E-TEST – Geological Field Investigations, Drilling Programs and Geophysical Logging

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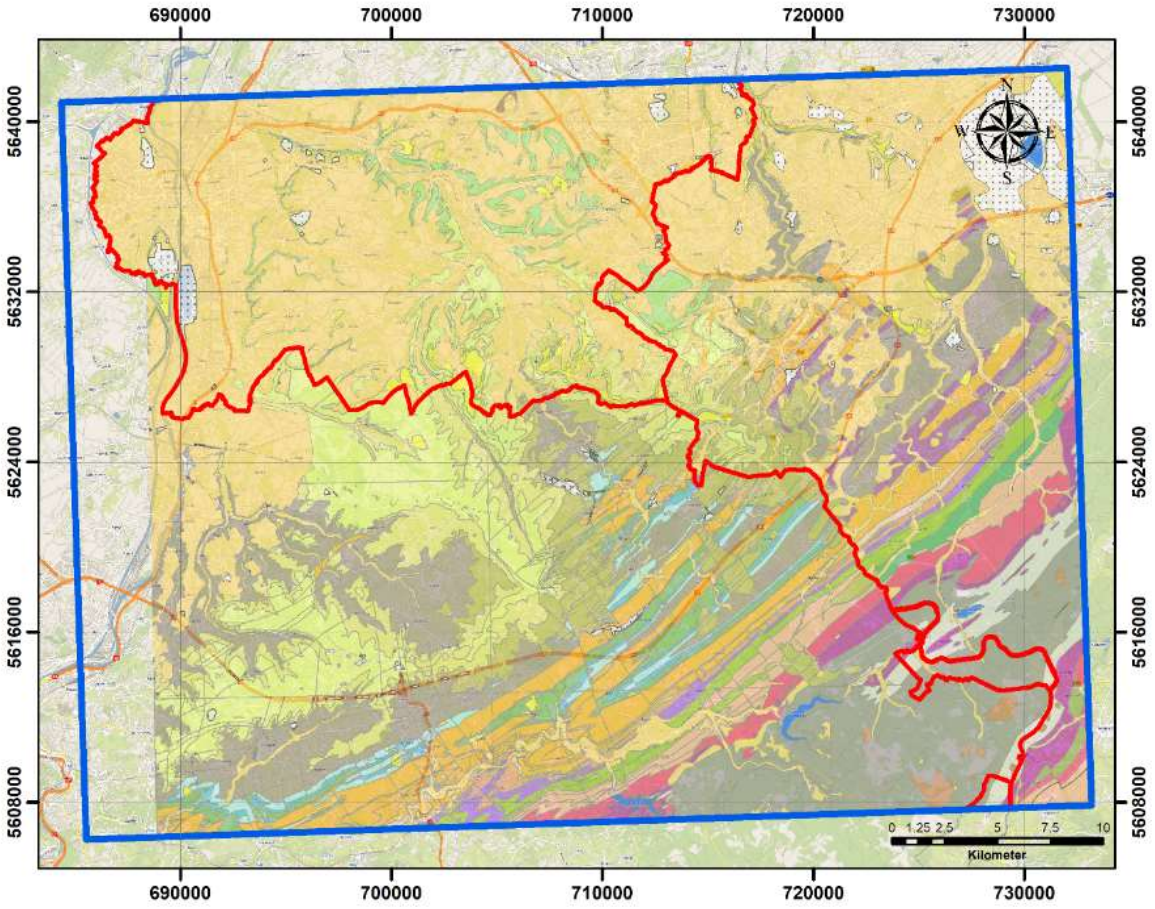
Main Objectives - WP T4

- **3D Cross-Border Open Geological Model**
  - Evaluation and incorporation of existing geological data sets
  - Implementation of new boreholes
  - Active and passive seismic survey
- **ET-Design**
  - Feasibility study and optimal positioning of the ET triangle
  - Extensive multi-disciplinary in-situ and laboratory testing campaign
  - Assessment of regional fracture characteristics by outcrop analogue studies

Rocks in the EMR Region

- Rocks of Paleozoic age
  - Carboniferous (361-300 Mio. years)
  - Upper Devonian (383-361 Mio. years)
- Rocks of Upper Cretaceous age
  - 85-66 Mio. years
- Distribution of rocks varies throughout EMR region

- General information from literature and outcrop studies
- Local subsurface information from drill cores



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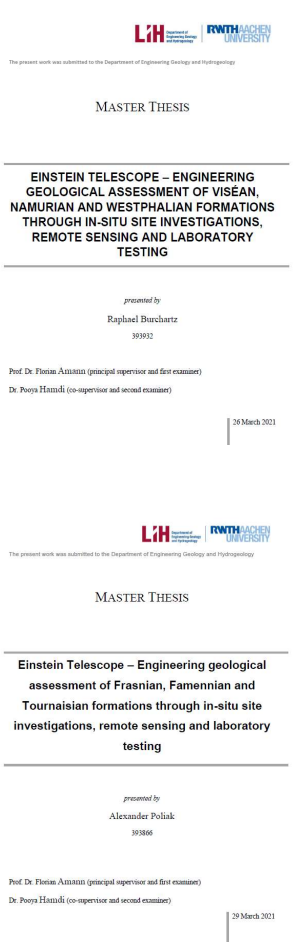
Geological Assessment of Representative Rocks within ET-Project



