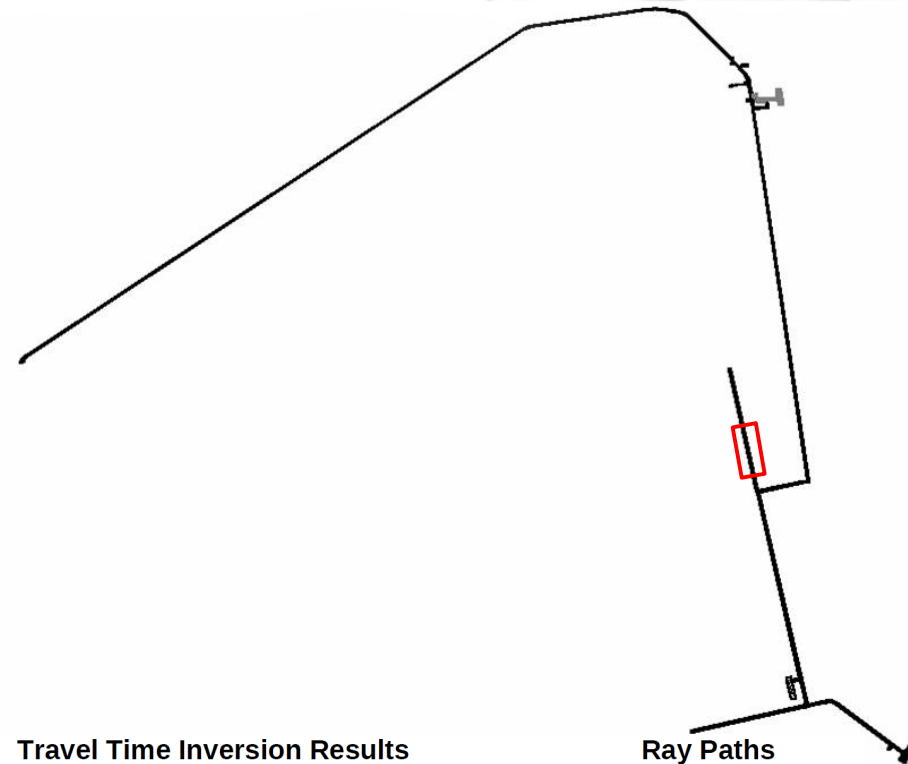
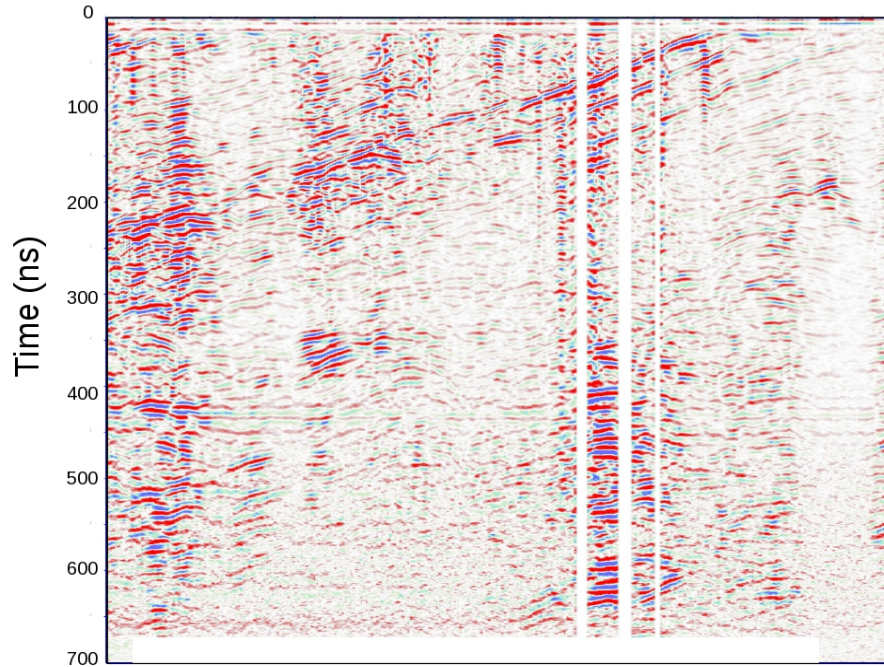


GAS data

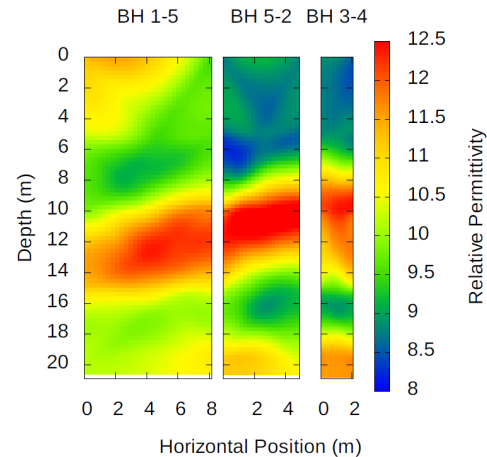


Principal Gallery data

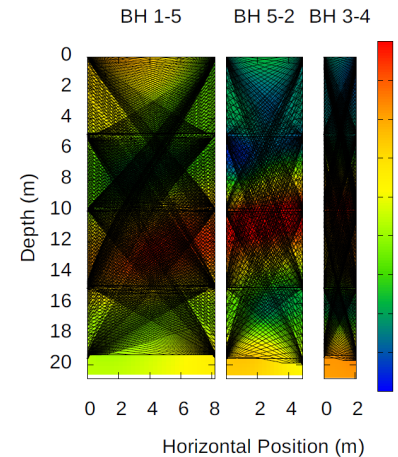
# Ground Penetrating Radar (GPR) investigations



