ET SPB and WP4 of ET-PP

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Outline

- The sites
- Organization and activities up to now
- Our goals
- What was accomplished at sites
- How to reach the goals of SPB and WP4

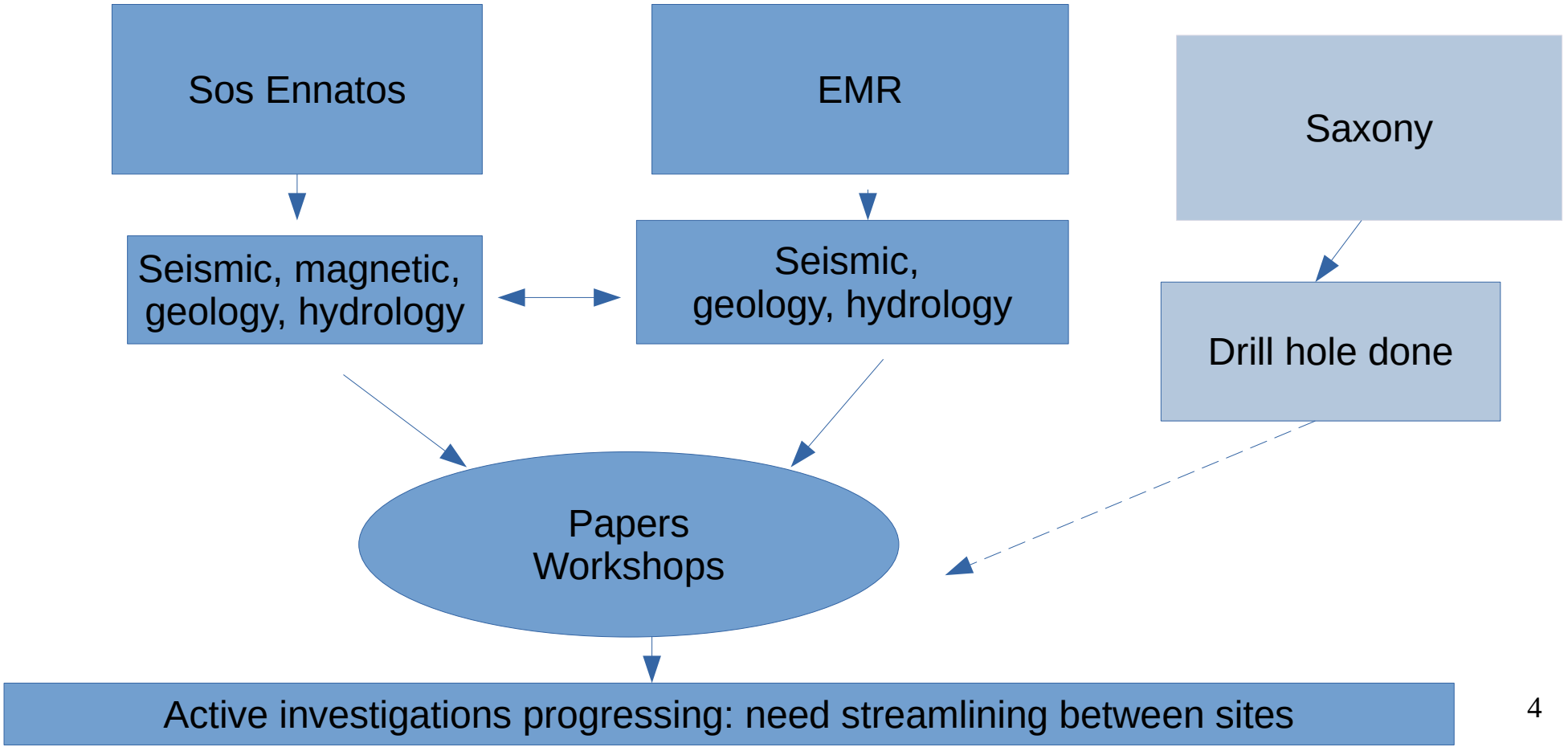
Acknowledgement: I have allowed myself freely used the slides from presentations at SPB workshop. Thanks!

EMR site

Sos Ennatos site

Saxony site

The work so far: needs change!



Organization and activities

Recently: Nuoro site workshop Nov'21

- Program: https://agenda.infn.it/event/28070
- 4 days of talks, visit to the Sos Enattos site.
- 50 participants
- Summary of status of investigation of the two sites
- Getting to know all the groups – forming a uniform site characterization team

Recently: SPB workshop May’22

- One hour bi-weekly thematic meetings
- Topical ½ day workshops:
  - SPB workshop 23rd May 2022
  - 3 hour online meeting
  - Update on the EMR and Sardinia studies and analysis
  - Program https://indico.ego-gw.it/event/451/

Our goals

ET SPB mandate - April 2022

- *T1: Collect, organize and/or produce all the characterizations and documentation needed for a fair comparison of the sites;*
- *T2: Propose a common framework and common basis for the evaluation of the candidate sites.*

This includes

- Physical variables: seismicity, acoustic noise, magnetic noise, wind, rain and lightning, etc.
- Geological information: sub surface structure, hydrology, faults, …
- Legal aspects and site quality preservation
- Socio-economic and environmental impact
- Site preservation plan
- Site related risk assesment
- Site specific costs and risks
- Schedule

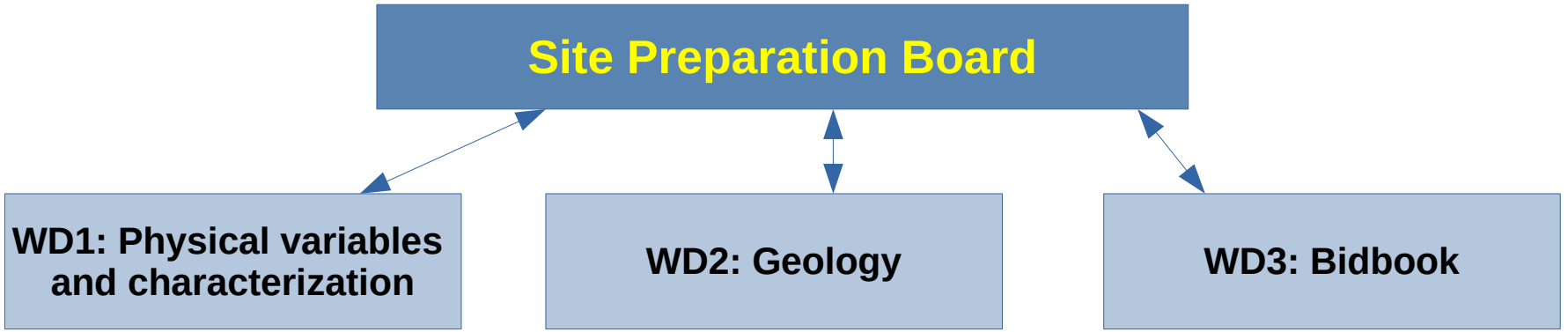
- (Bid book standards)

WP4 of ET-PP (Infradev)

Deliverables

- **D4.1 – M10/Nikhef** Scan of legal procedures, permitting and land acquisitions i.e. the steps to be taken prior to starting excavations
- **D4.2 – M15/INFN** Updated socio-economic impact studies. Scan of accessibility, quality of life etc.
- **D4.3 – M28/UW** Complete quantification of all the aspects impacting the ET performance for each site
- **D4.4 – M30/INFN** 3D geology, hydrology, etc. model with detailed localisation of the ET infrastructure
- **D4.5 – M42/Nikhef** Robust and complete cost and schedule estimates of the excavations. Including, if necessary: instrumentation for Newtonian Noise cancellation; costs of debris removal;costs of land acquisition, permitting, etc.

Target structure



Need confirmation and inputs from Collaboration, PD and BGR

Each WP needs to address all sites.

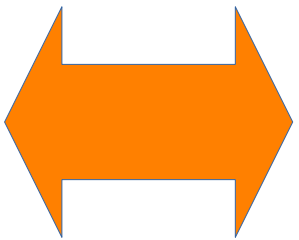
Links to other boards and groups

- OSB – needs to define the requirements for specific science goals
- ISB – need to specify requirements for the site to reach the science goals
- WP2 (ET-PP) to address the legal aspects of sites, bidbook
- WP6/7 socio economic

Accomplishments at sites

Where do we stand

- Sites
  - Sardinia site
  - EMR site
  - Saxony site
- Tunelling cost estimates



