GWADW2021 Gravitational Wave Advanced Detector Workshop

Geophysical imaging and characterization to study the implementation of the Einstein Telescope infrastructure

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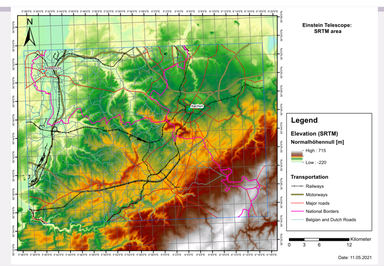
Introduction

In the feasibility study E-TEST, the potential of the border region between Belgium, Germany and the Netherlands (Fig. 1) to host the Einstein Telescope (ET) infrastructure is investigated. As ET is planned to be installed in ca. 250 m depth, a firm understanding of the subsurface needs to be accomplished in the E-TEST project. Geophysical techniques allow to image and characterise the subsurface. Therefore, different geophysical methods will be used during the E-TEST project. The results of these geophysical survey will serve as input for geological, geotechnical and hydrogeological models.



Shallow seismic survey

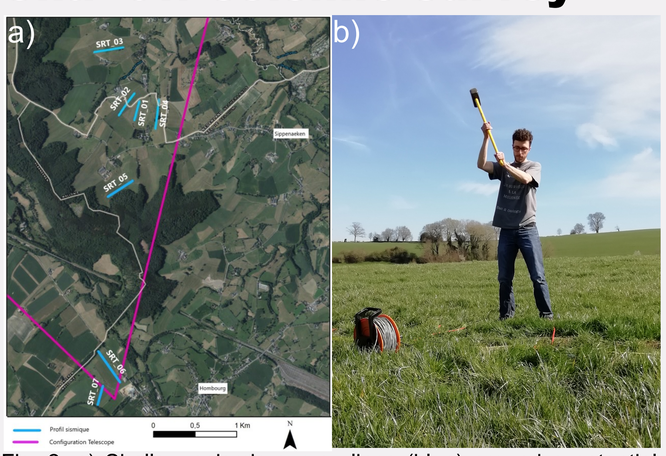


Fig. 2: a) Shallow seismic survey lines (blue) around a potential corner point of the ET triangle (pink). b) Energy input using a sledge hammer.

- Geophones along a straight line.
- Energy input by a sledge hammer.
- Measuring of seismic wave velocities.
- Seismic waves velocities to map subsurface.
- Imaging to a depth of ca. 50 m.
- Seismic properties characterise rock type and / or rock properties.
- Change in seismic properties allow to map structures

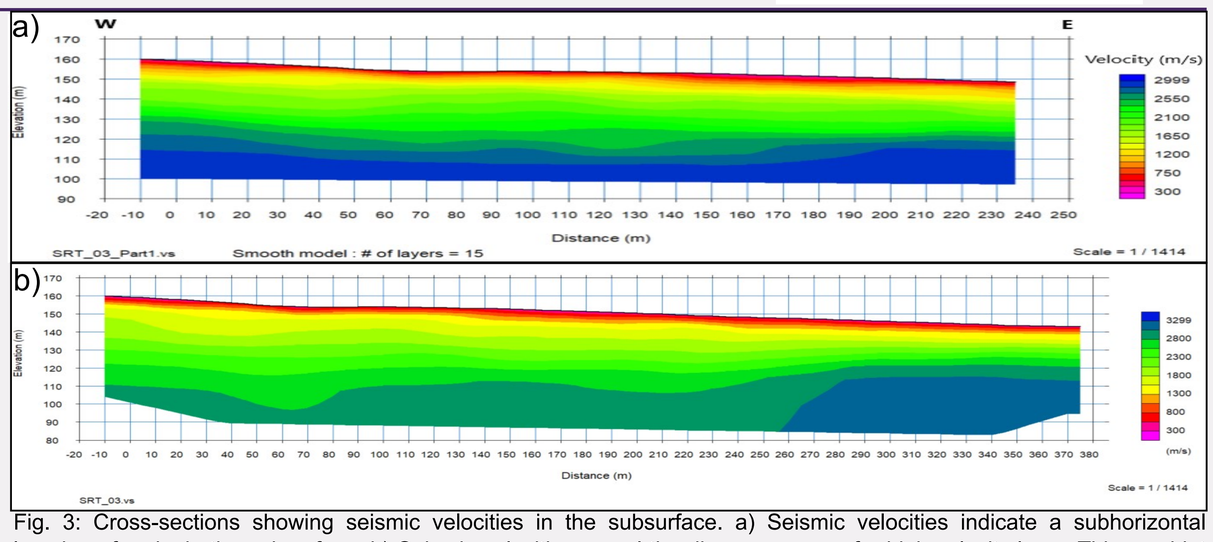


Fig. 3: Cross-sections showing seismic velocities in the subsurface. a) Seismic velocities indicate a subhorizontal layering of rocks in the subsurface. b) Seismic velocities reveal the disappearance of a high-velocity layer. This can hint to the presence of a blind fault.