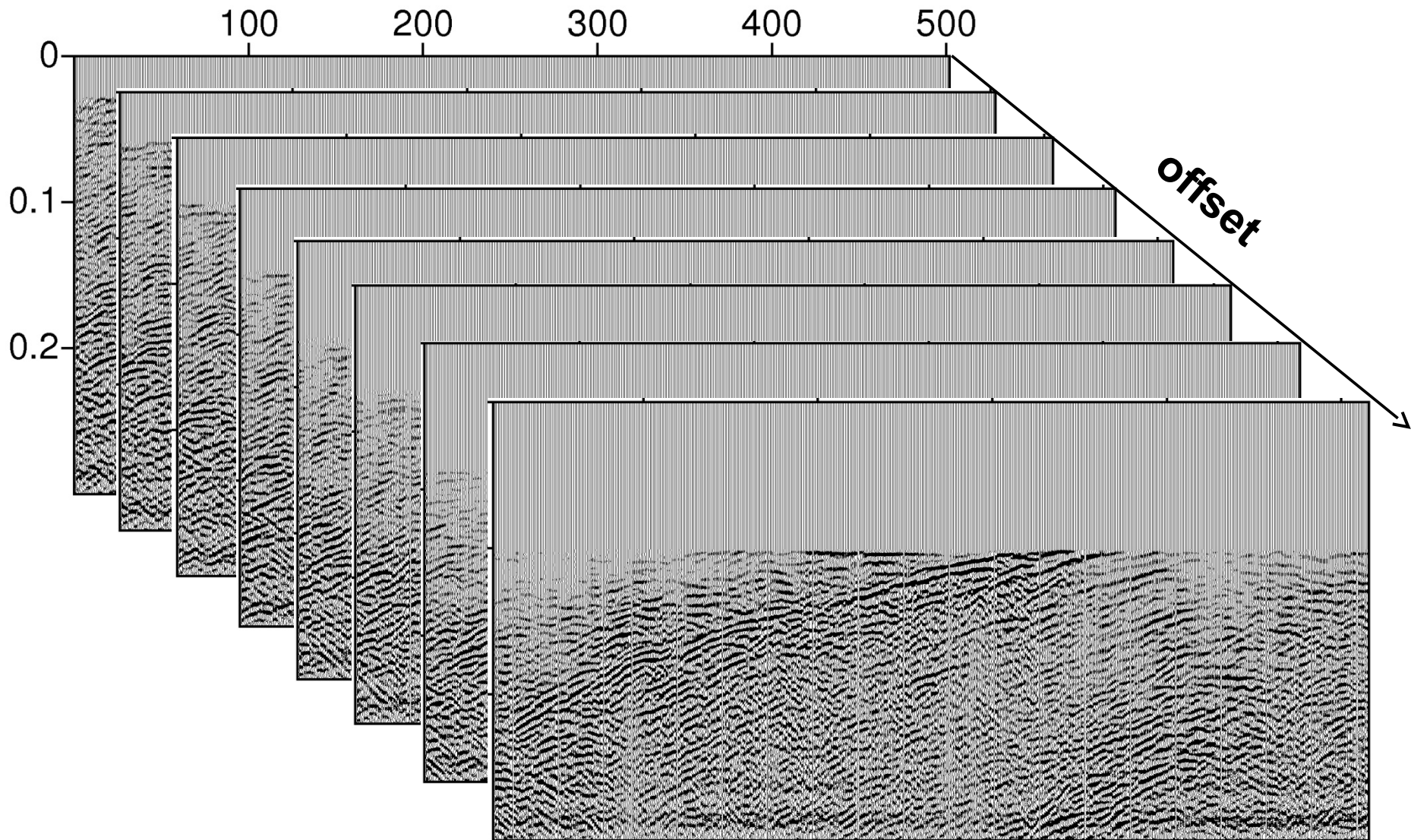
Travel Time Inversion Results



Ray Paths

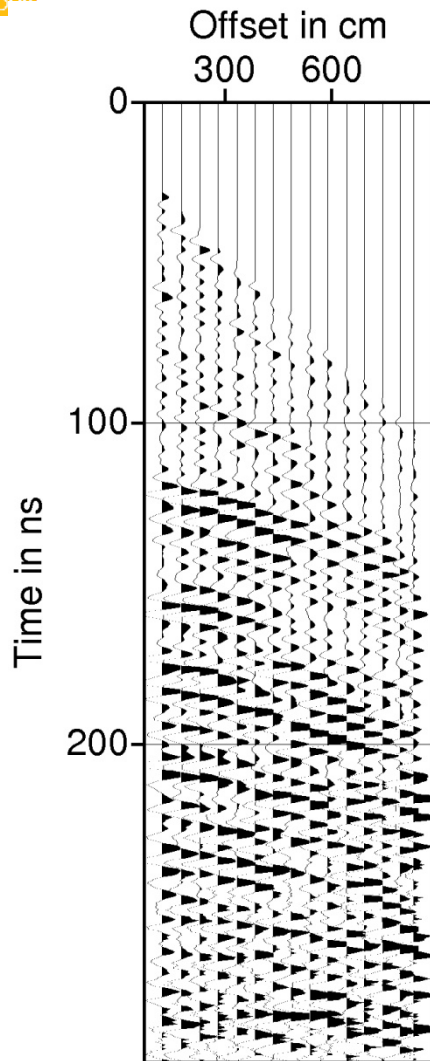


# Multi-offset GPR acquisition

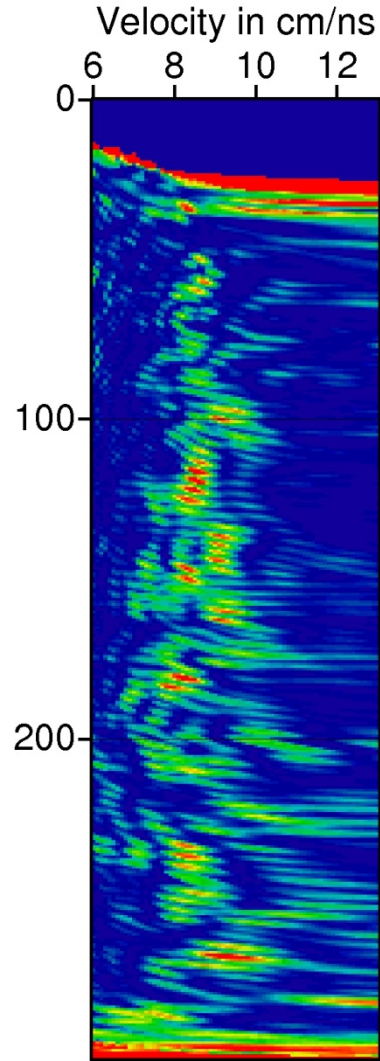