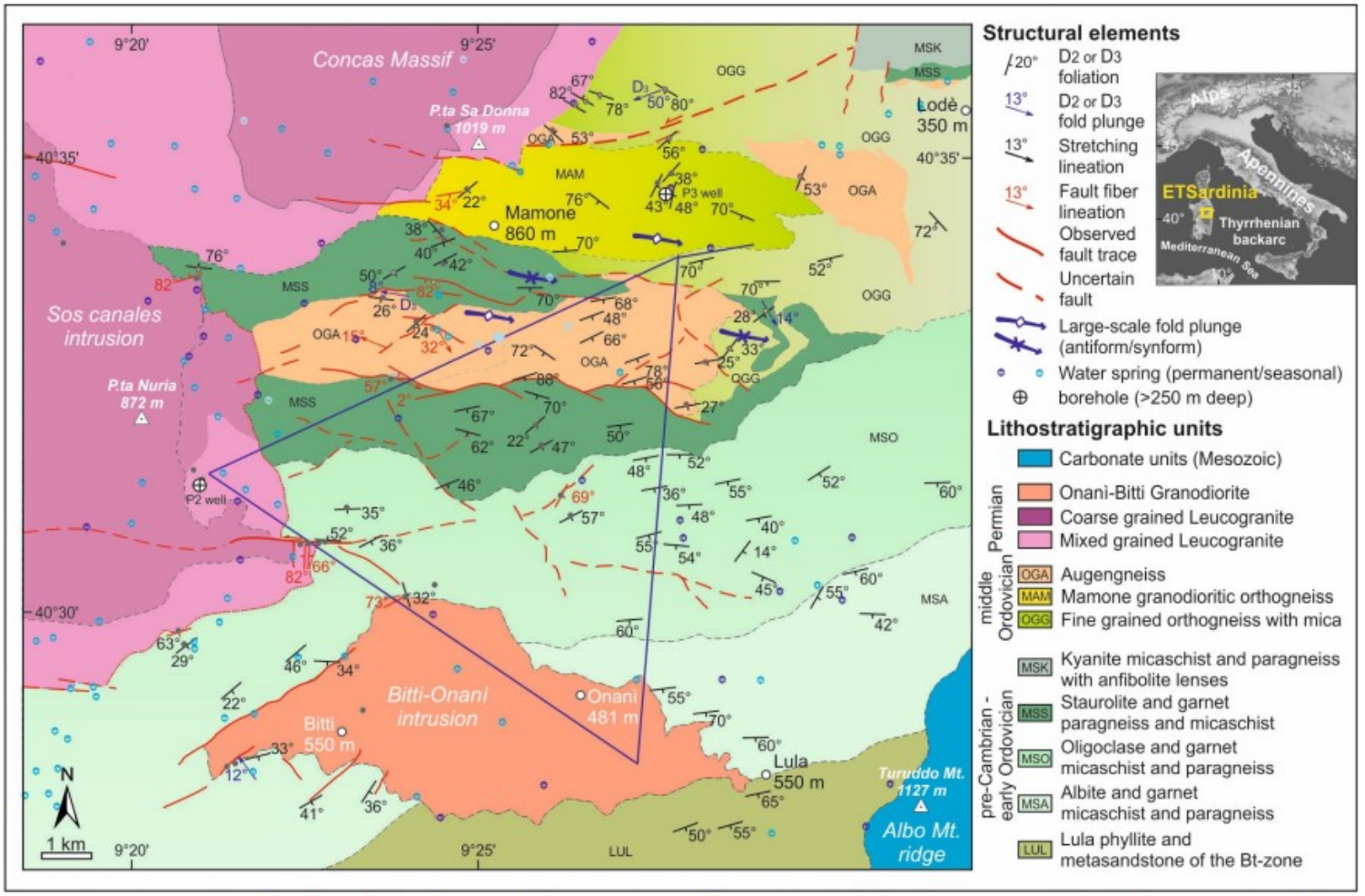
- Noise measurements
- Geology studies
- Hydrology

Sardinia site studies summary

- Seismic studies
- Geological studies
- Magnetic measurements
- Data Analysis

A NEW STRUCTURAL MAP

Sardinia - geology

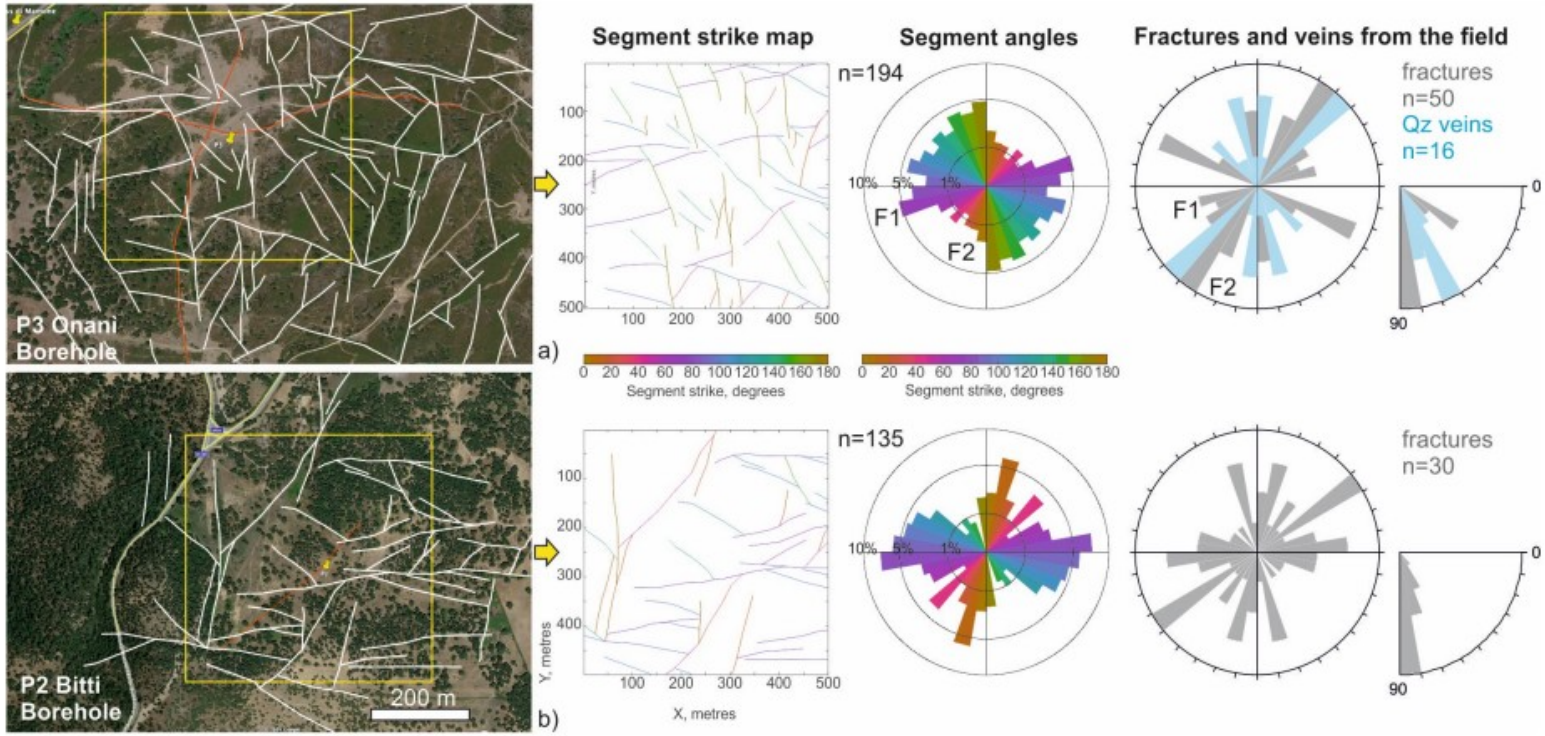


We have merged the lithologic information from published maps (also by comparing satellite images) and added new data collected in the field.

Courtesy of G.L. Cardello et al.

FRACTURES AT BOREHOLE SITES

Detailed studies @ boreholes



Morpho-structural segment trace maps at P3 and P2 boreholes, created from the interpretation of satellite images, used to estimate fault segment orientation using FracPaQ (Healy et al., 2016). On the right, comparison of stereographic projects of both interpreted segments and measured fractures in the field.

Courtesy of G.L. Cardello et al.

Status - geology

- New insights on the lithological distribution and nature of contacts and fault zones, which are relevant for the prediction of mechanic behaviour of the rocks along the tunnel tracks.

- **Geological results:**

Preliminary structural map of the ET Sardinia area

Definition of lithologies and structures

Relative chronology of deformation events

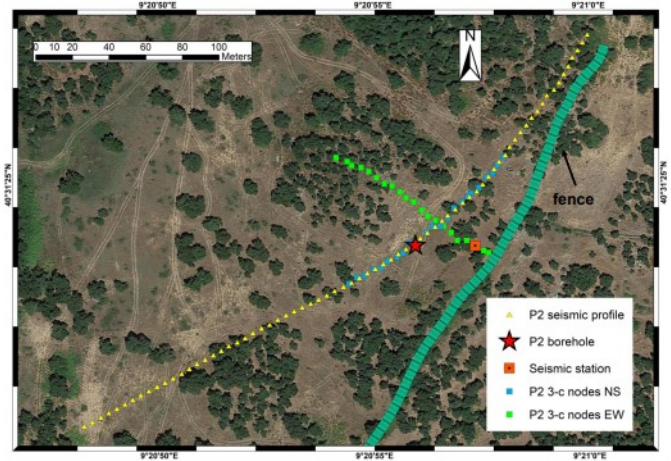
- **ERT results:**

Recognize the thickness of altered zones above the bedrock

identify superficial or suspended aquifers

Reconstruct the geometry of fault and fracture systems of limited extension and interconnectivity

Sardinia – seismic studies



Site P2
location map and seismic surveys

Unfavourable local logi conditions hampered acquisition of two long (> 35 and intersecting seismic profile

Thus, we have collected:

1 high-resolution sei profile
1 vertical seismic pr (downhole)

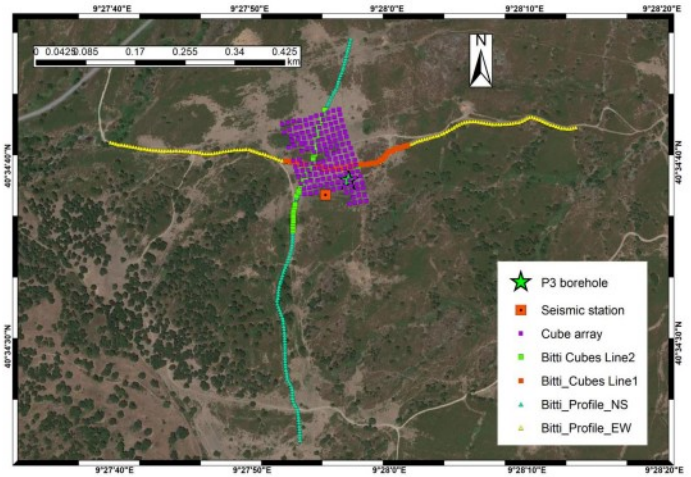
Instruments deployed by other te
2 linear arrays of 3-c nodes (**K.I.T**
1 broadband station (**INGV-Pisa**)

Site P3: surveys
1 vertical seismic profile

2 high-resolution seismic profiles with multi-fold wide-aperture geometry

Deployment by other teams:

nodal array of 153 3-D component cubes (K.I.T.)
2 linear arrays of 3-D component cubes (K.I.T.)
DAS vertical array (K.I.T.)
1 broadband seismic station (INGV-Pisa)



Site P2:
active-source seismic data

All the available space in the site was used.
It was not possible to deploy profiles > 360 m long

Seismic Profile	
Source	**Minibang**
N° Sources	39
Sources spacing	10 m
N° Geophones	72
Geophones spacing	5 m
Profile lenght	360 m
Total traveltime readings	2,520

Vertical Seismic Profile	
Source	**Minibang**
N° Sources	100
Maximum depth	234 m
Acquisition interval	2-4 m