Active and passive seismic survey

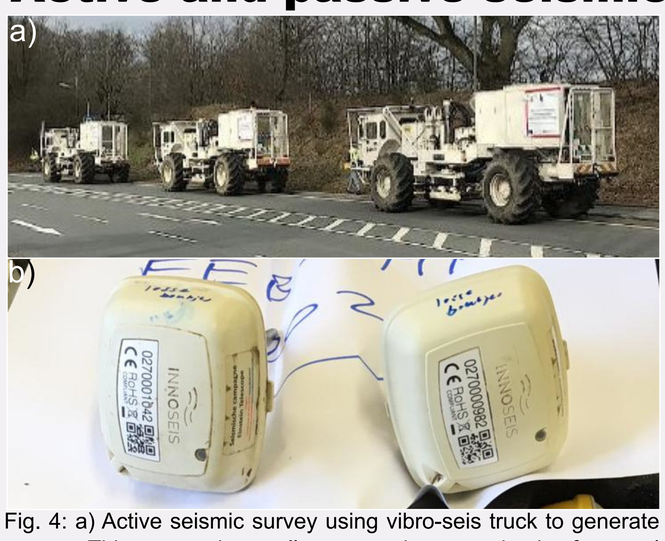


Fig. 4: a) Active seismic survey using vibro-seis truck to generate energy. This energy input allwos mapping to a depth of several kilometres b) Battery-operated sensors recording any occurring seismic signal.

- Active survey: Energy input by vibration
- Passive survey: Any occurring seismicity
- Measuring of seismic wave velocities.
- Seismic waves velocities to map subsurface.
- Imaging to a depth of several km depth.
- Mapping of rock layers and structures.
- Mapping as cross-sections or maps

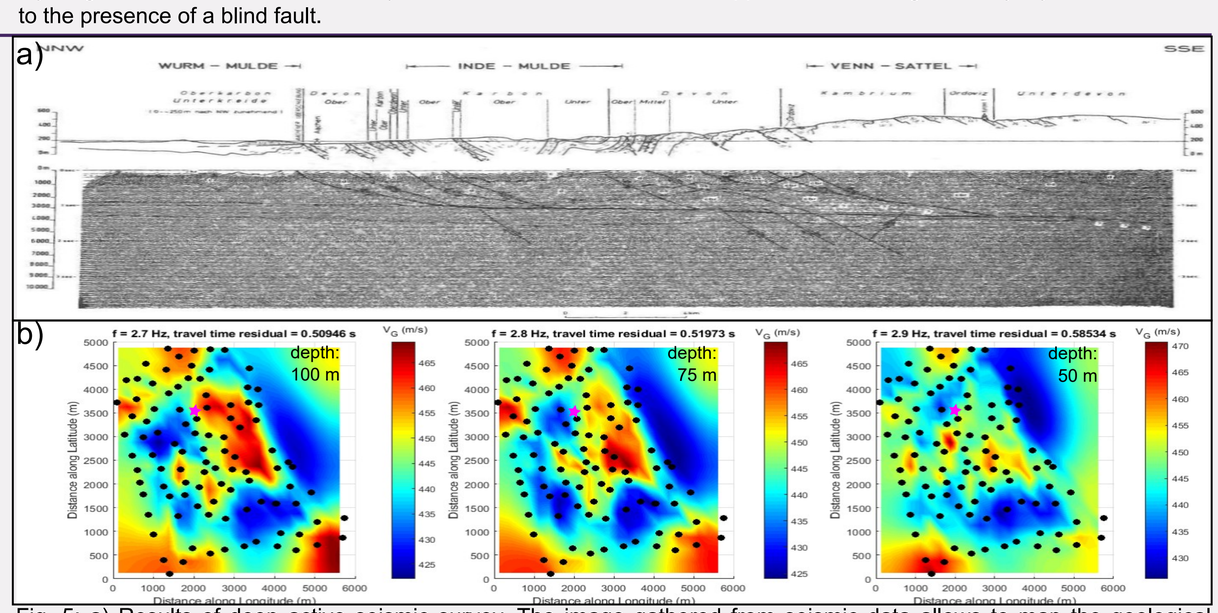


Fig. 5: a) Results of deep active seismic survey. The image gathered from seismic data allows to map the geological structures in the subsurface [von Winterfeld; 1993]. b) Results of a passive seismic campaign in the E-TEST area. Red coulours indicate hard rocks. Maps from various depth reveal their spatial occurrence. The pink star shows the town of Epen. The black dots represent the positions of the individual battery-operated geophones.

Electrical Resistivity Tomography (ERT) and Induced Polarization (IP)

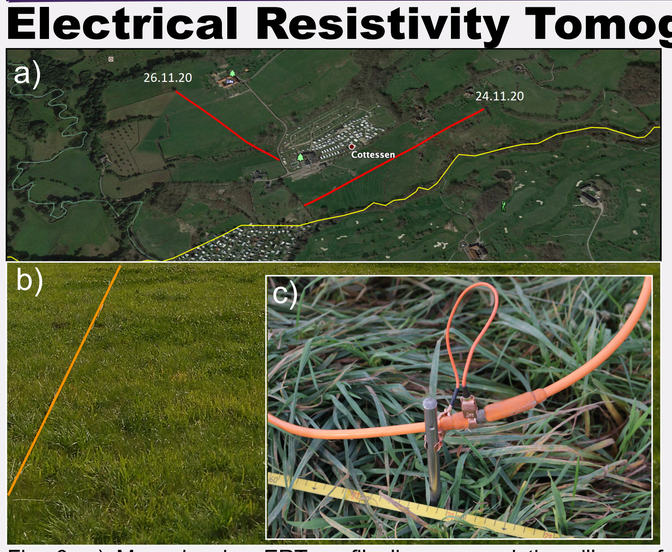


Fig. 6: a) Map showing ERT profile lines around the village of Cottessen. b) ERT profile line on a field (orange line). c) Electrode to measure the resistivity.