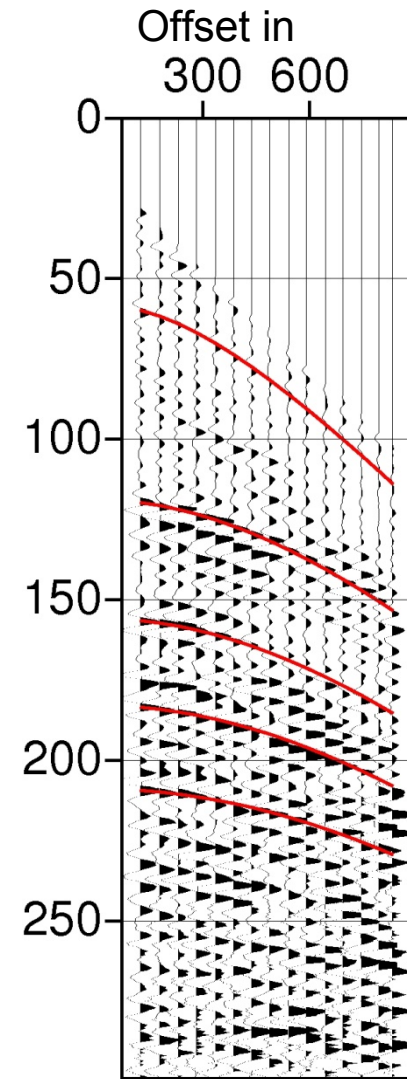
# Multi-offset GPR acquisition



**CMP 15**

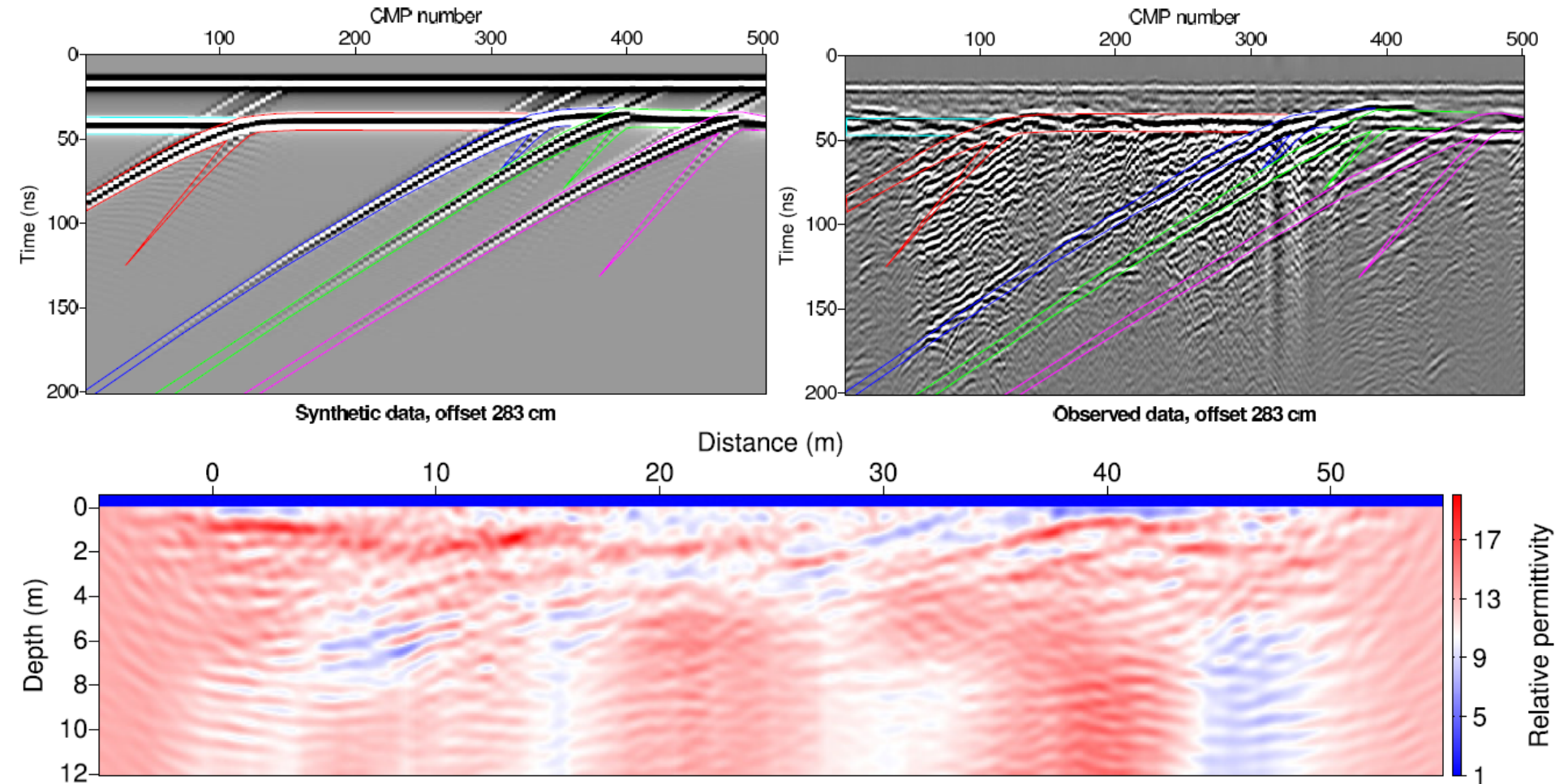


**Semblance CMP 15**