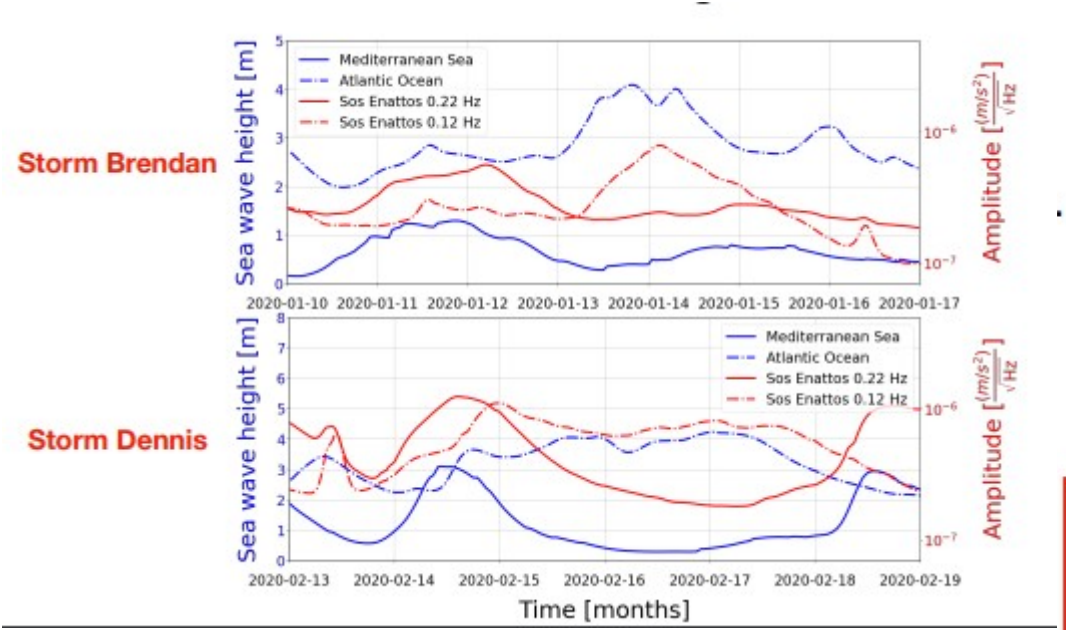
N-S HR seismic profile	
Source	**IVI-Minivib**
N° Sources	69
Sources spacing	10 m
N° Geophones	144
Geophones spacing	5 m
Profile lenght	720 m