MASTER THESIS

EINSTEIN TELESCOPE – ENGINEERING GEOLOGICAL ASSESSMENT OF VISÉAN, NAMURIAN AND WESTPHALIAN FORMATIONS THROUGH IN-SITU SITE INVESTIGATIONS, REMOTE SENSING AND LABORATORY TESTING

presented by

Raphael Burchartz

393932

Prof. Dr. Florian Amann (principal supervisor and first examiner)

Dr. Pooya Hamdi (co-supervisor and second examiner)

26 March 2021

MASTER THESIS

Einstein Telescope – Engineering geological assessment of Frasnian, Famennian and Tournaisian formations through in-situ site investigations, remote sensing and laboratory testing

presented by

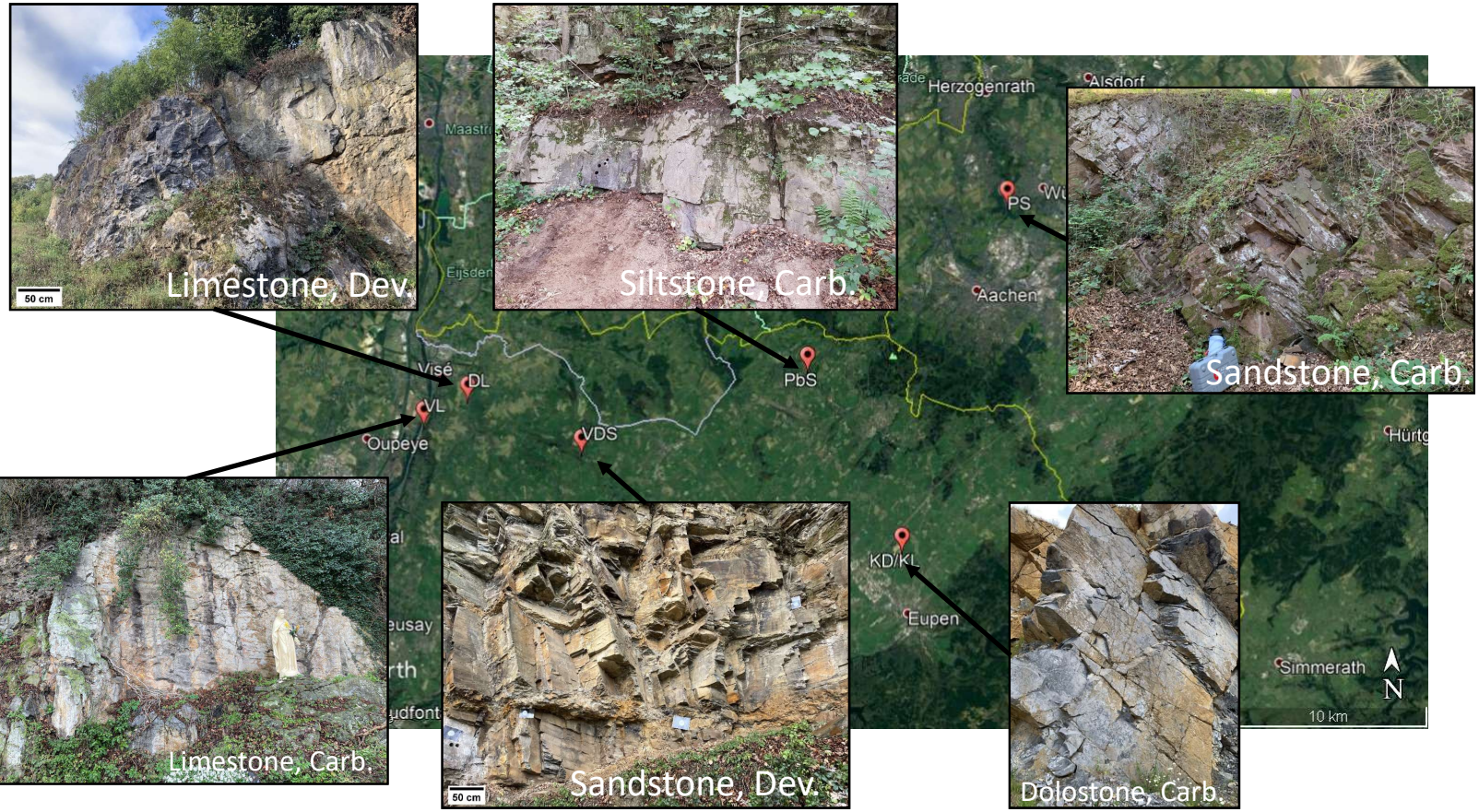
Alexander Poliak

393866

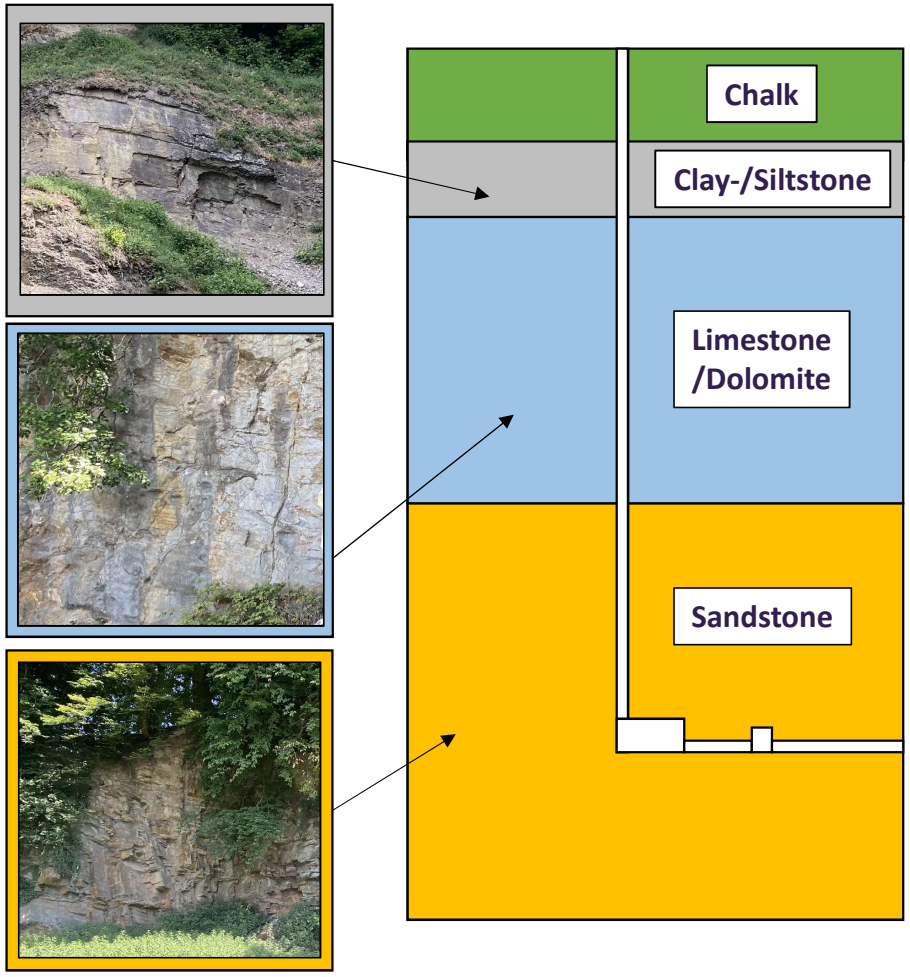
Prof. Dr. Florian Amann (principal supervisor and first examiner)

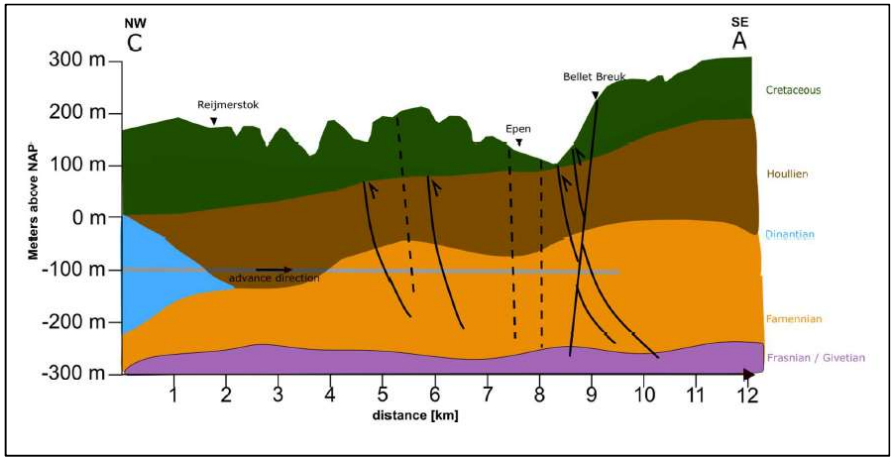
Dr. Pooya Hamdi (co-supervisor and second examiner)