- ERT: measures resistivity of earth
- Measured in the field
- Imaging down to decametres of depth
- ERT depends on rock type, porosity and fluid in pores
- Mapping of lithology and rock parameters

- IP: describes chargeability of earth
- Measured in the field and in the laboratory
- Imaging down to decametres of depth
- IR to characterise mineralogy and fluids in rocks
- Lab measurements to calibrate results
- Mapping of rock parameters

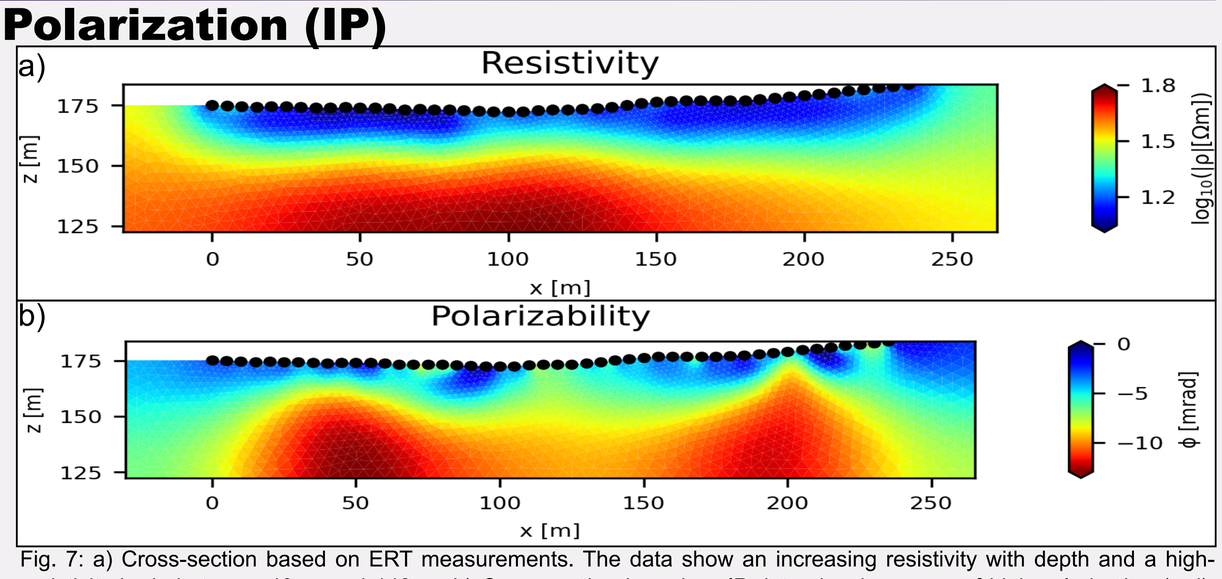
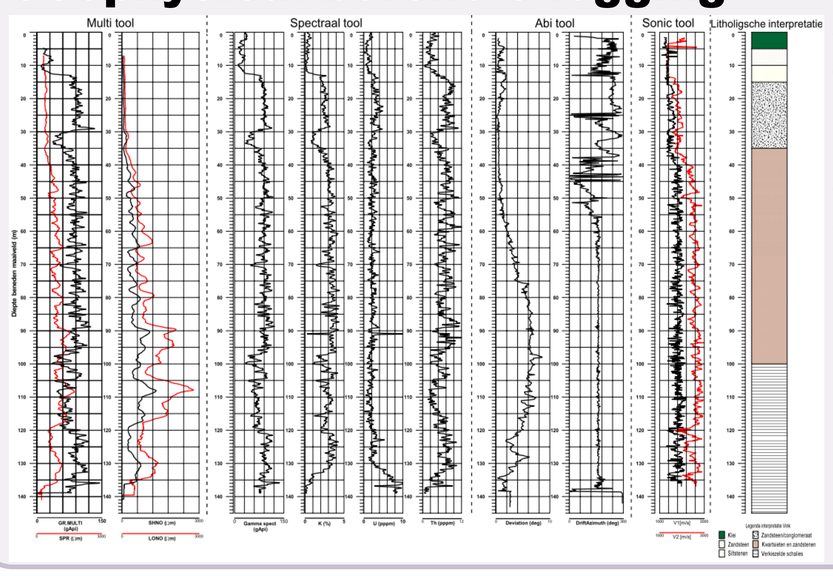


Fig. 7: a) Cross-section based on ERT measurements. The data show an increasing resistivity with depth and a high-resistivity body between 40 m and 140 m. b) Cross-section based on IP data showing areas of high polarization (red). These zones may indicate changes in petrophysical parameters. Laboratory data are used to calibrate the field results.

Geophysical borehole logging



- Measuring takes place in drilled wells
- Logging of various physical parameters of the rocks along the borehole
- Combination of results allows to conclude on: Lithology, Porosity, Pore Fluid Type

Fig. 8: Logging results from the Terziet-1 borehole. The combination of various logs results in a lithological interpretation

Input for modelling

Geological	*Hydrogeological*	*Geotechnical*
Stratigraphic boundaries	Lithology & Porosity	Rock & Soil parameters
Lithology	Pore Fluid composition	Lithology
Faults	Permeability	Thickness
Folds	Faults	Distribution of homogeneous rock volumes