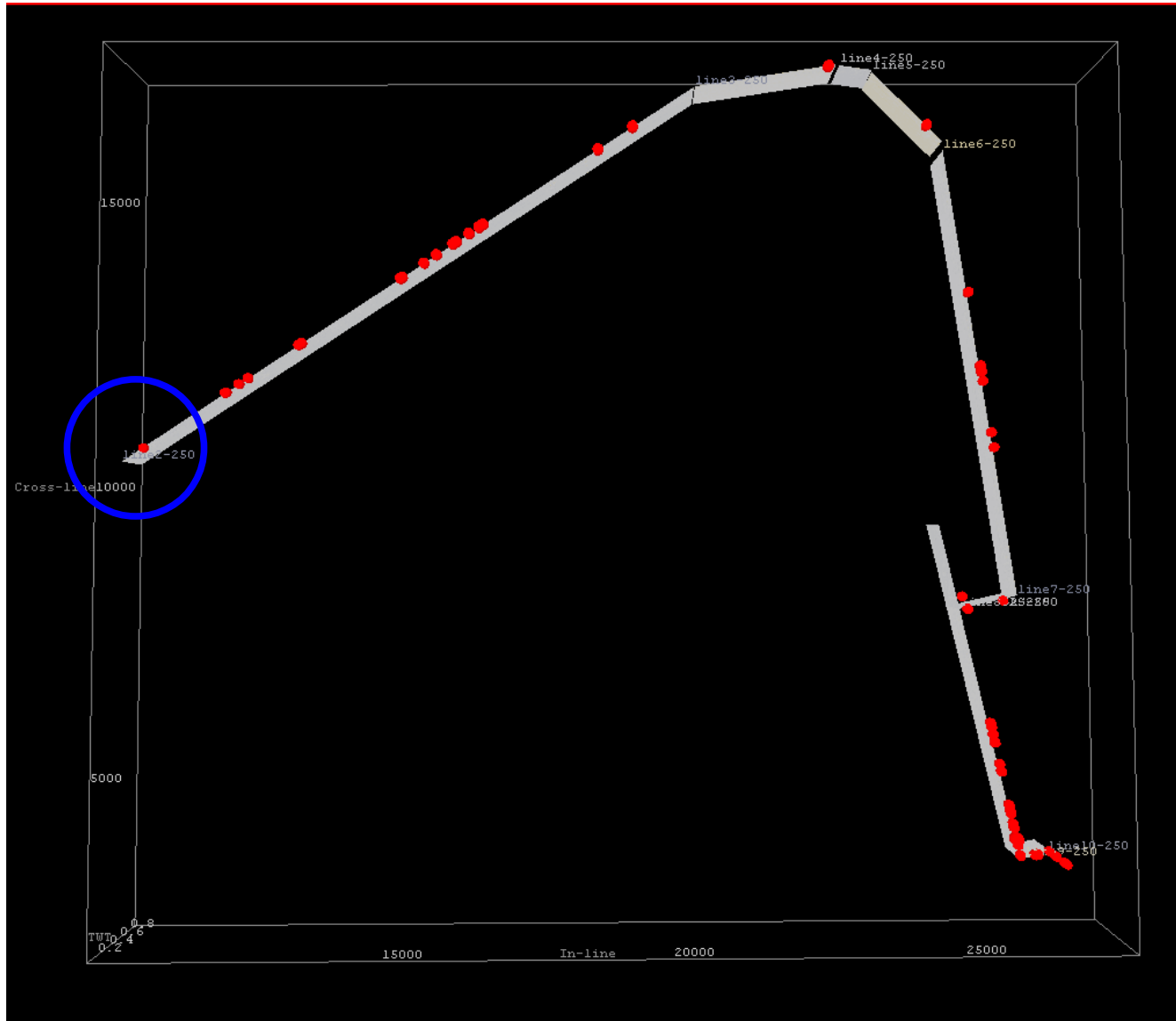
**CMP 15**

# Full wave inversion



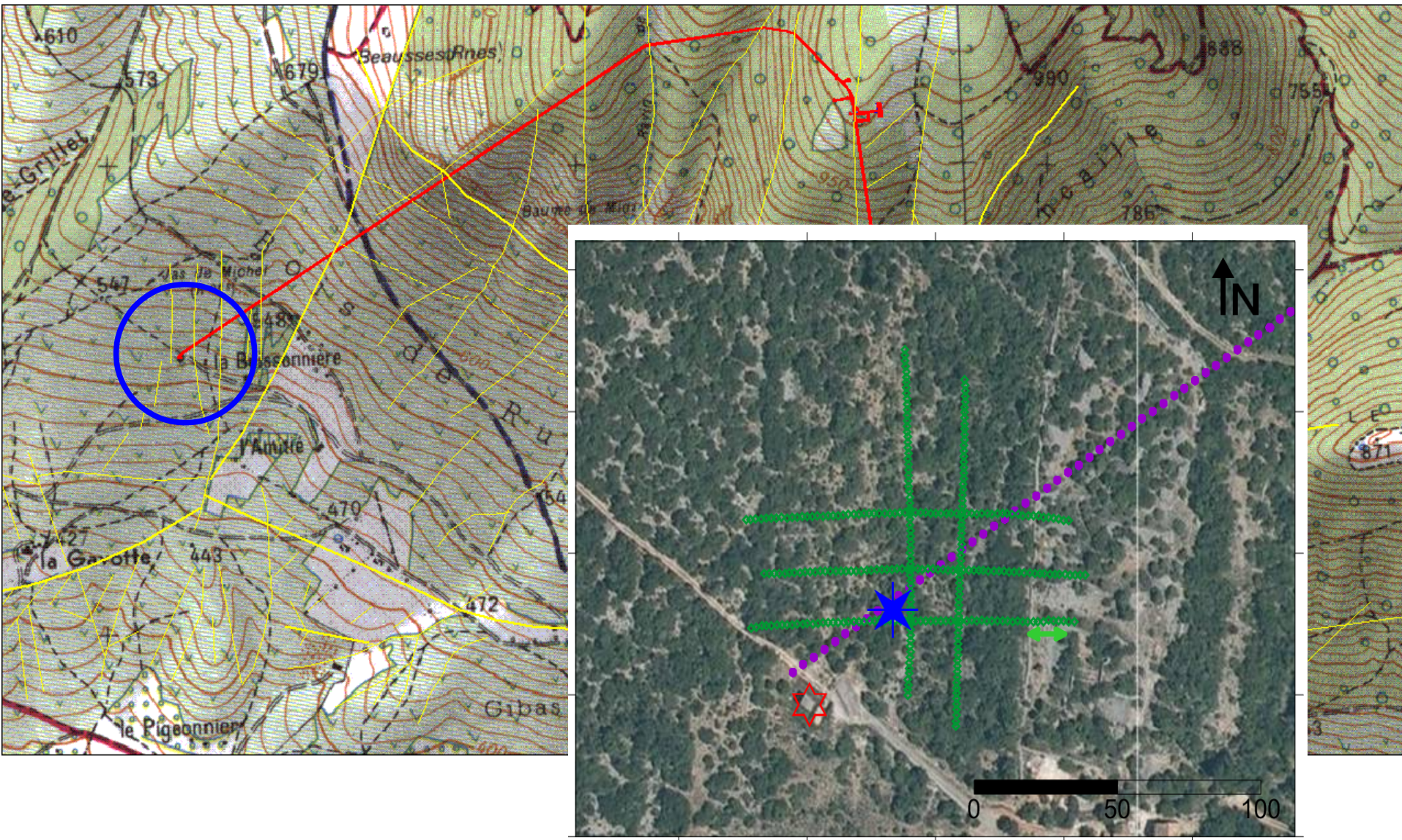
(I) Time-domain estimated wavelet (26 iterations, 65% misfit decrease).