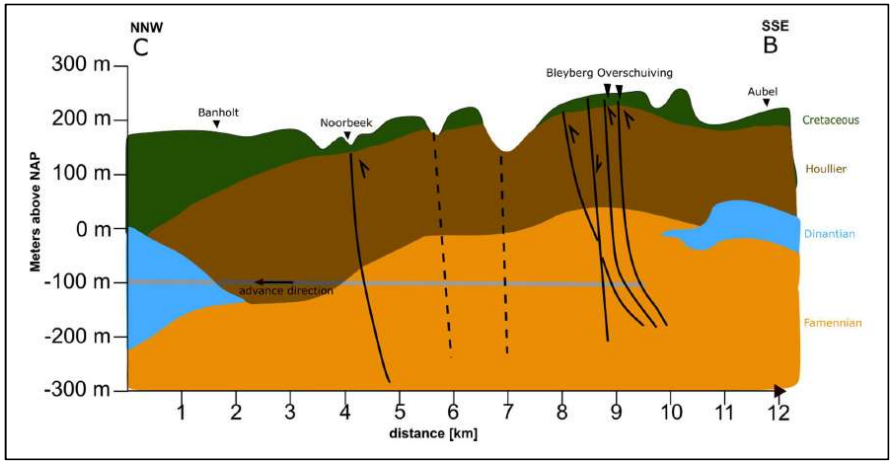
29 March 2021



Ideal vs Real Rock Column in the EMR Region



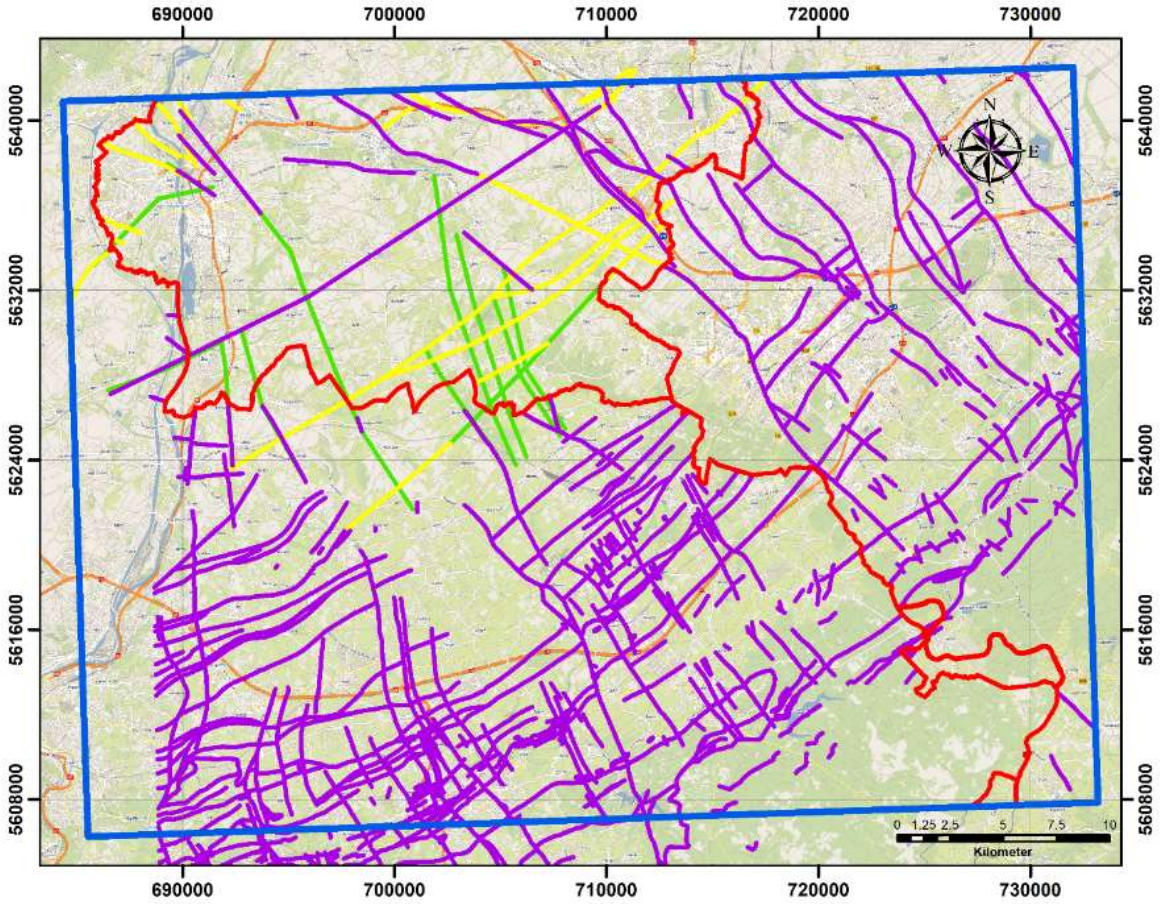




(Ott, 2021)

Geological Structures in the EMR Region

- Structure set A
  - Running NE – SW
  - Originate from Late Paleozoic orogeny
  - Affects only Paleozoic rocks
- Structure set B
  - Running NW-SE
  - Origin in Devonian, reactivated several times
  - Affects all rocks
- Information about large-scale structures from literature & maps
- Local information on small-scale features by outcrops & drill-core data



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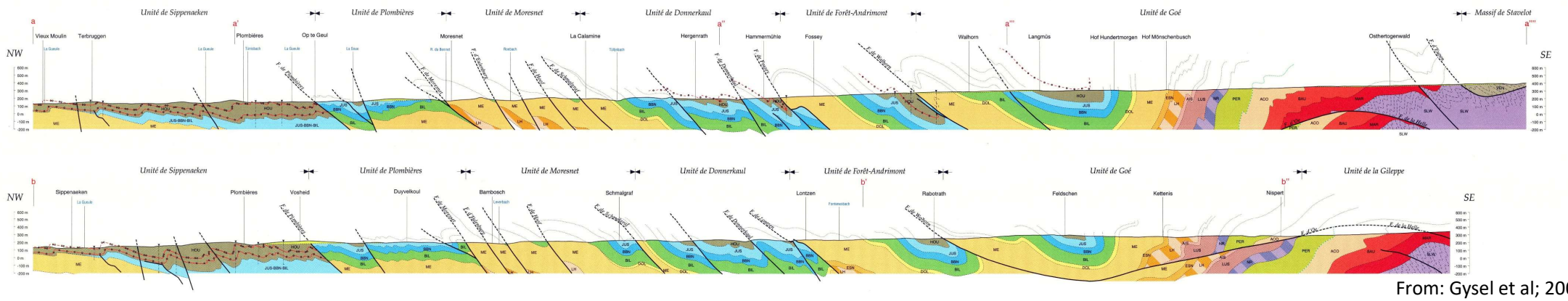
Structure Set A: Running NE-SW

- Folds and thrust faults on large scale
- Fractures on small-scale: Open and closed