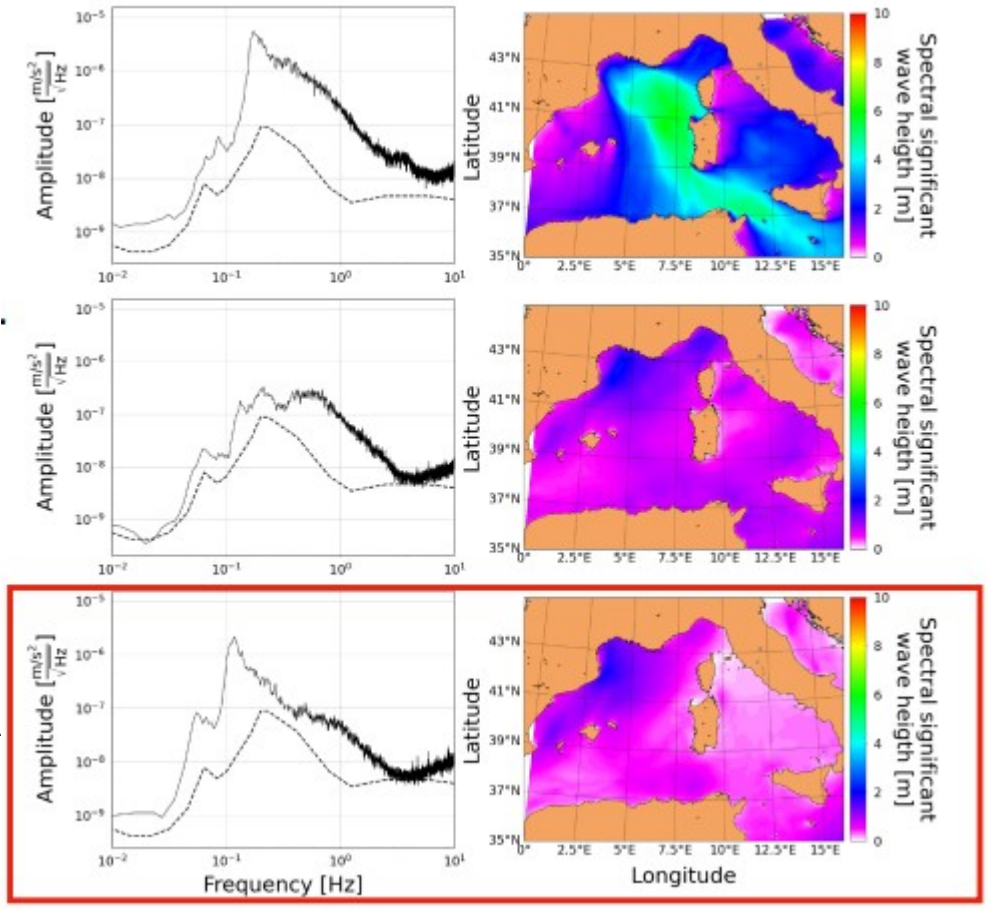
Site P3: seismic profile N-S

Sardinia – sea waves impact

Storm Brendan

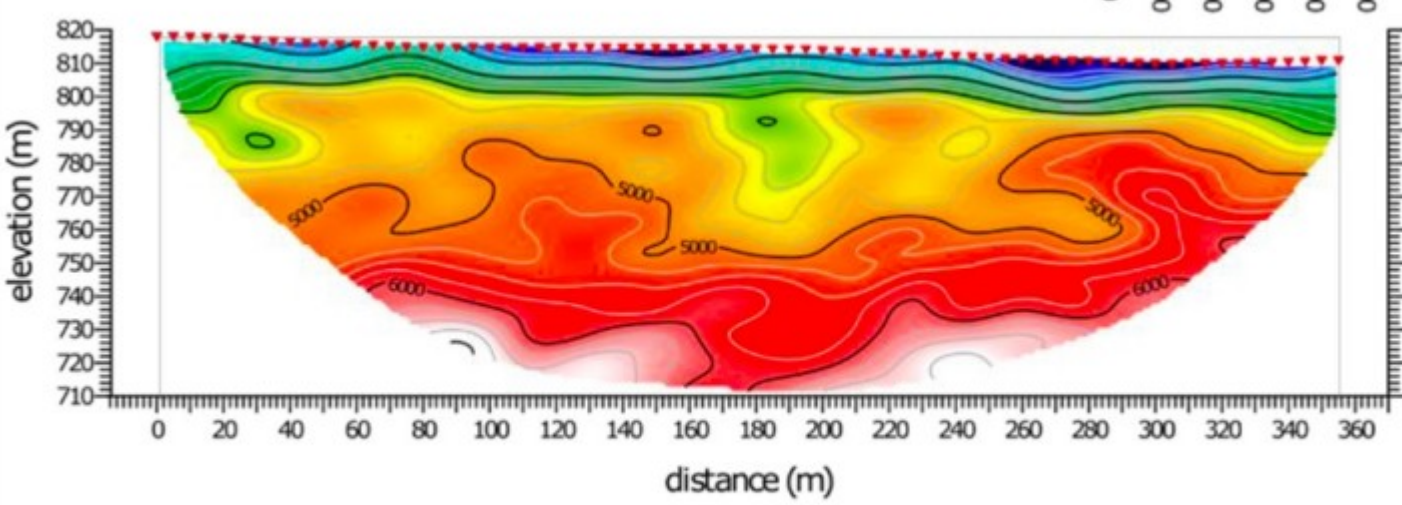
Storm Dennis





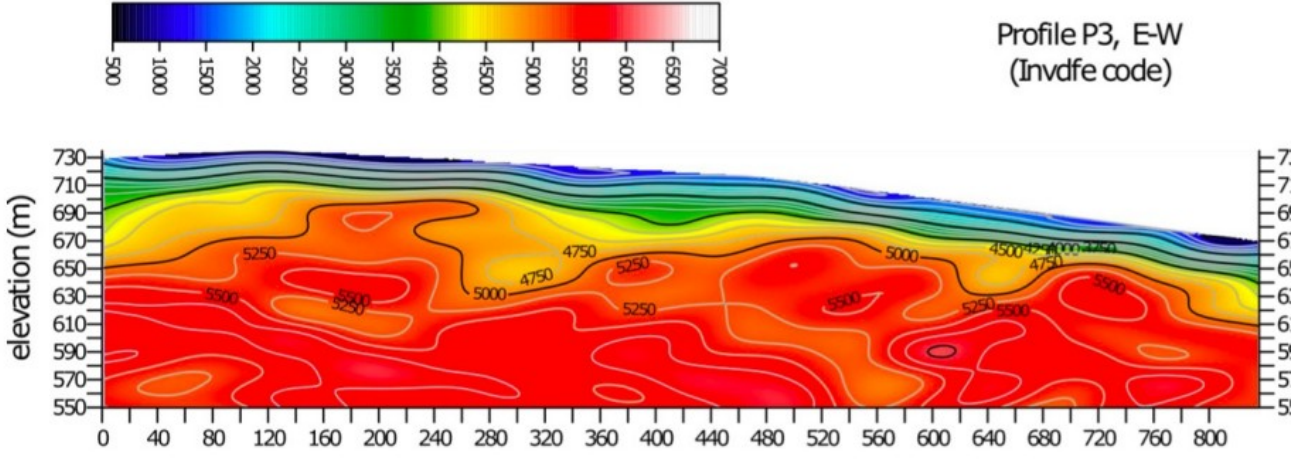
Depth profiles

P2



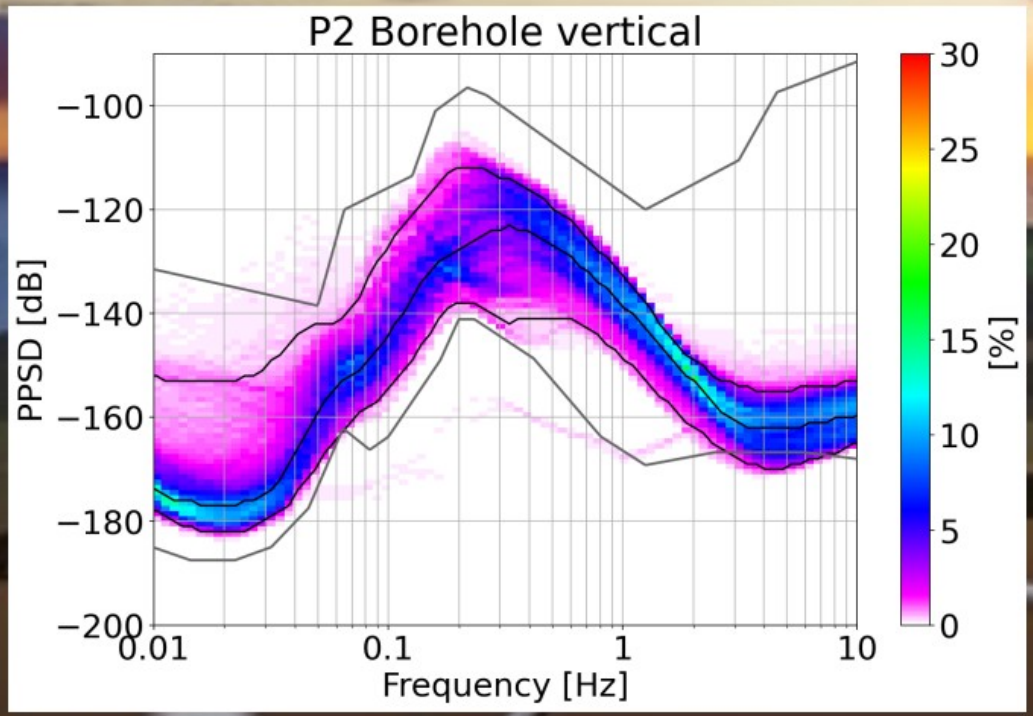
Invdfe code (final rms = 1.29 ms)

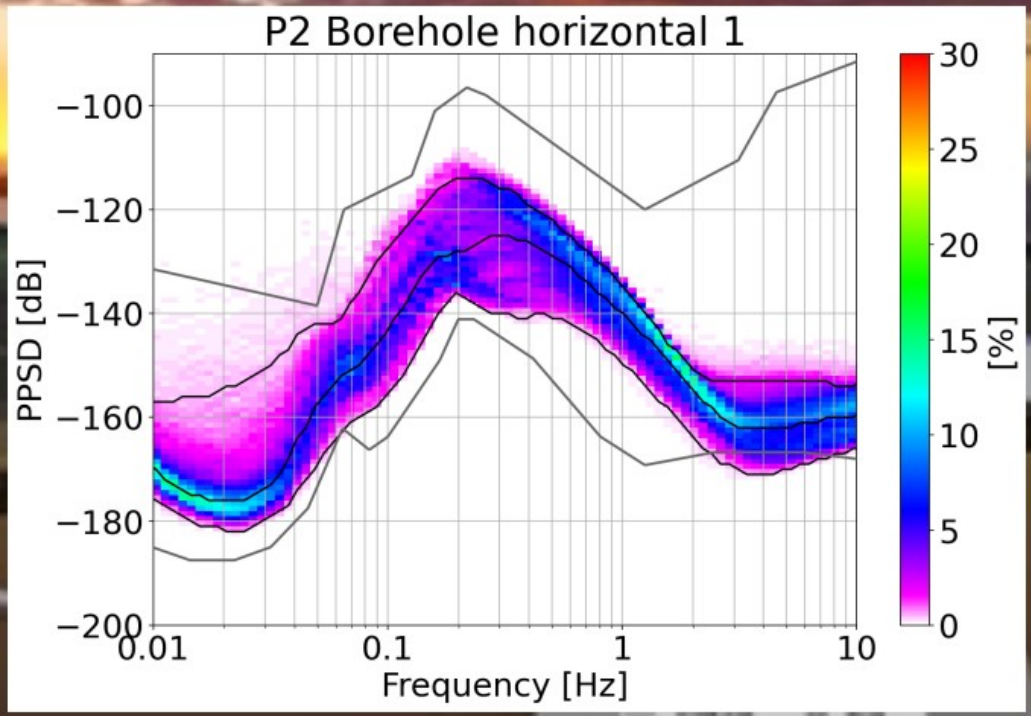
P3



Seismic noise P2 borehole

About half-year of continuous underground seismic measurements from the P2 and P3 boreholes, e.g.:





P2 (-264m) : 01 October 2021 – 20 March 2022

Sardinia – magnetic measurements

Probes at Bitti (P2)

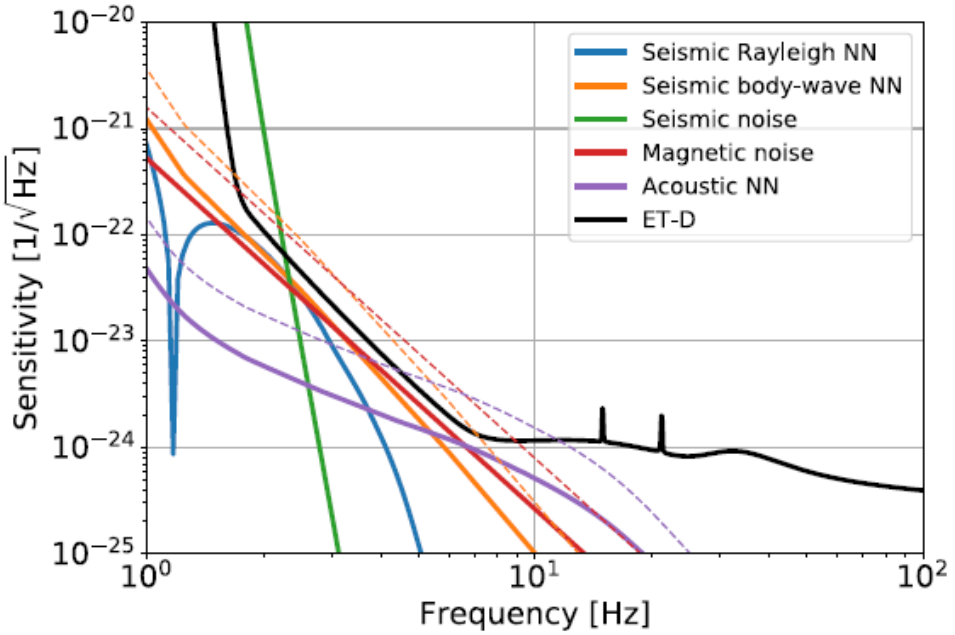
- Last September 17 a couple of magnetometers were instal in P2 (Bitti – NU), N-S and E-W orientation;
- The probes are the same used for Sos Enattos, with a different data logger (Metronix ADU 08) sampling at 512 Hz;

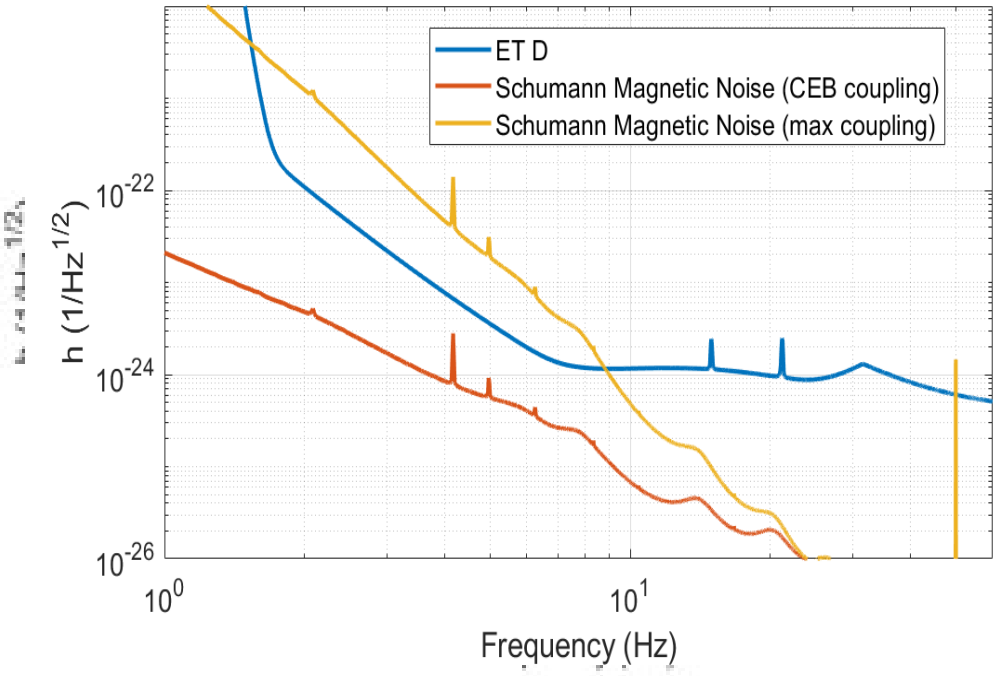
- The surface magnetometer (SOE0: N-S orientation) is also active.
- Several stops during the last years.
- Data taking periods:
  - 1 - 2020 August 6 to November 9;
  - 2 – 2021 March 13 to April 30;
  - 3 – 2021 July 27 to September 14;
  - 4 – 2021 October 16 ongoing