# Geophysical investigations vs water circulation



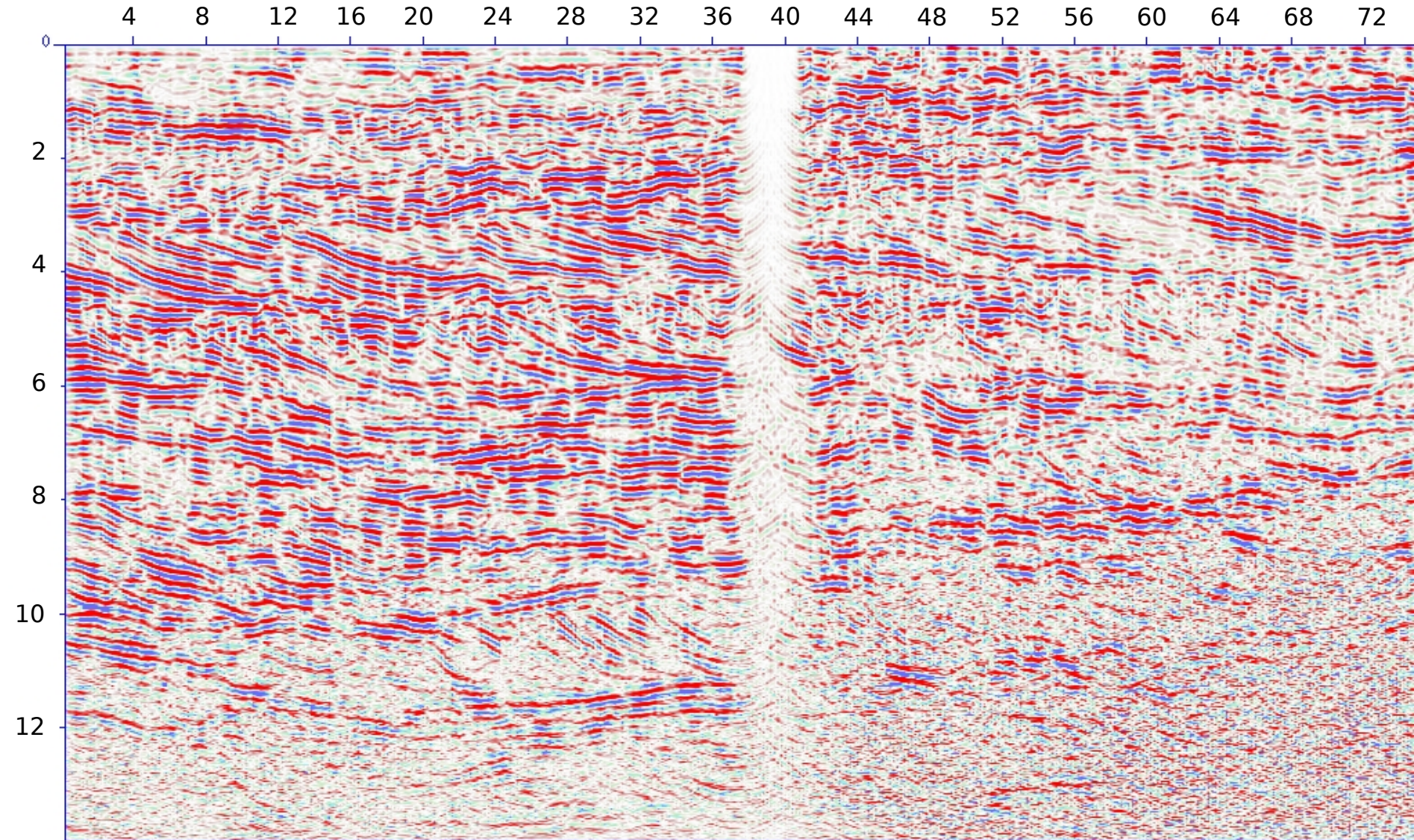


# Geophysical investigations vs water circulation





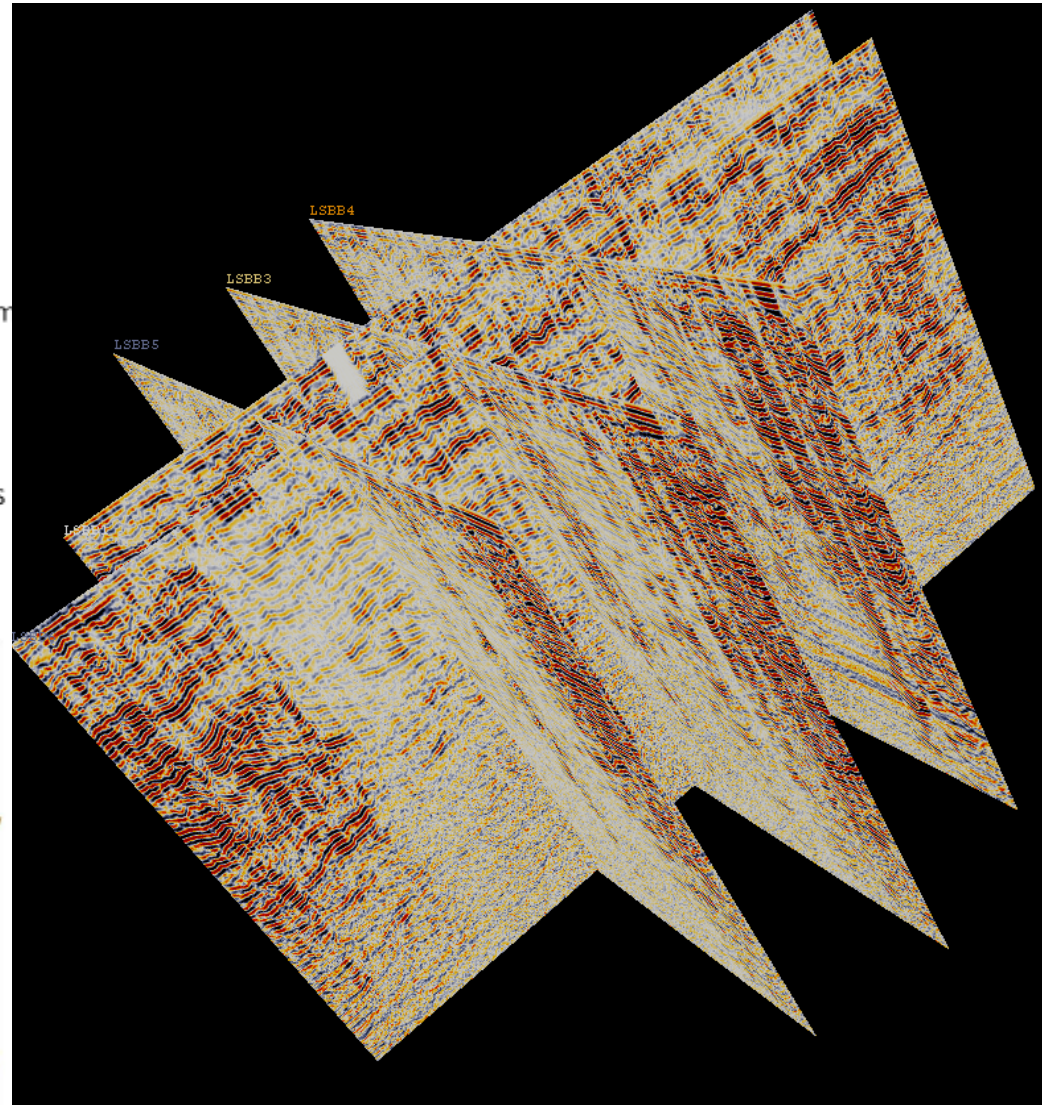
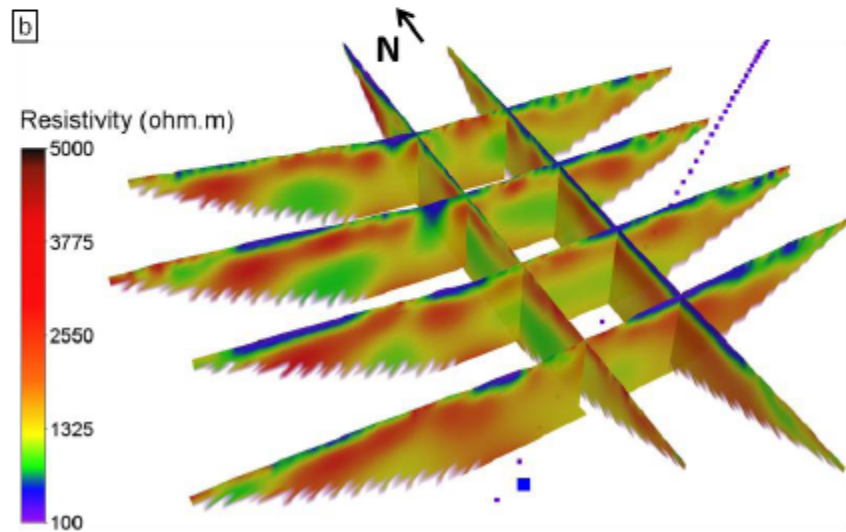
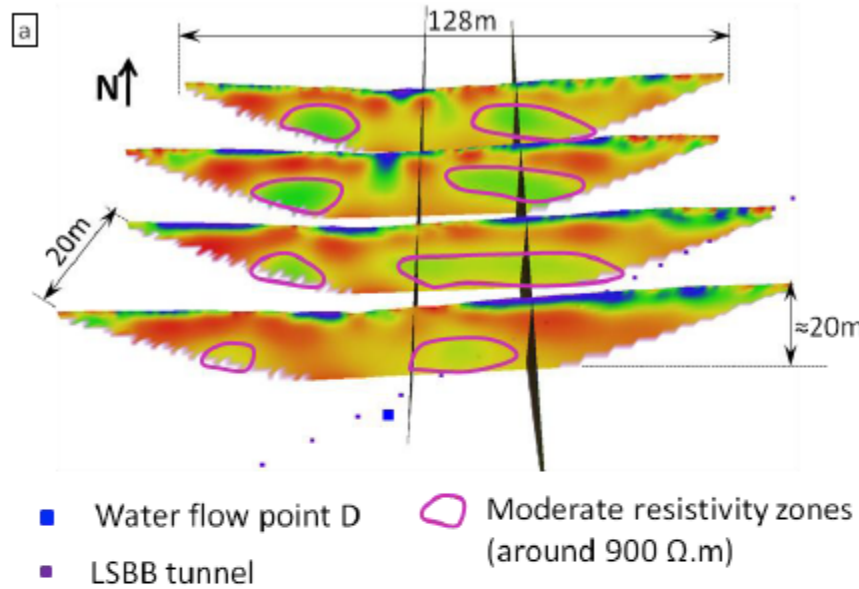
# Geophysical investigations vs water circulation