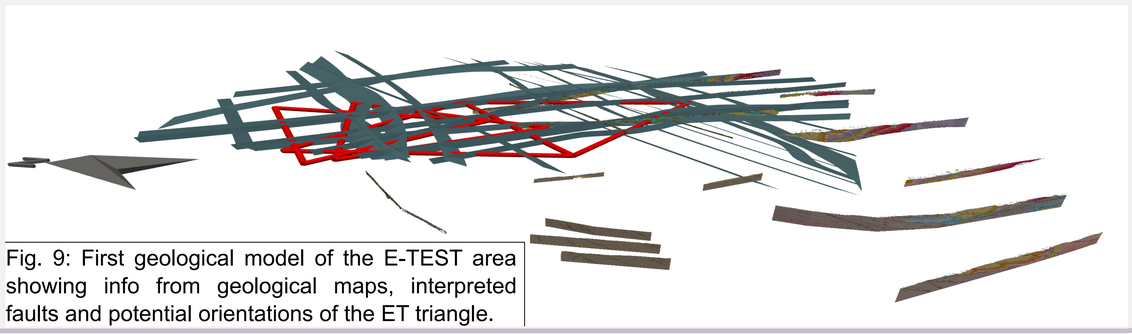


Fig. 9: First geological model of the E-TEST area showing info from geological maps, interpreted faults and potential orientations of the ET triangle.

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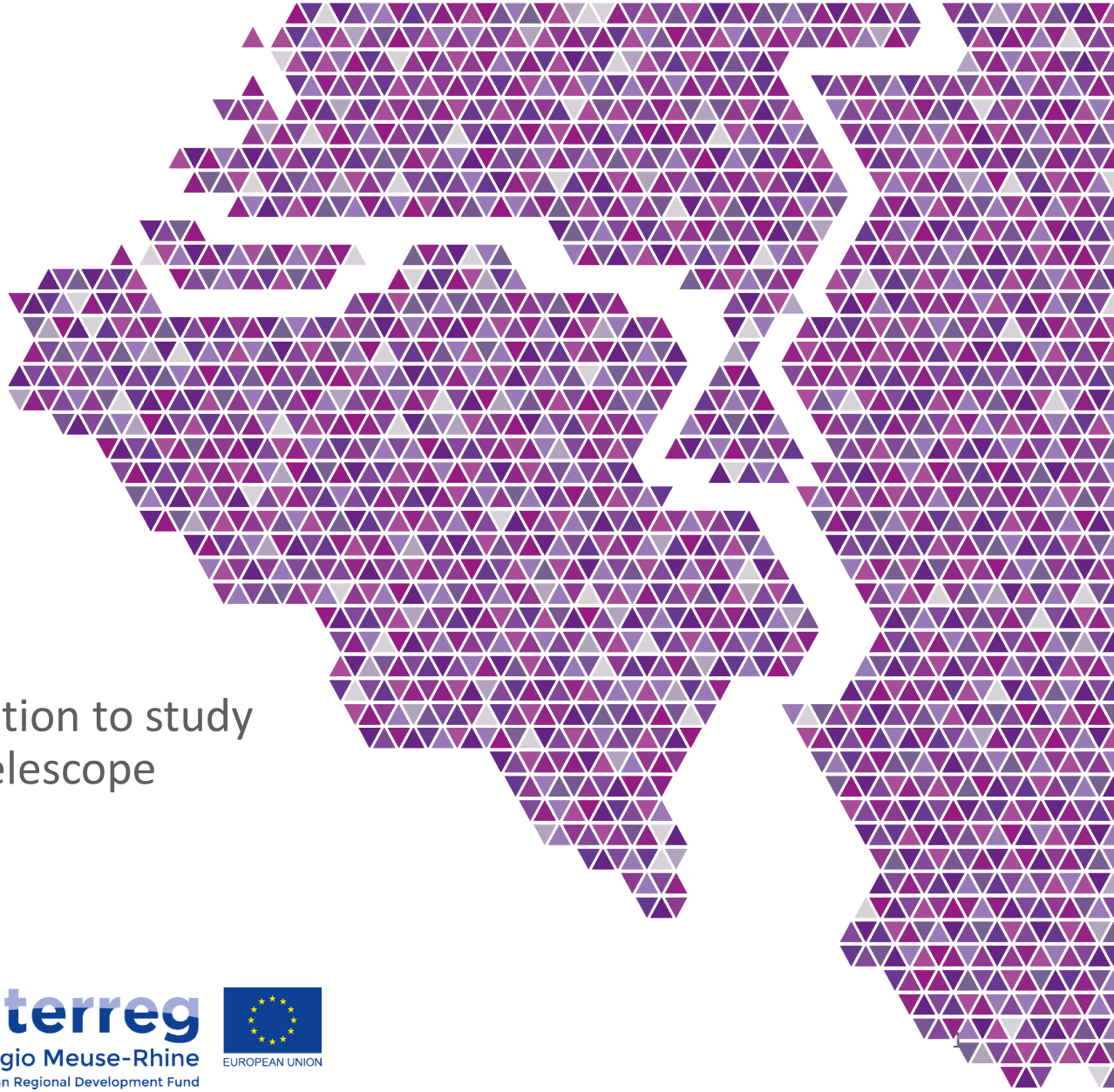

Geophysical imaging and characterization to study the implementation of the Einstein Telescope infrastructure