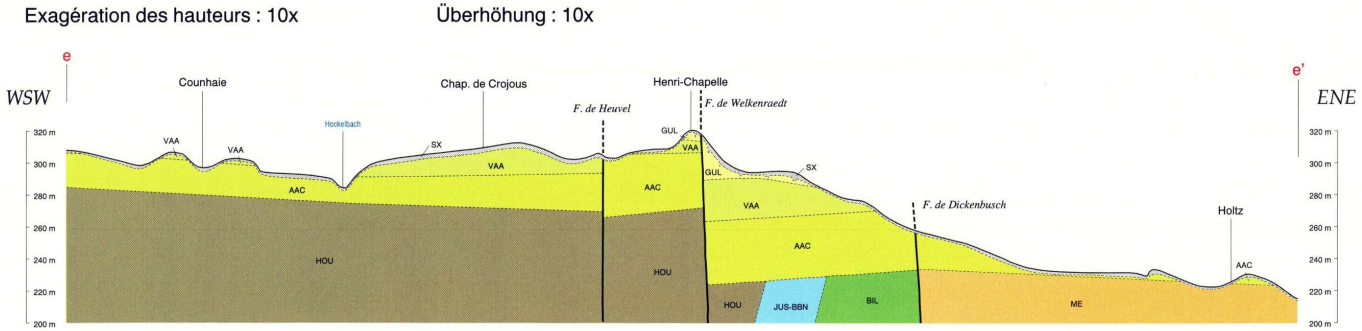


From: Gysel et al; 2000

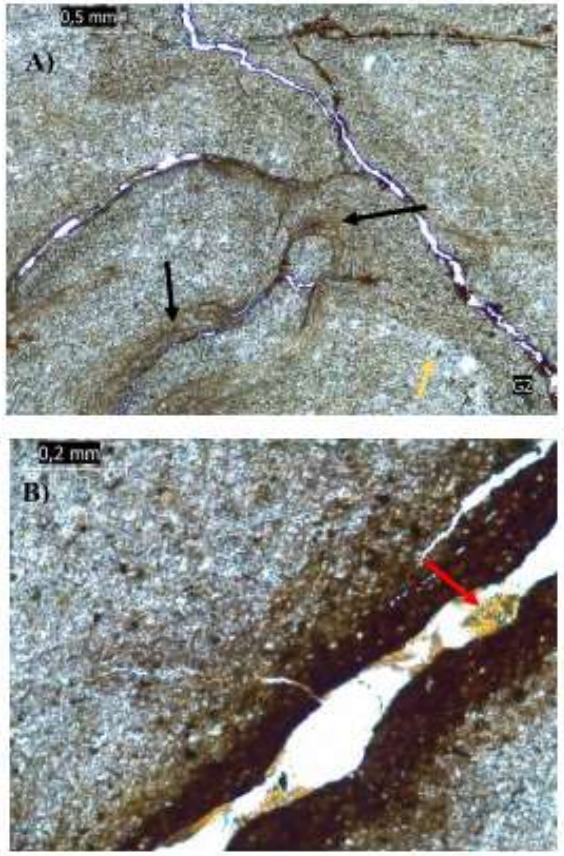
- Orientation unfavorable to recent stress field
  - Not active
- Water may circulate in open fracture

Structure Set B: Running NW-SE

- Normal and strike-slip faults on large scale
- Fractures on small-scale: mainly open



From: Gysel et al; 2000

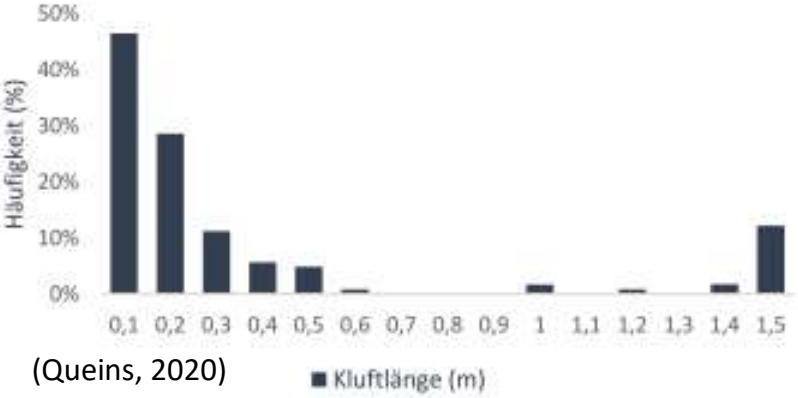


(Queins, 2020)

- Orientation favorable to recent stress field
  - Active in Lower Rhine Embayment
- Water very likely to circulate in open fracture

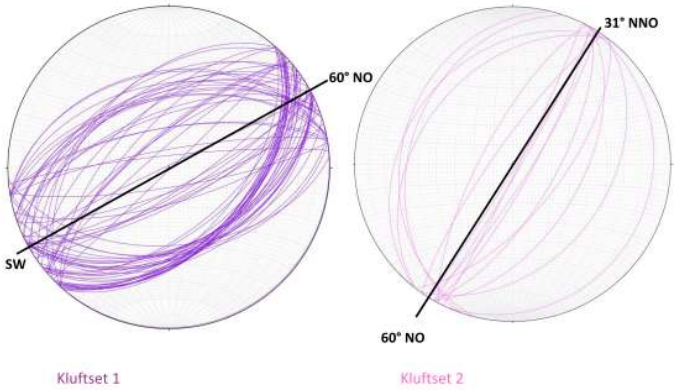
Fractures and Potential for Water Flow

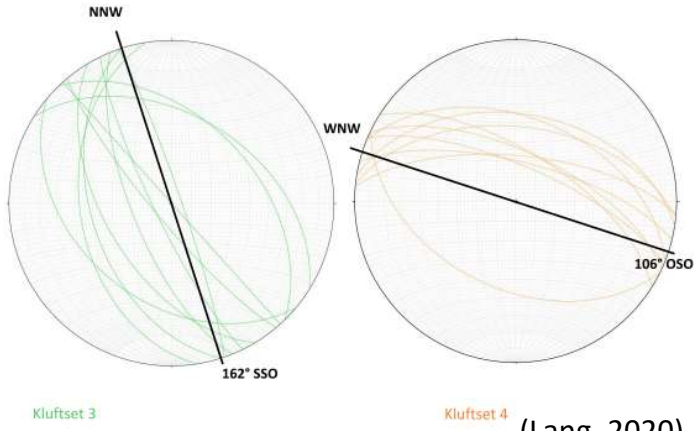
- Water can flow easily along open fractures
- Connected open fractures enhance possible flow
- Field study on orientation, length and connectivity of fractures