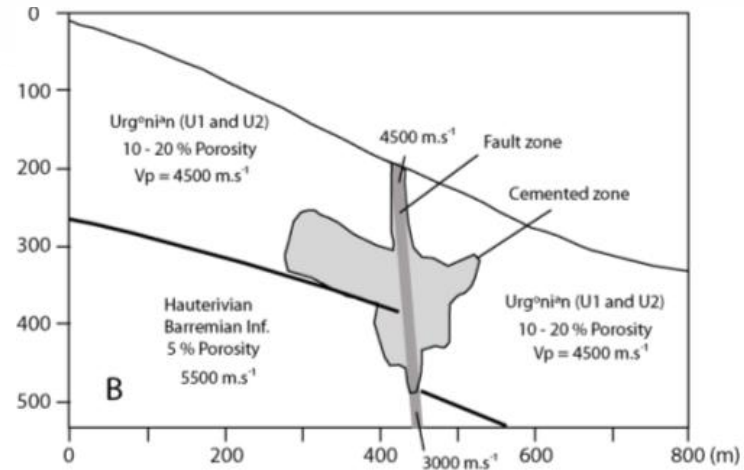
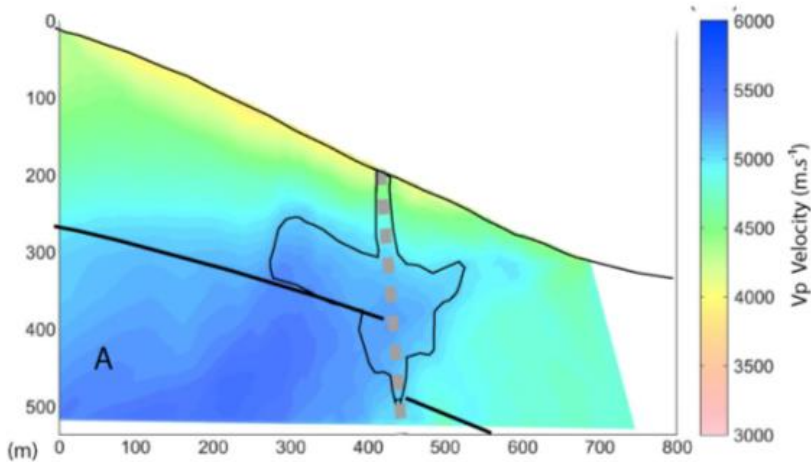
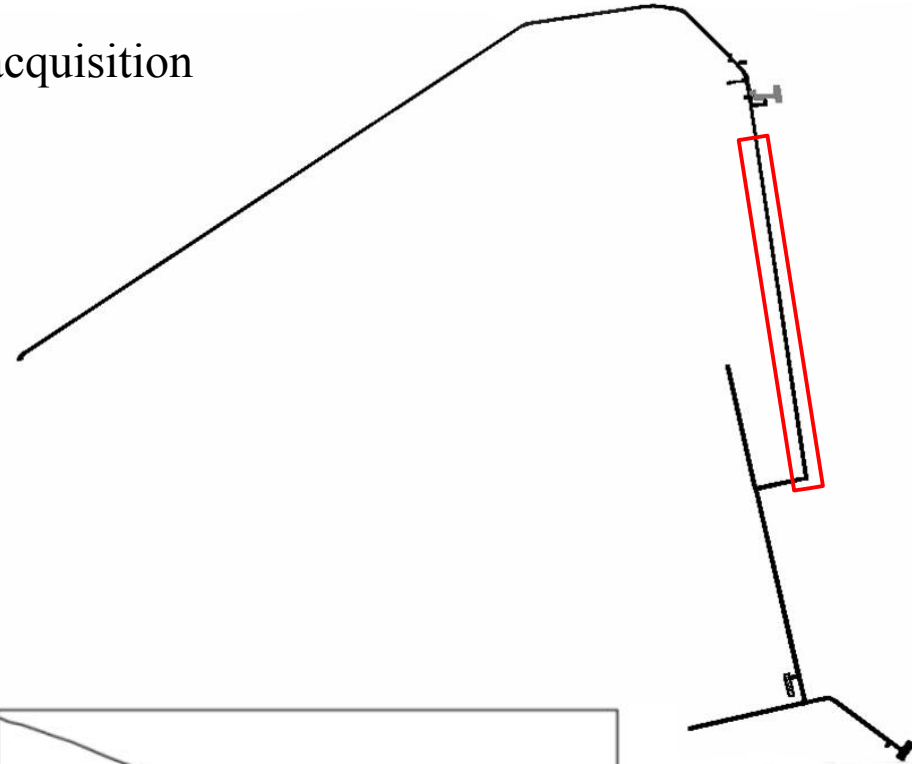
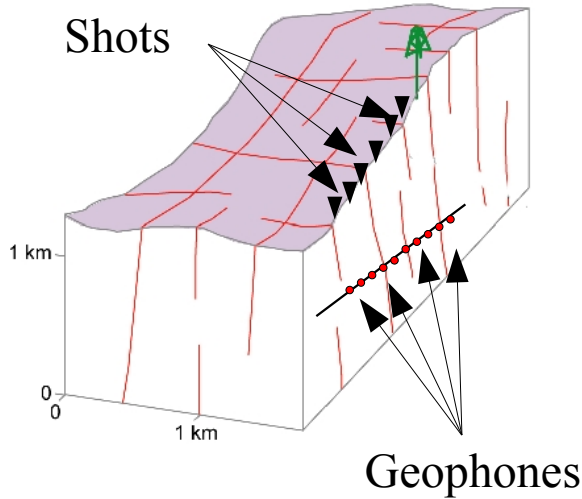
# Geophysical investigations vs water circulation