14.05.2021

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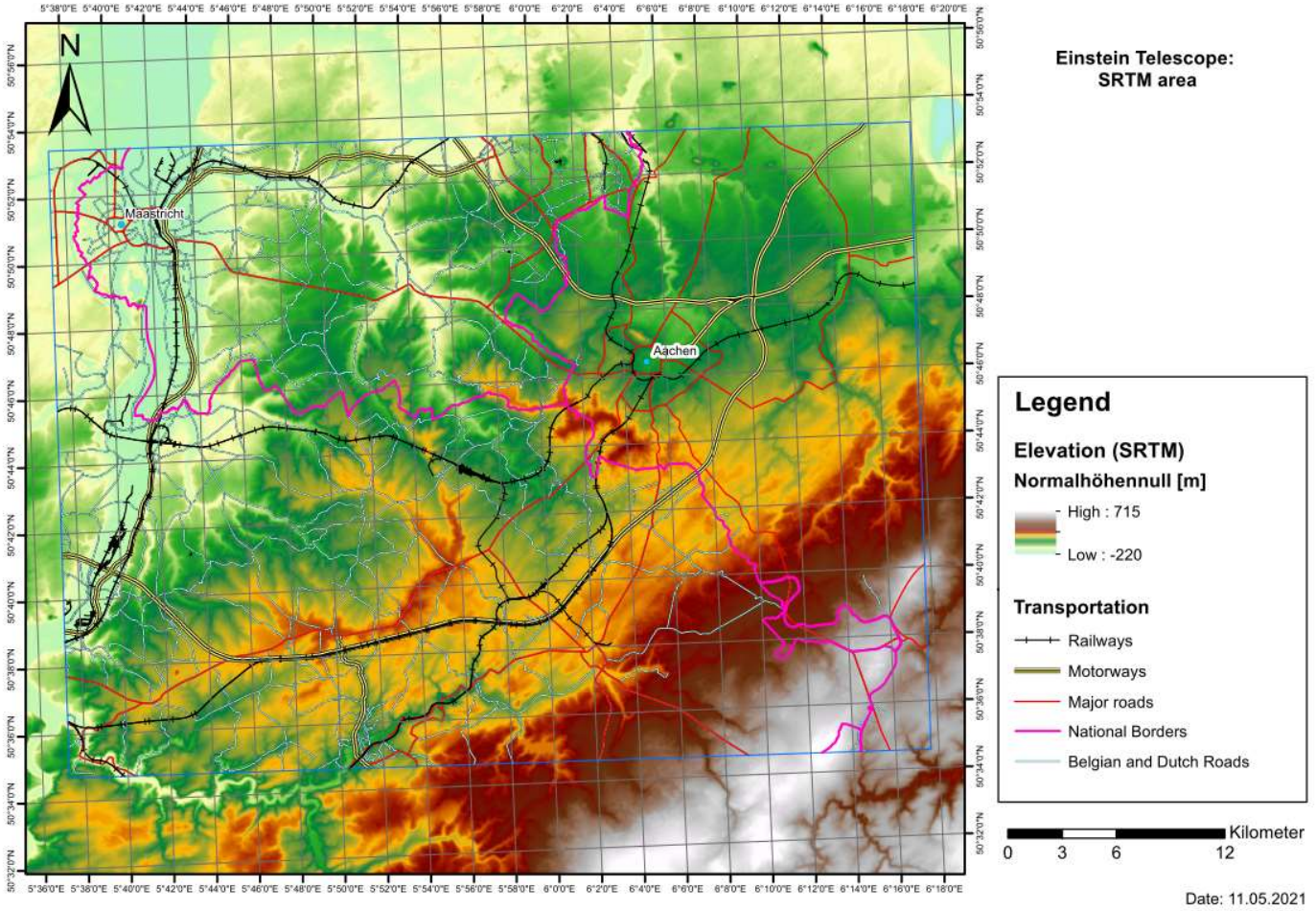
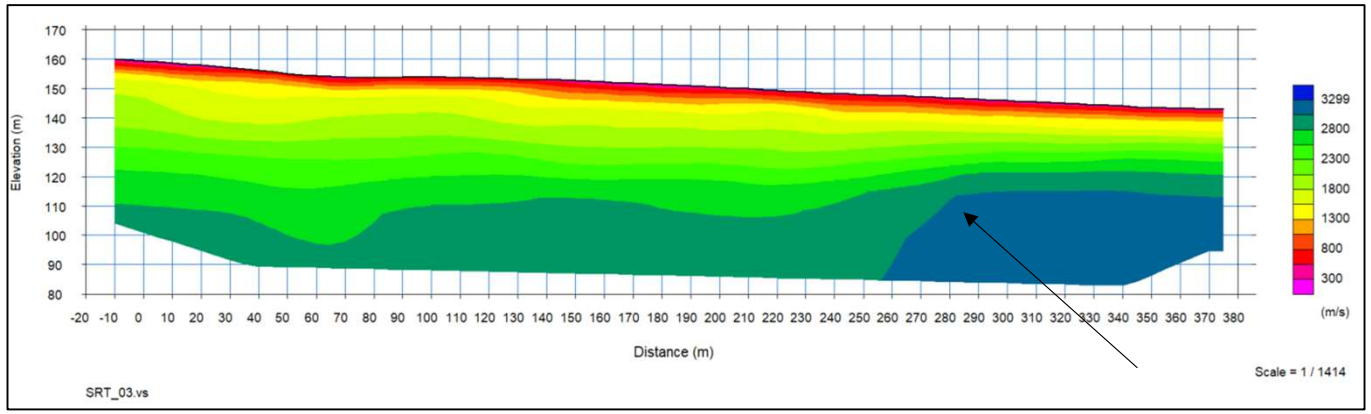
Location and aim

- Border region between Belgium – Germany-the Netherlands
- Investigate the subsurface
- Use geophysical methods for this investigation