Sardinia – magnetic measurements

Horizontal and vertical measurements

Preliminary results

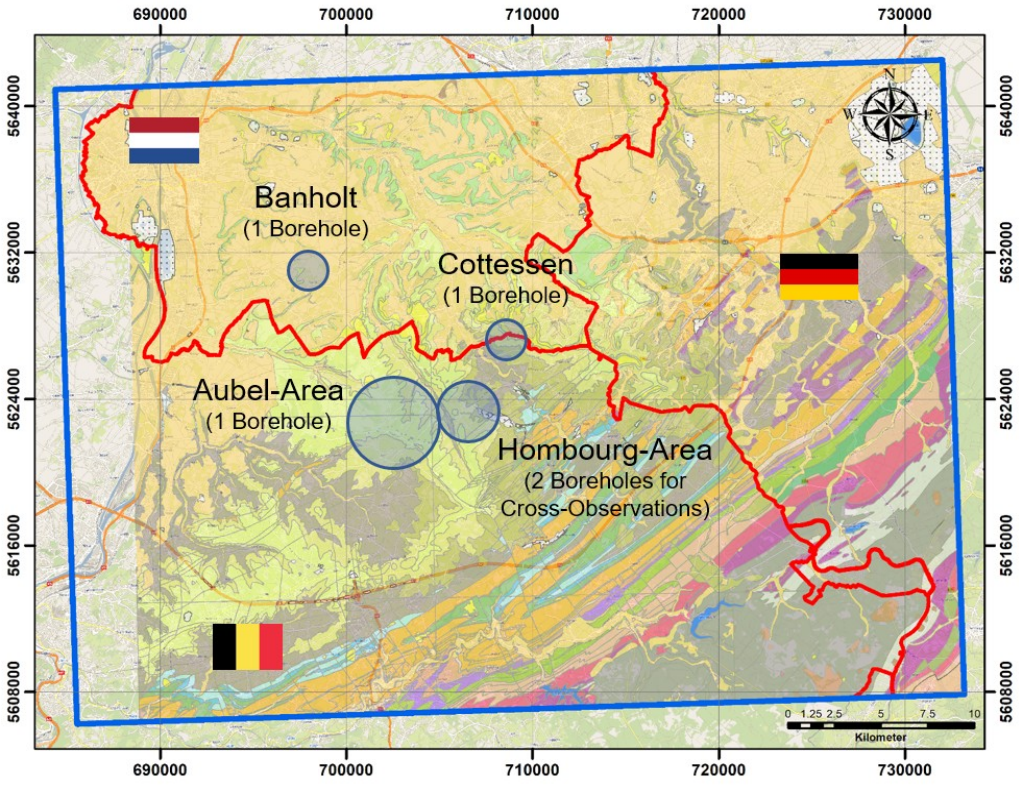




F. Amann et al. Rev Sci Instrum 91 (2020) 094504
K. Janssens et al. PhysRevD 104 (2021) 122006

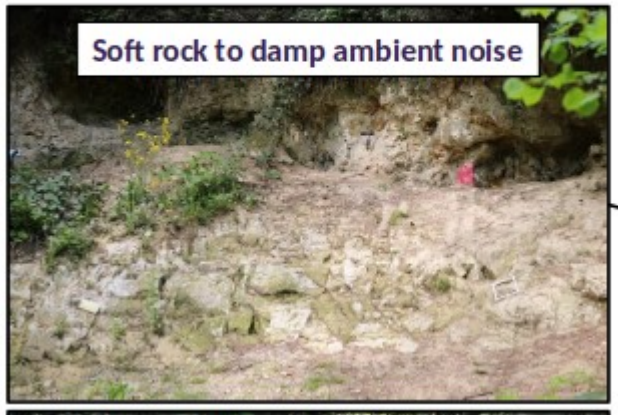
EMR site studies summary

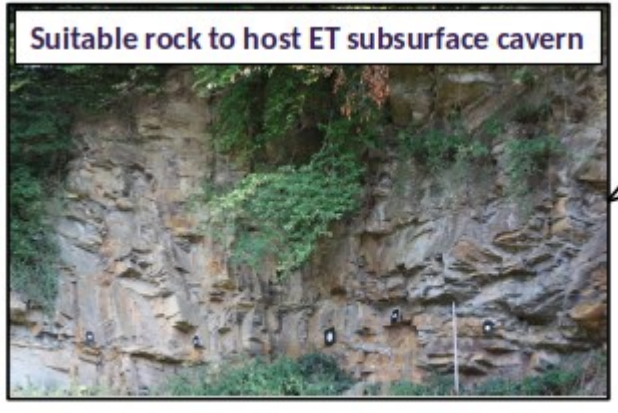
- Seismic studies
- Geological studies
- Data Analysis

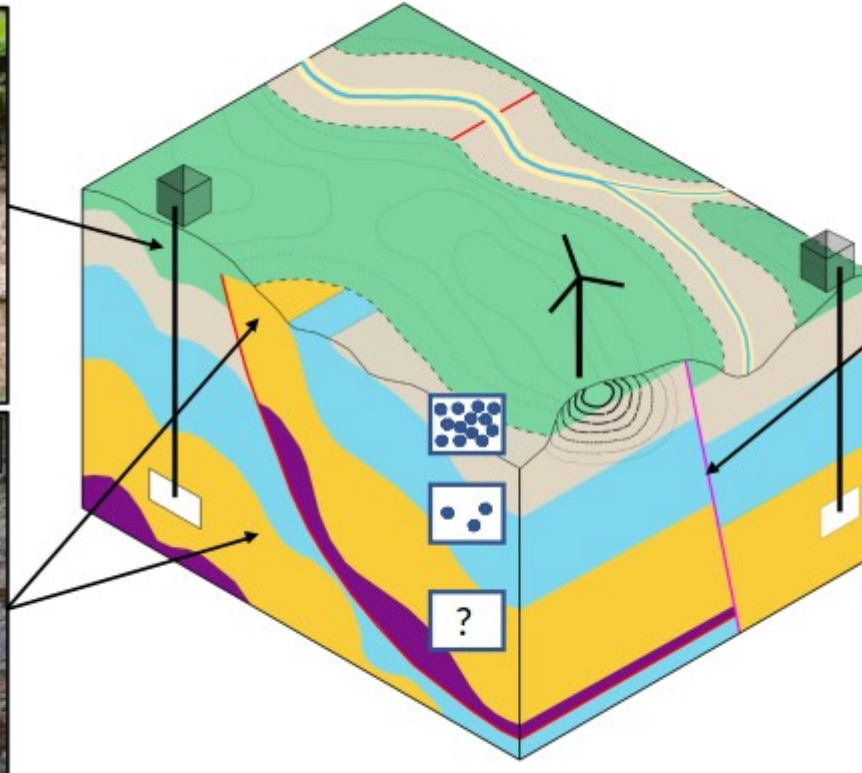


Geology -test site

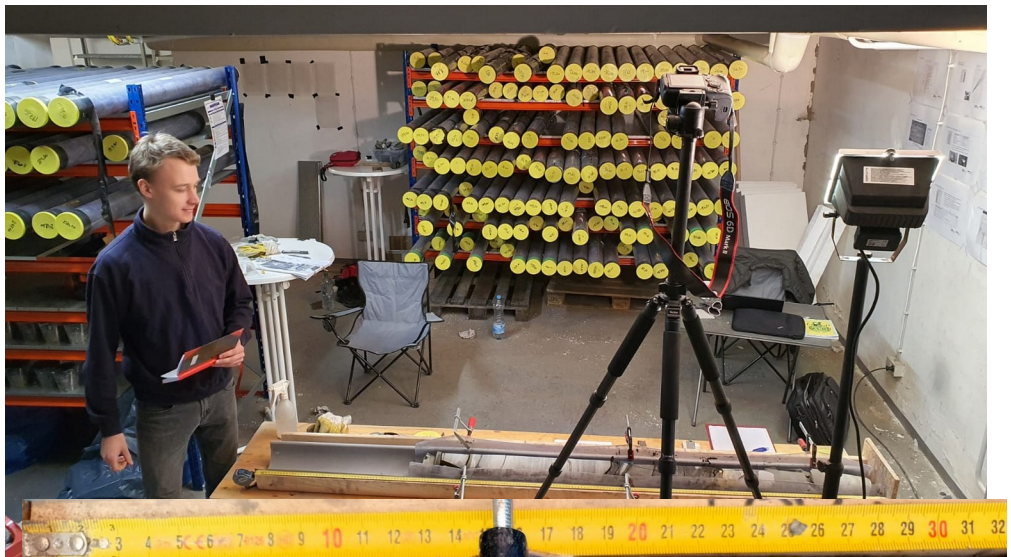
- Plan for 5 deep boreholes (up to 250m)
- 2 boreholes are completed
  - Cottessen
  - Banholt
- Borehole logging and in-situ testing including hydraulic testing and stress measurement is planned
- Detailed laboratory testing is conducted to estimate the strength of the rock