(from Carrière et al., 2013)

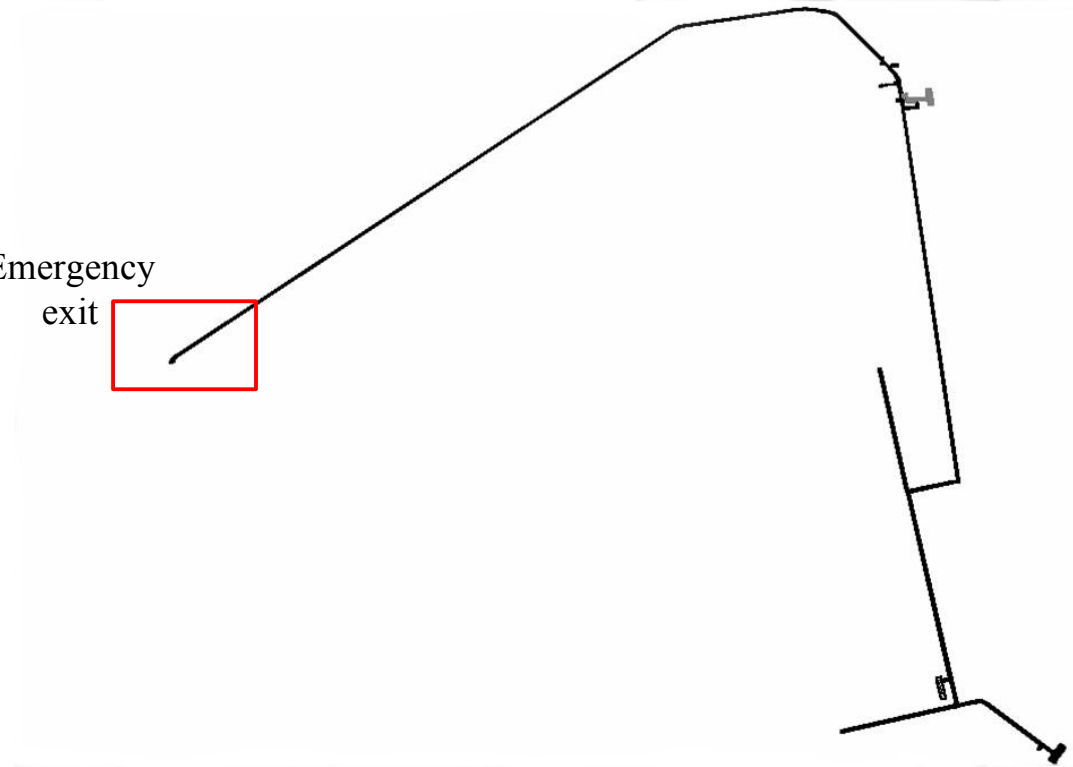
# From small to large scale seismic investigations

surface/tunnel seismic acquisition



# Recent seismic investigations from the surface ..

Emergency  
exit





# Recent seismic investigations from the surface ..



Emergency  
exit





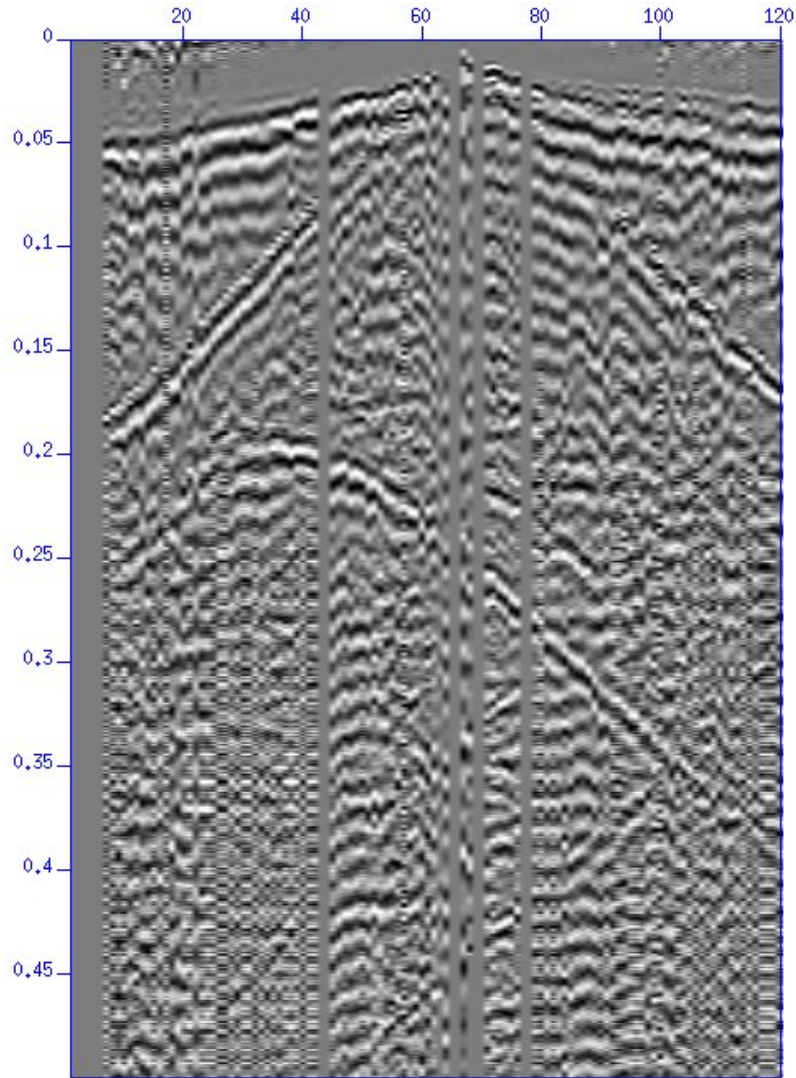
# Recent seismic investigations from the surface ..