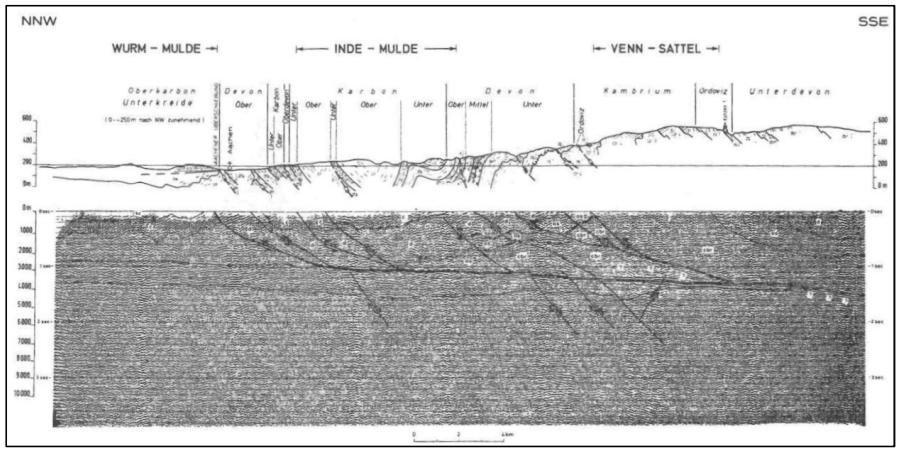


Seismic surveys: Mapping of stratigraphy and structures

Shallow active seismic

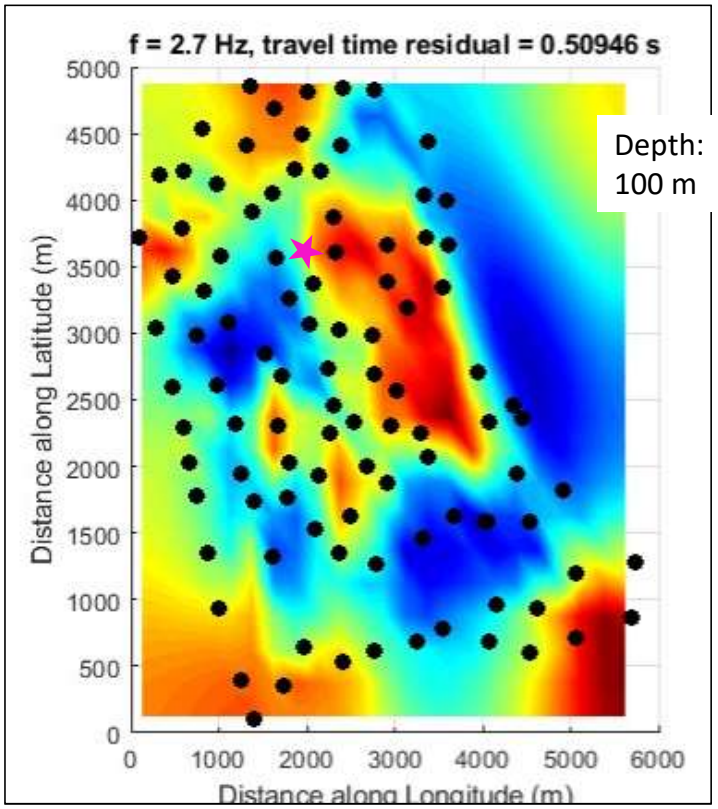


Deep active seismic



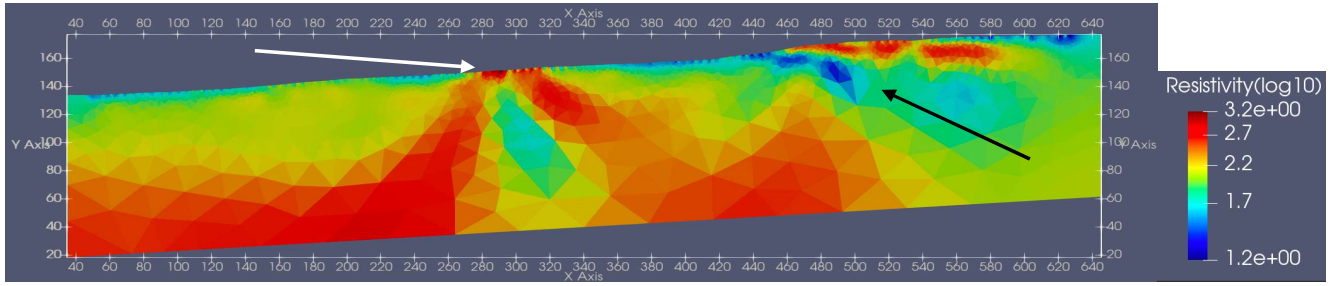
von Winterfeld; 1993

Passive seismic

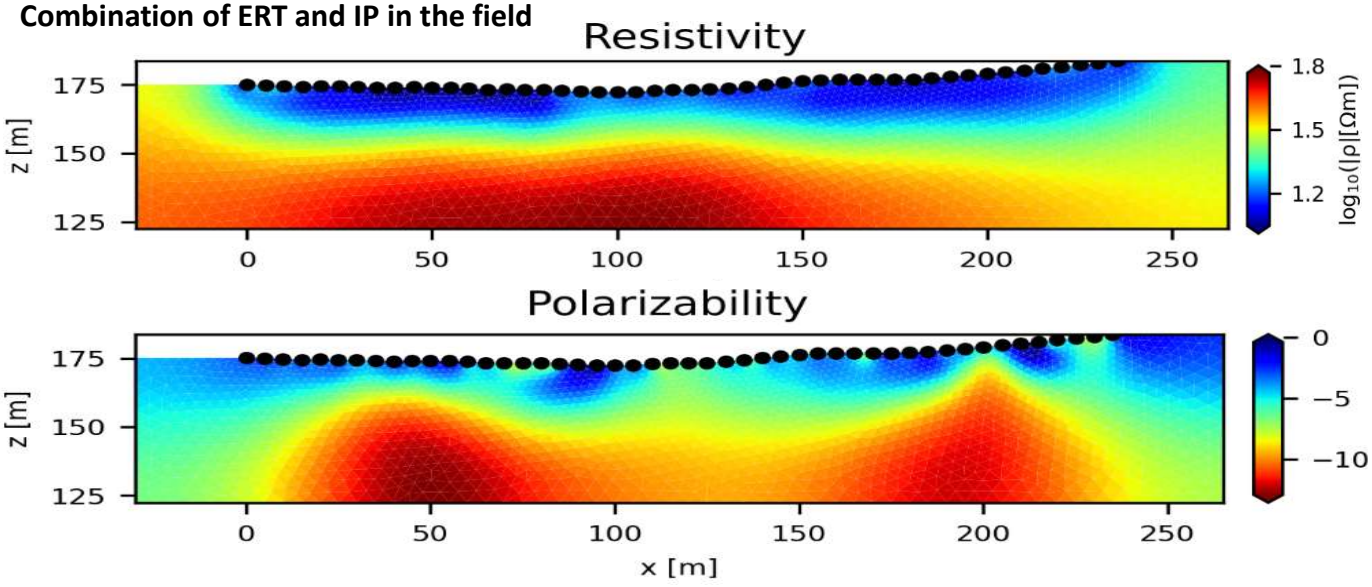


ERT and IP: Mapping for rock properties