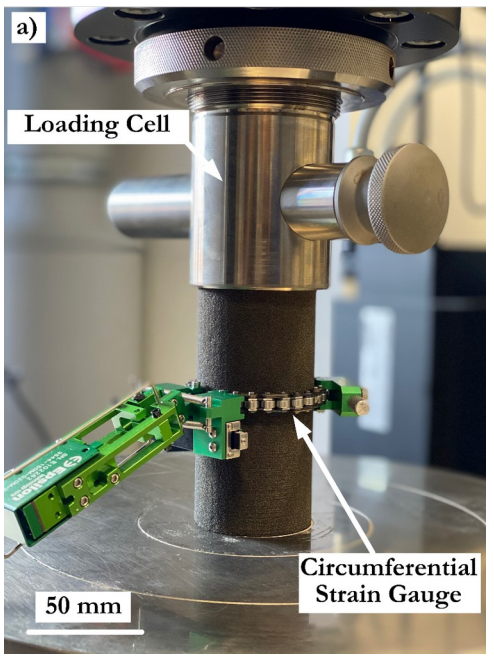


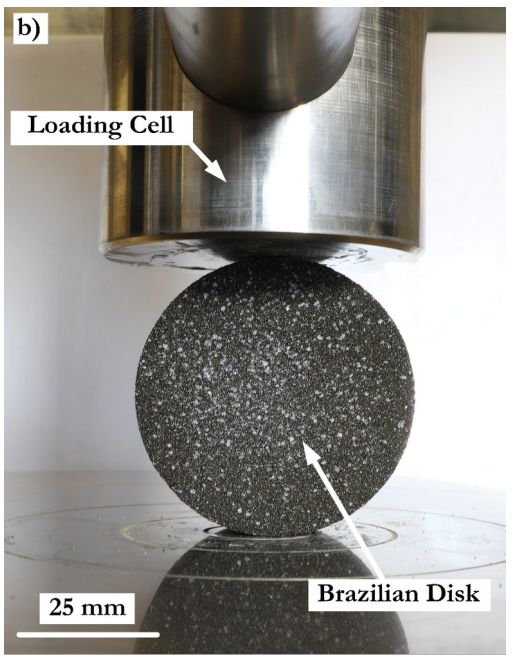




Borehole analysis

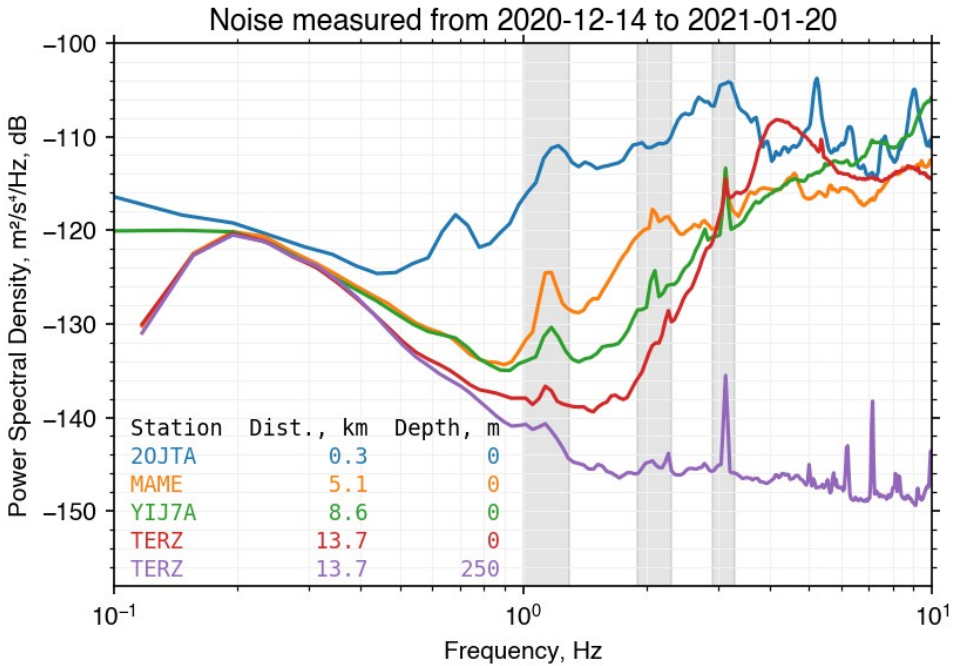




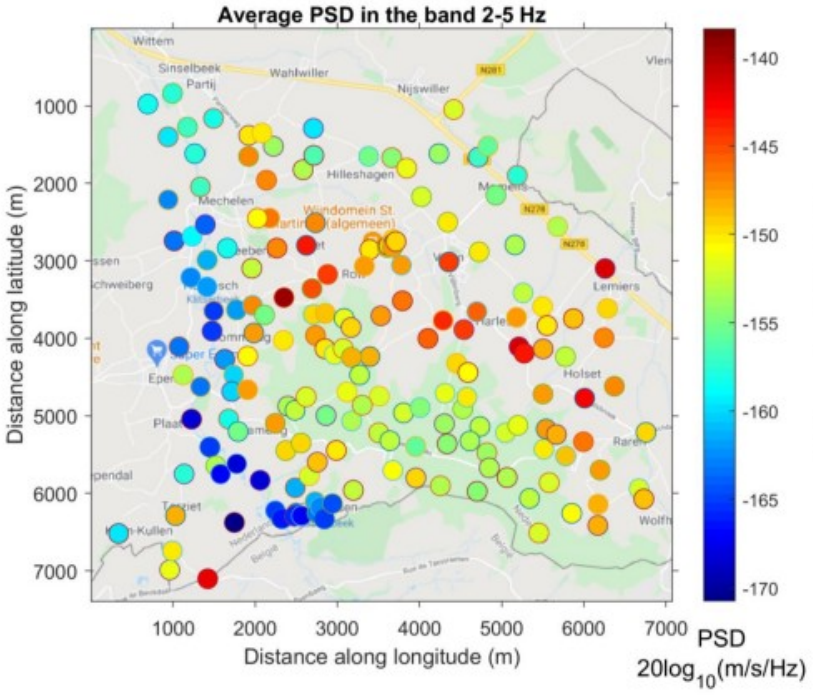


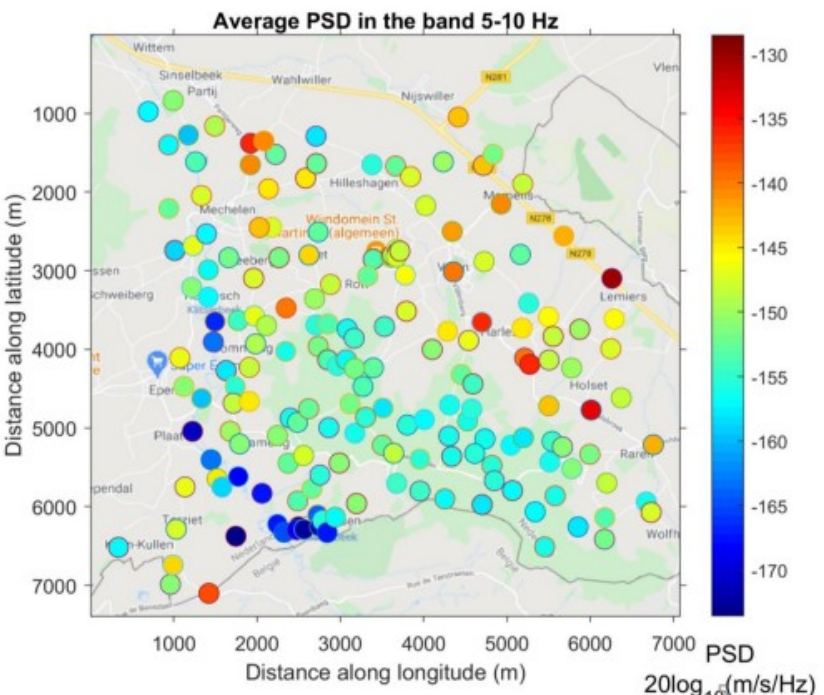
EMR seismic studies

- Boreholes
- Surface measurements
- Active and passive



Passive campaign

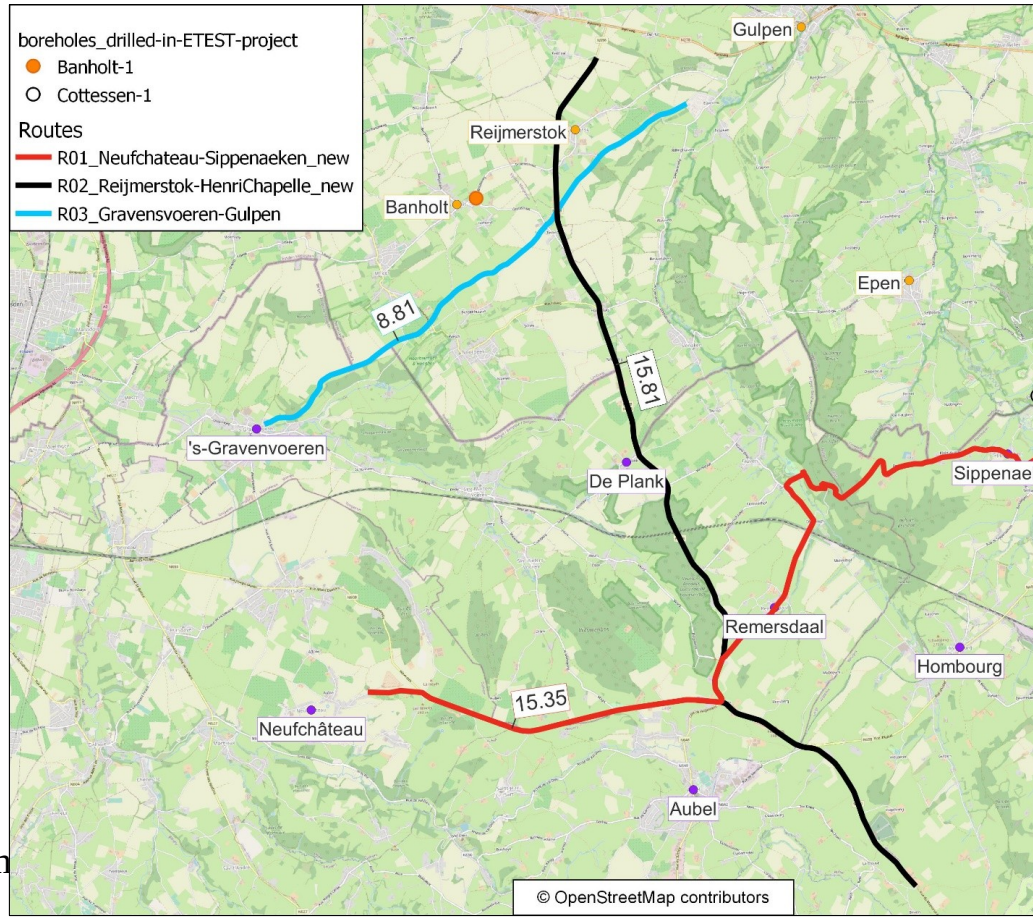




Active campaign

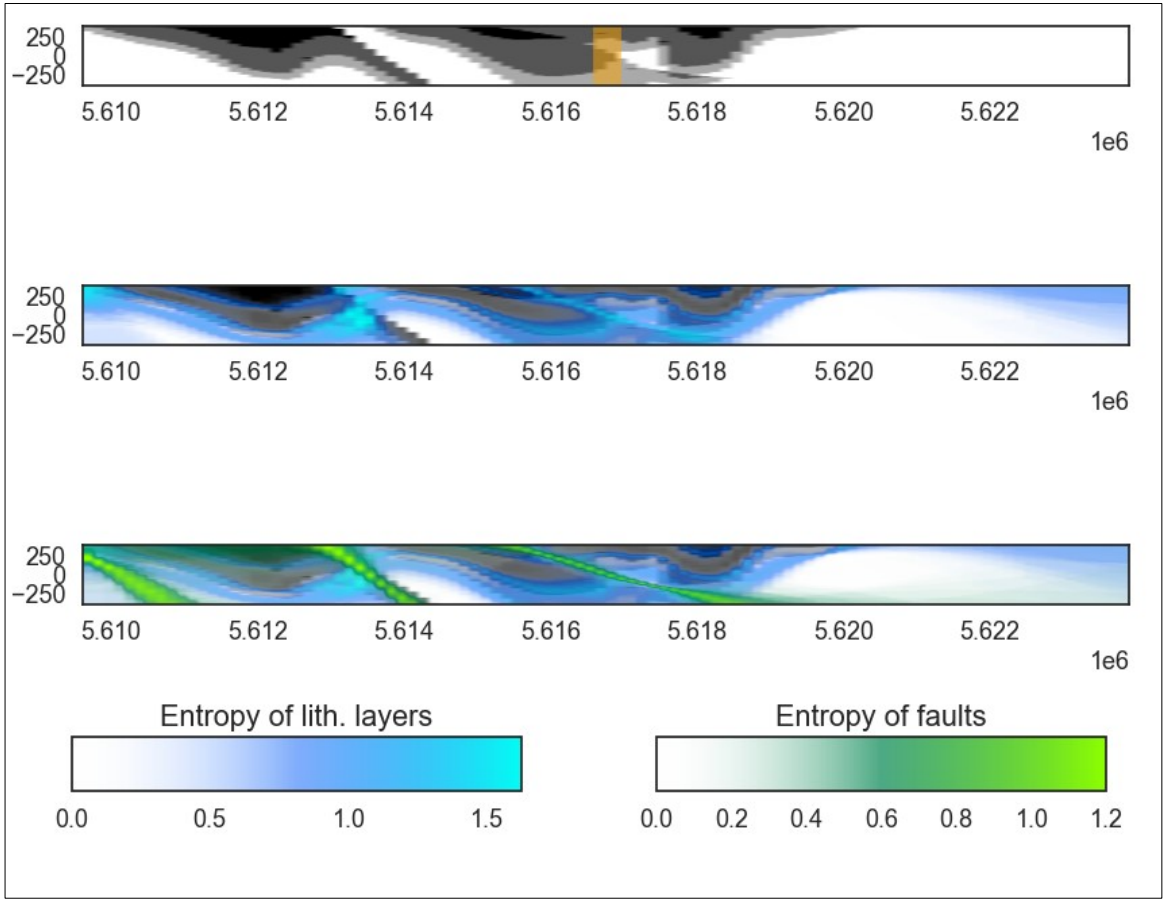
- Two targets:
  - Shallow: 100 – 500 m
  - Deep: 500 – 2000 m
- Shallow: image the target depth of ET laboratory