(Queins, 2020)

Identified fracture orientations





(Lang, 2020)

Mapping of fracture connections

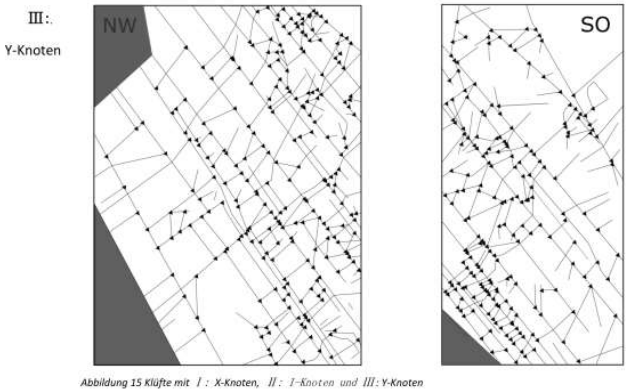
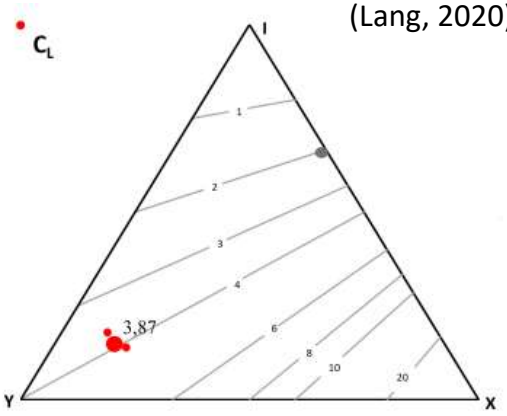


Abbildung 15 Klüfte mit I: X-Knoten, II: I-Knoten und III: Y-Knoten

Classification of fracture connections

(Lang, 2020)



(Lang, 2020)

First Step - Surface Investigations

- Surface investigation of outcropping rocks provides
  a. The possibility to get a first approximating technical data source by in-situ and laboratory testing
  b. derive possible formations of special interest for further investigation

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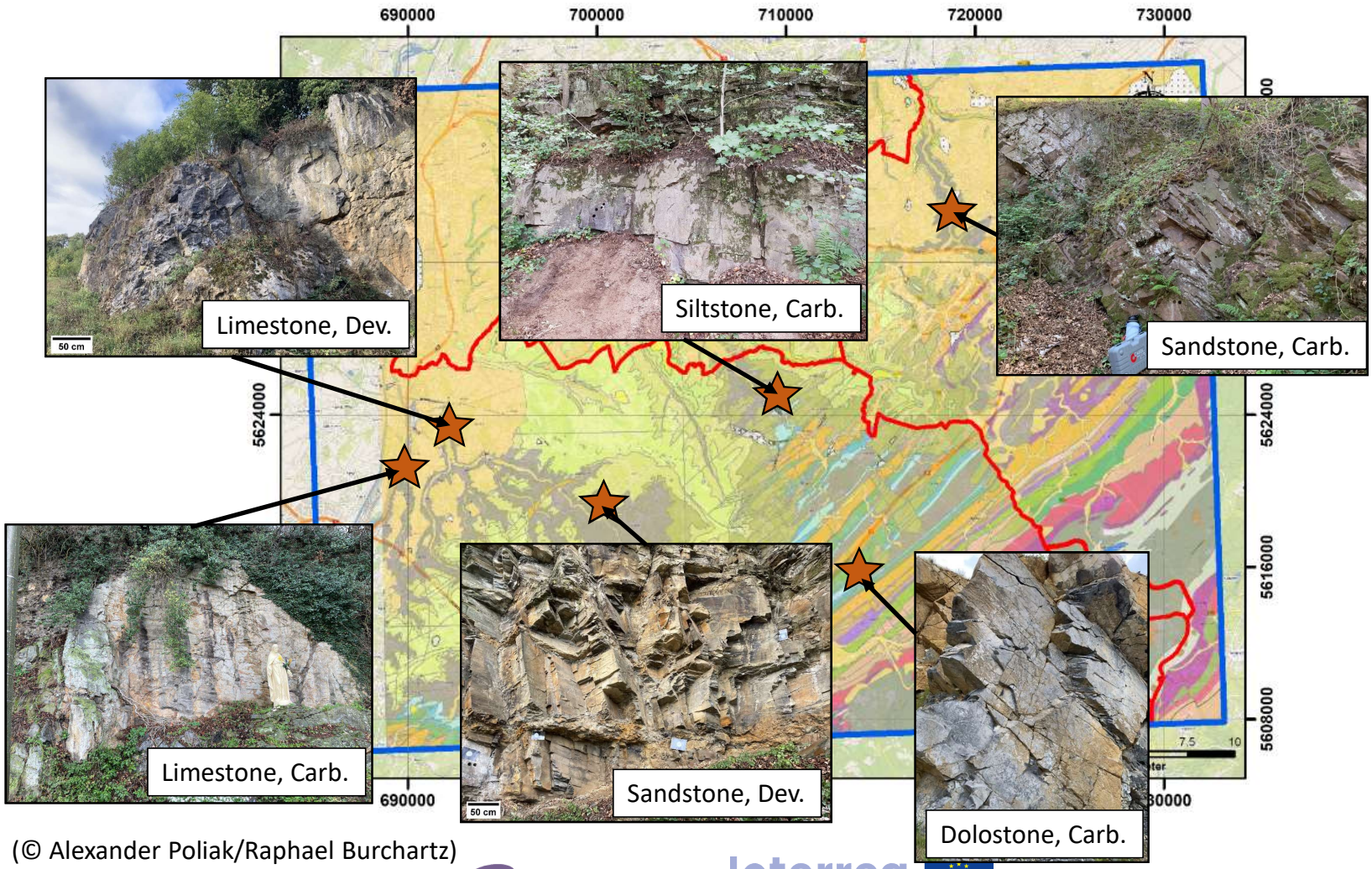
Surface Investigations