Emergency  
exit

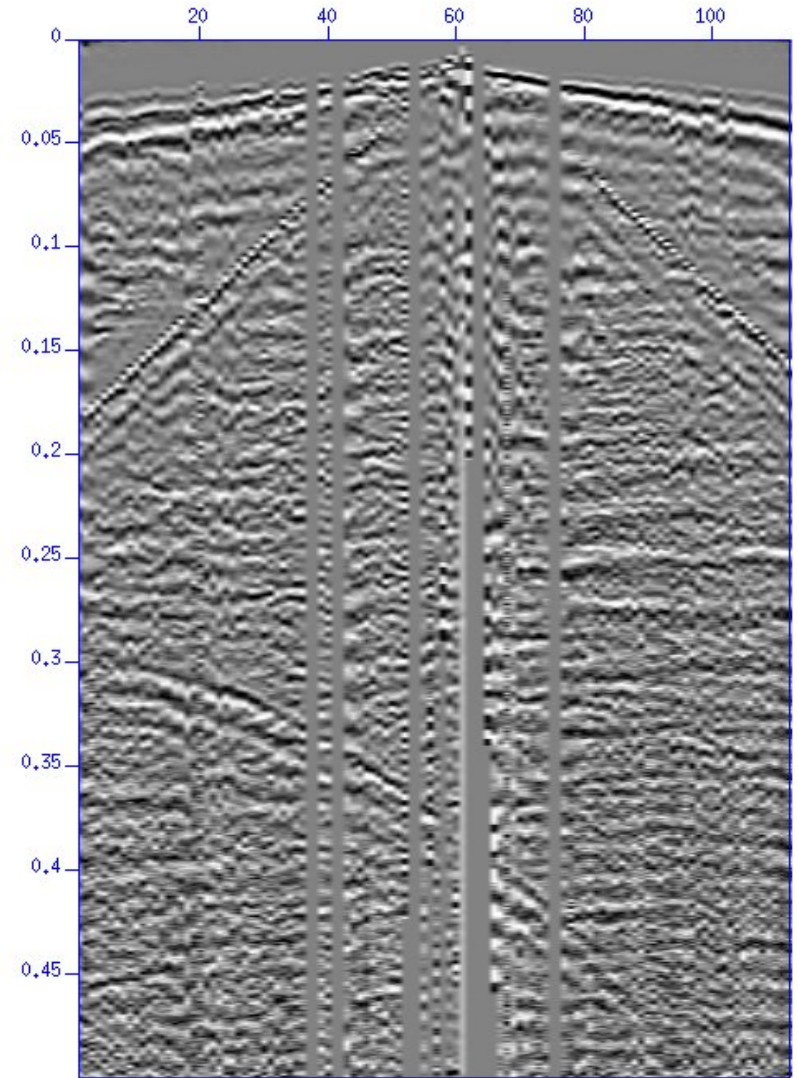




# Recent seismic investigations from the surface ..



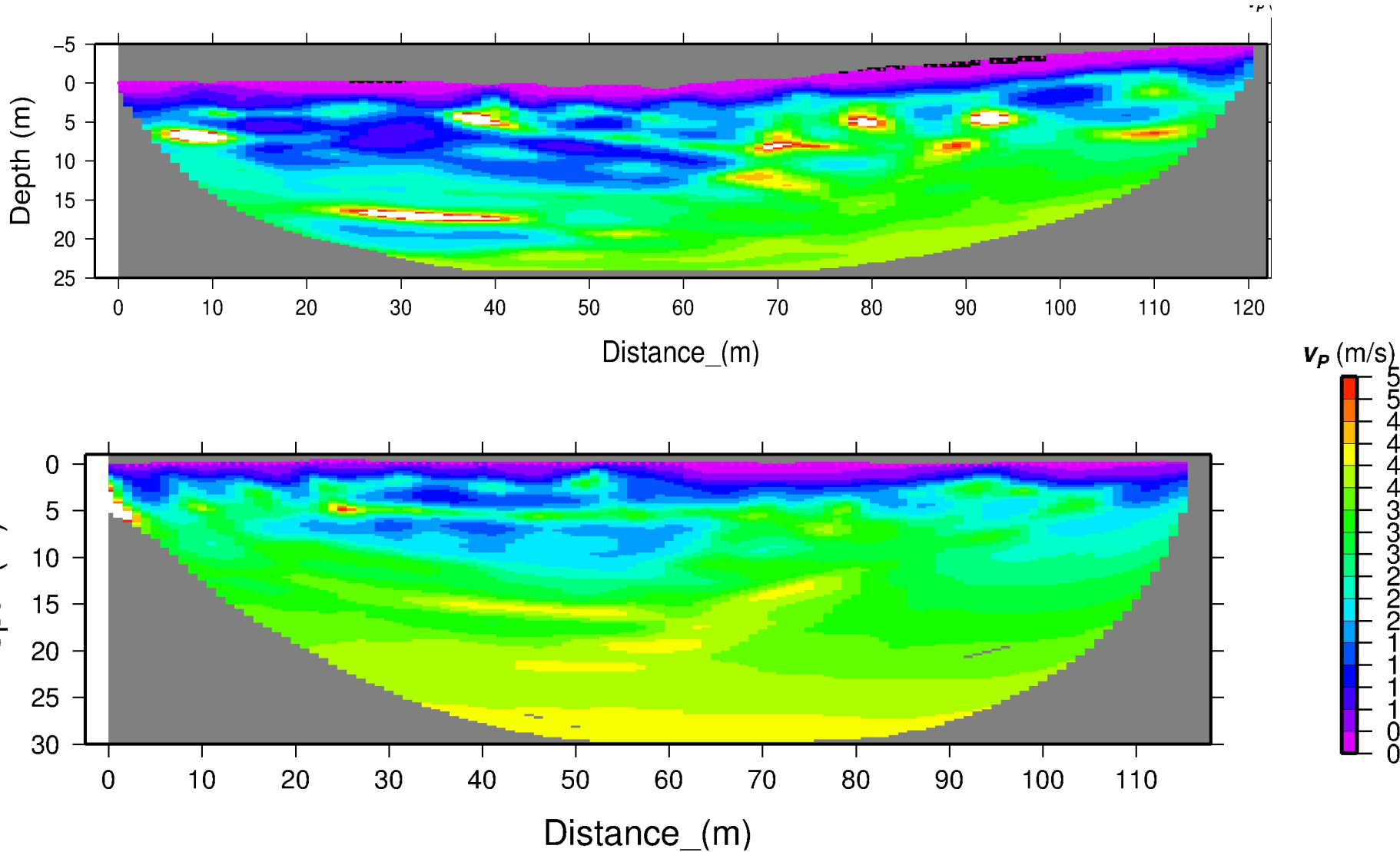
Jour 1



Jour 2

# Recent seismic investigations from the surface ..

## seismic surface tomography





## Conclusions

Geophysical investigations focus on the in situ characterisation

- Mainly based on seismic , GPR and ERT data
- Actual research topics focus on the water effect on the measurements :
  - Seismic and ERT anisotropy → thesis J. Beres (Orsay)
  - GPR velocity model determination → thesis F. Lavoué (Grenoble)
  - Hydrogeological study → thesis S. Carrière (Avignon)

Thank you