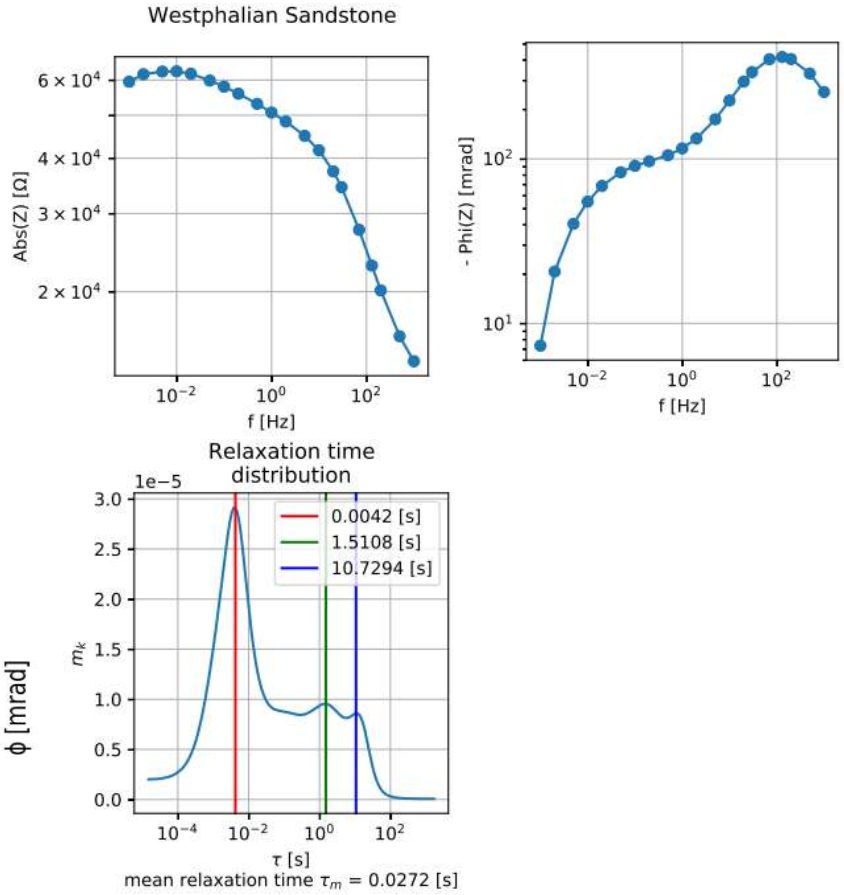
ERT



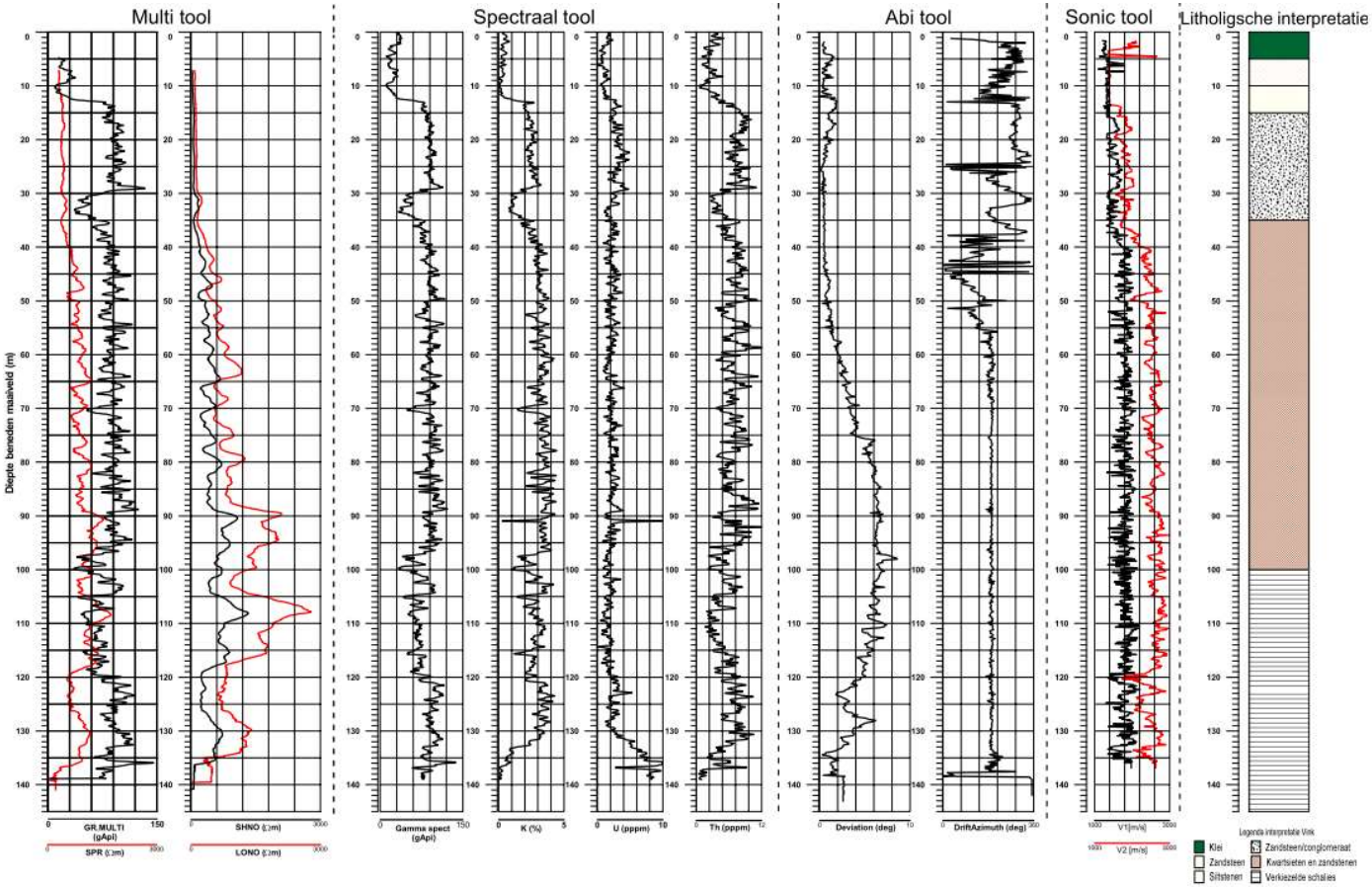
Combination of ERT and IP in the field



IP in the laboratory

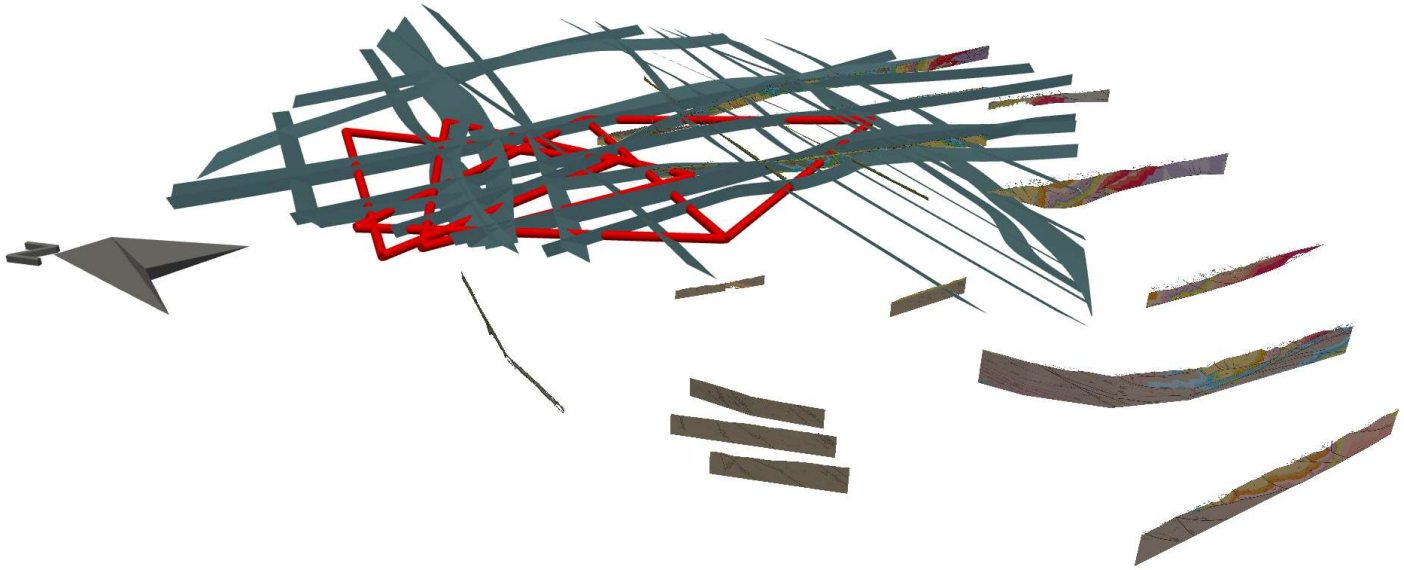


Borehole logging for lithology & rock properties



Geophysical data prove input for models

- Geological model
  - Stratigraphic boundaries
  - Lithology
  - Faults & Folds
- Hydrogeological model
  - Lithology & Porosity
  - Pore fluid composition
  - Permeability
  - Faults
- Geotechnical model
  - Rock & Soil parameters
  - Lithology
  - Thickness
  - Distribution of homogeneous rock volumes



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