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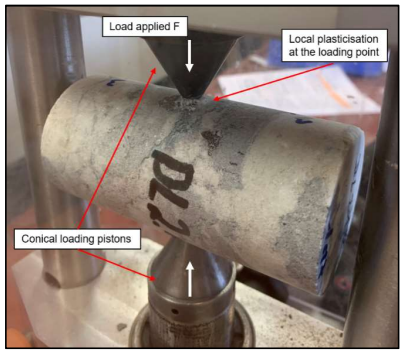
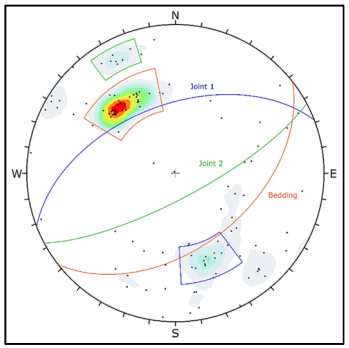
Surface Investigations

In-situ tests	Laboratory tests
• Photogrammetry • Point-load tests • Scan-line mapping	• P-wave velocity measurements • Brazilian Tensile Strength (BTS) • Uniaxial Compression Strength (UCS)





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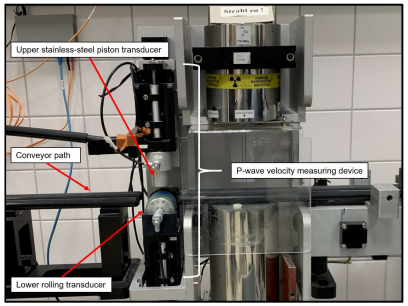

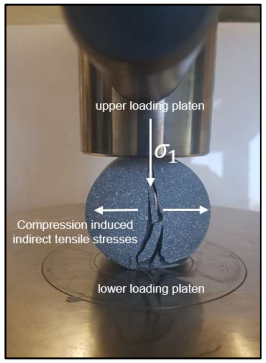

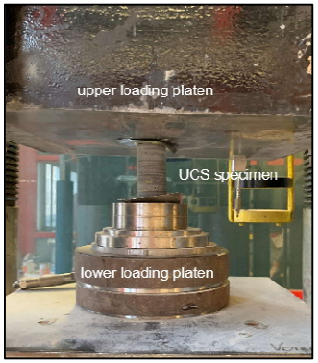

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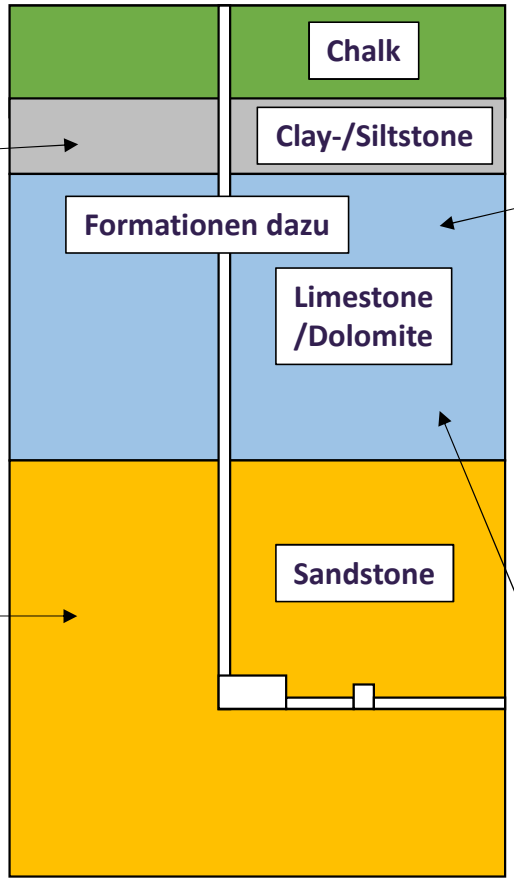
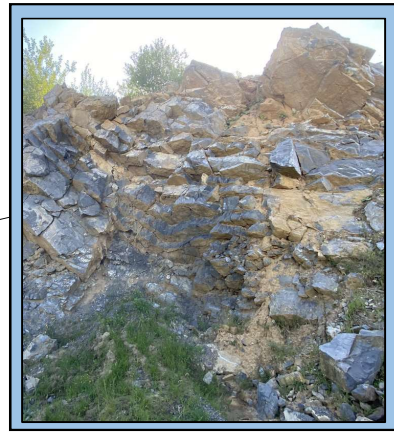
Geological Assessment of Representative Rocks within ET-Project