- Deep : image the structures that influence the ET target depth

Sym

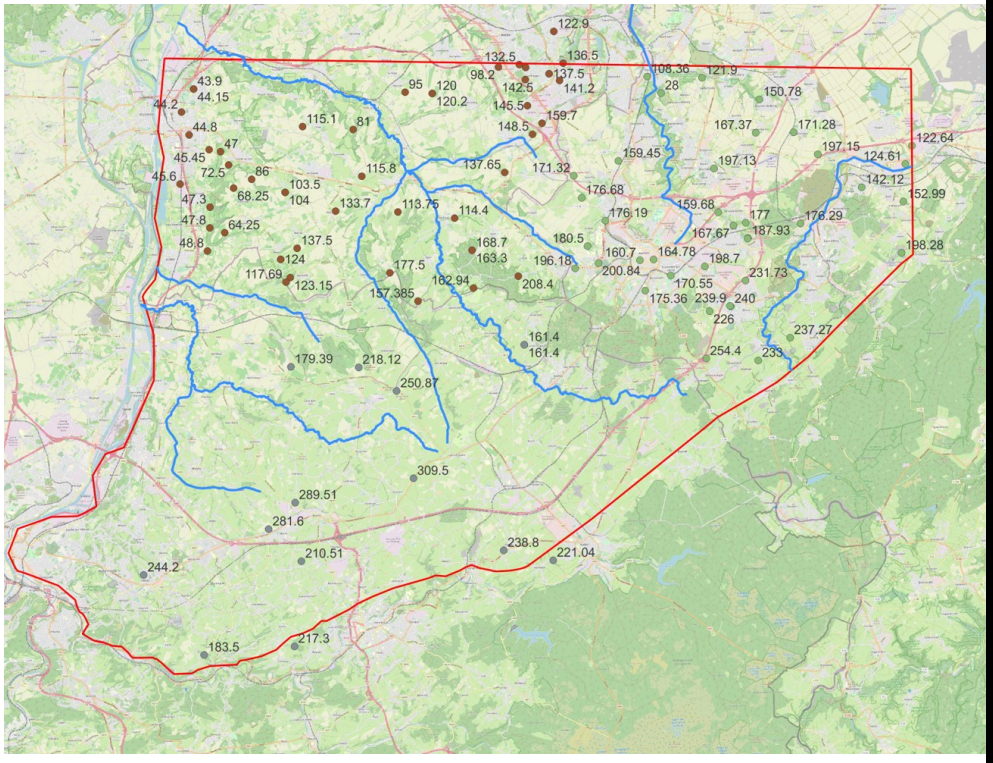


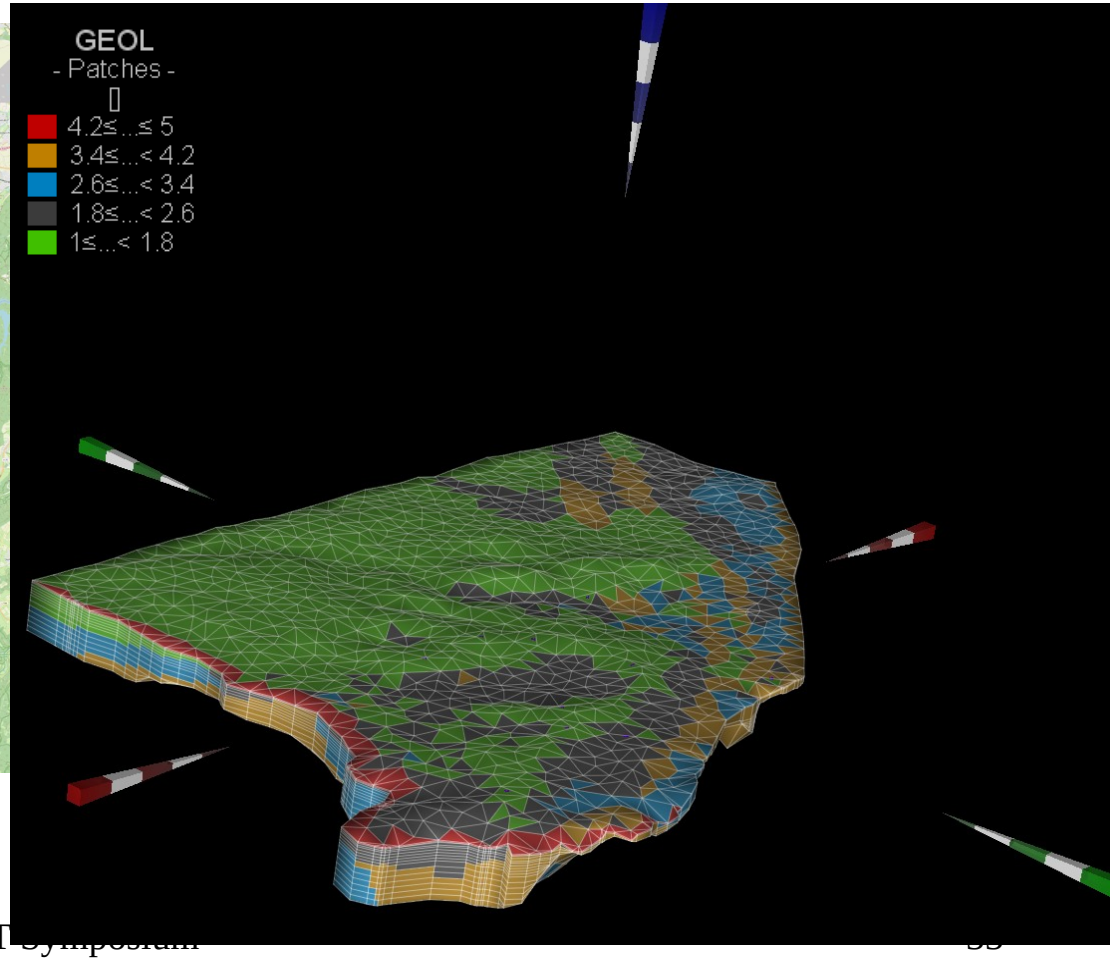
EMR geology

Assessment of uncertainties
(entropy of models)



EMR hydrology studies



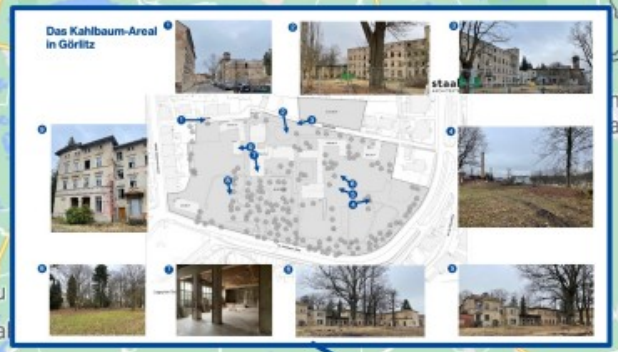


- Rivers and piezometres heads to calibrate model

Saxony site

Saxony site

Möglicher Standort des Einstein-Teleskop mit dem unterirdischen Low-Seismic-Lab



Ein Zentrum für Astrophysik mit fortschrittlicher Computertechnik und Technologieentwicklung

DZA

TECHNISCHE UNIVERSITÄT DRESDEN

Initial results very promising:

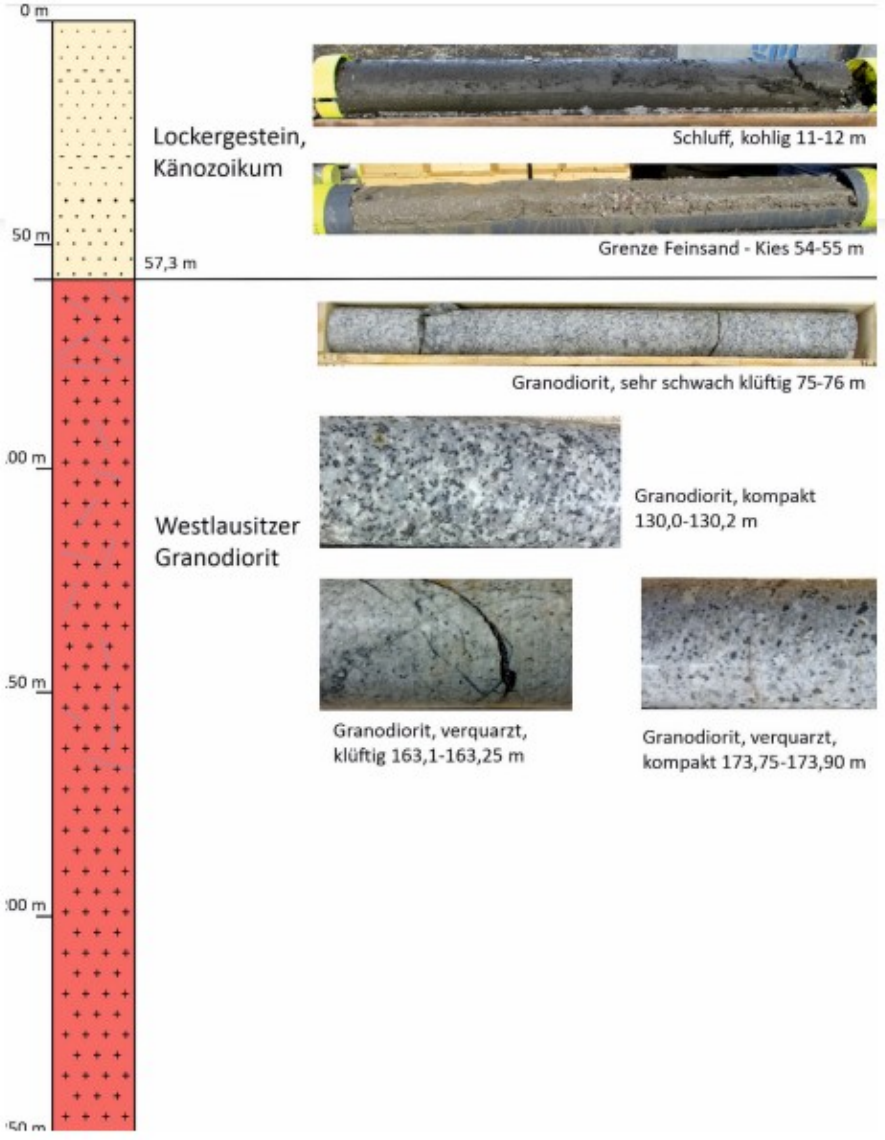
Very hard rock starting about 60 meters below the ground.

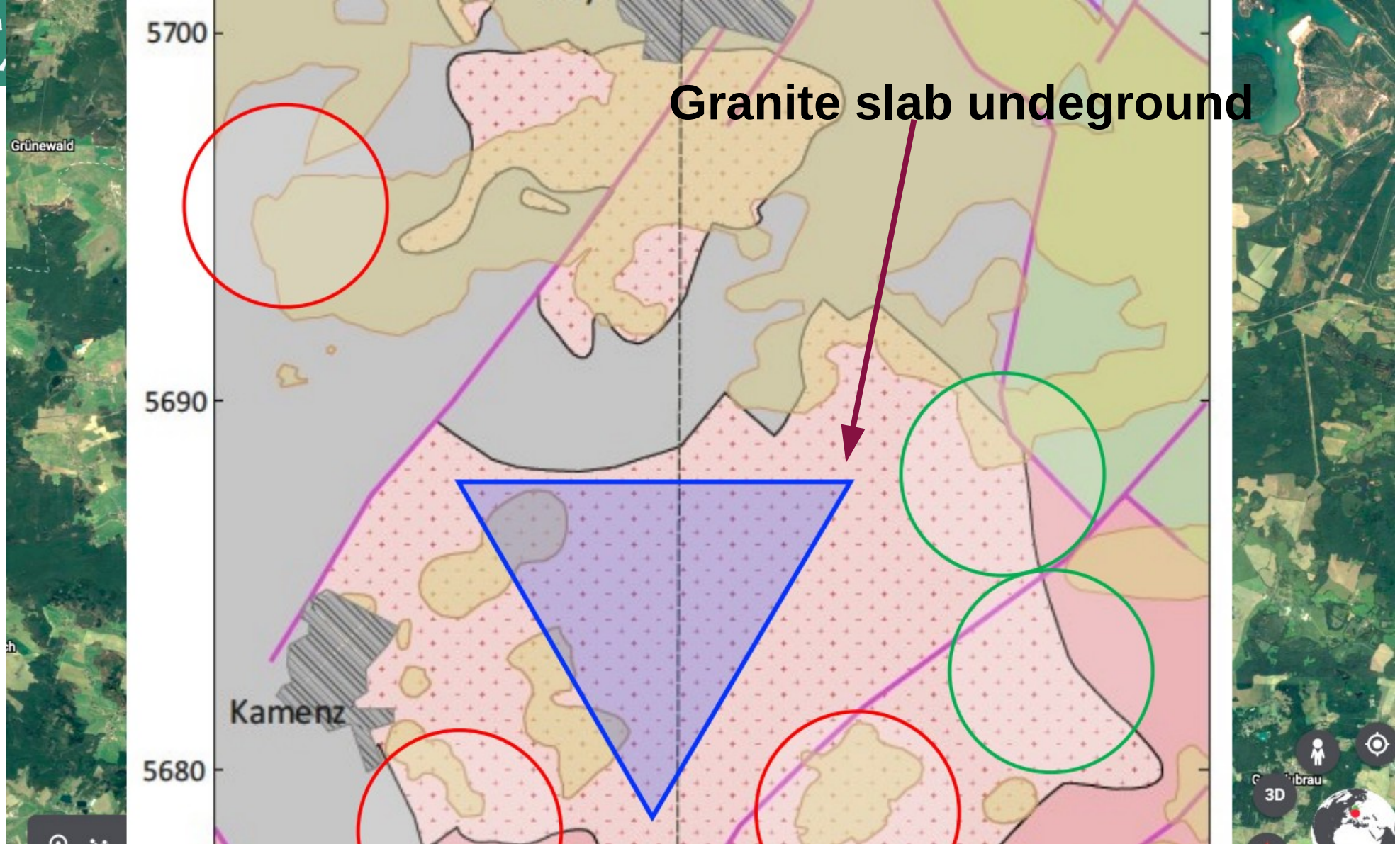
Next steps:

- hydrogeology

- widening of the borehole

- geo seismic studies

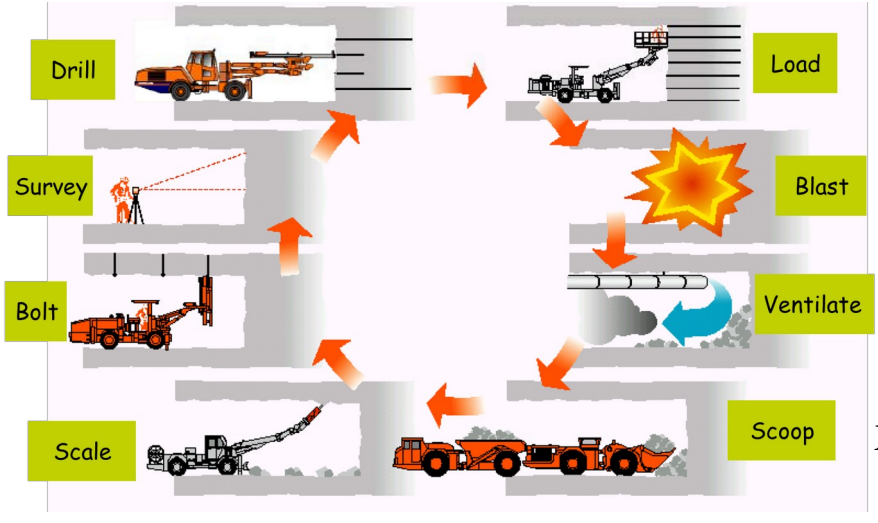


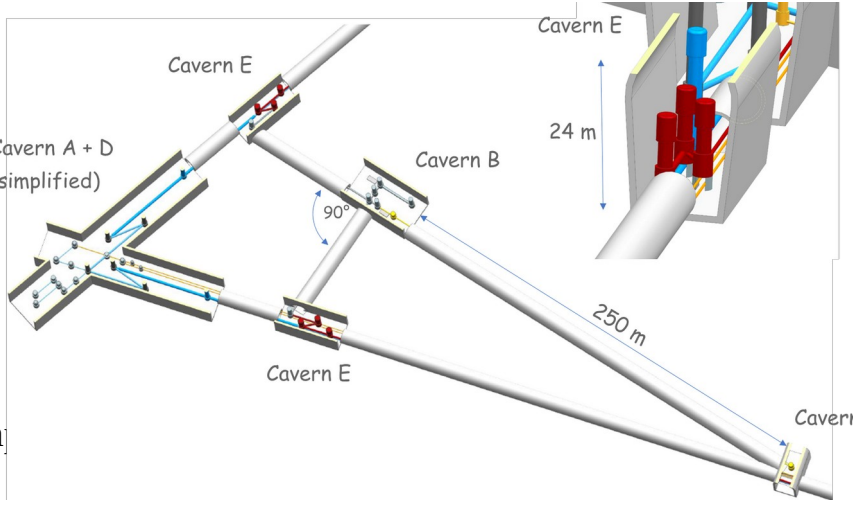

Granite slab undeground
5700
5690
5680
Kamenz
Grünewald
3D

Tunnel and civil engineering

- Ongoing studies at both sites
- Summary at the recent SPB meeting
- See the ISB talk

  https://indico.ego-gw.it/event/451/





The road ahead

Challenges ahead

- Change workflow to top down
- Significant new funding for the site studies
- Defining a set of required measurements for both sites
- Linking the work to other Boards/WPs

Funding

- Funding required at the level od O(10M€) per site
- EMR – site- national funds
- Sardinia site – Recovery fund, and local funds
- Should be sufficient until site selection

Work plan

- Heads for SPB sub tasks
- SPB bi-weekly thematic meetings
- Work at both sites is ongoing – need to know more about Saxony
- 2nd SPB and WP 4 in October 2022 in EMR region.

Heigh Ho...