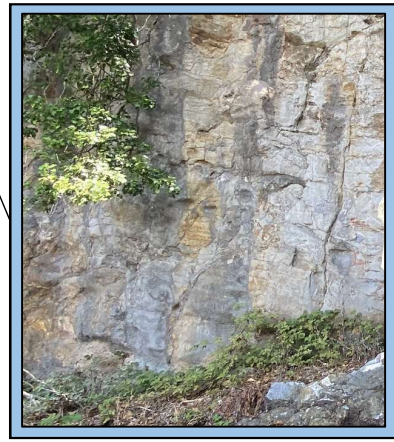
Density	2.32 g/cm³
Porosity	18.7 %
E-Modul	23 GPa
UCS	104 MPa
BTS	9 MPa
P-Wave-V.	4309 m/s

Density	2.64 g/cm³	UCS	119 MPa
Porosity	4.5 %	BTS	15 MPa
P-Wave-V.	5160 m/s	E-Modul	25 GPa





Density	2.76 g/cm³
Porosity	3.2 %
E-Modul	29 GPa
UCS	143 MPa
BTS	10 MPa
P-Wave-V.	4276 m/s

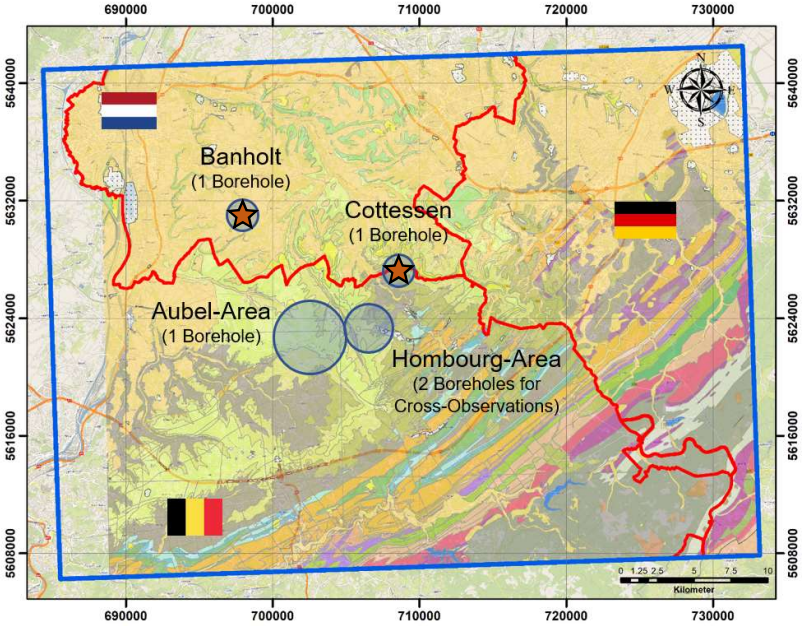


Density	2.68 g/cm³
Porosity	1.6 %
E-Modul	25 GPa
UCS	107 MPa
BTS	6 MPa
P-Wave-V.	5620 m/s

(Zinser, 2021)

Second Step - Drilling Campaigns

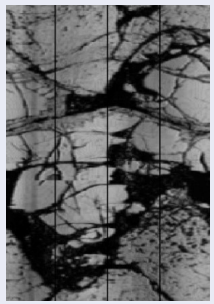
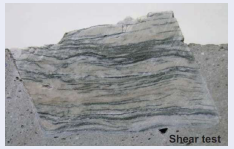
- Two currently ongoing drilling campaigns shall give information about the actual rock conditions/properties down to a target depth of 250 m
- Different borehole tests will be performed as well as core logging and mechanical tests on the core material



	October 2021					Nov-21				December 2021					
	27.09.-03.10.	04.10.-10.10.	11.10.-17.10.	18.10.-24.10.	25.10.-31.10.	01.11.-07.11.	08.11.-14.11.	15.11.-21.11.	22.11.-28.11.	29.11.-05.12.	06.12.-12.12.	13.12.-19.12.	20.12.-26.12.	27.12.-02.01.	03.01.-09.01.
Drilling Cottessen															
Logging Cottessen															
Hydraulic testing Cottessen															
Drilling Banholt															
Logging Banholt															
Hydraulic testing Banholt															

Drilling | Possible time adjustment | Logging | Hydraulic testing/fracturing

Borehole Geophysics/Logging

Geophysical Borehole Investigations		Hydraulic Testing & Fracturing		Laboratory Tests	
 	• Optical Televiewer Scan • Acoustic Televiewer Scan • 3-Component Magnetometer Log • Natural Gamma Log • Spectral Gamma Log • Full-Wave Velocity Log • Inflow/Outflow measurements • Formation Resistivity Log		• Pump-/Slug-/Pulse-Tests (~ 5-10 tests/borehole) • HF/HTPF-Tests + Impression-Packer-Tests (~ 5-10 tests/borehole in 3 boreholes)	  	• Uniaxial Compression Tests • Triaxial Compression Tests • Indirect Tensile Tests • Shear Tests • Cerchar-Test • P-Wave Velocity Measurement • Porosity Measurement

(Zinser, 2021)

Drilling Cottessen

- Started at 4th of October
- Drilling currently at 151 m
- Reached carboniferous hard rock at 2.5 m
- Previous ERT and GPR measurements were executed

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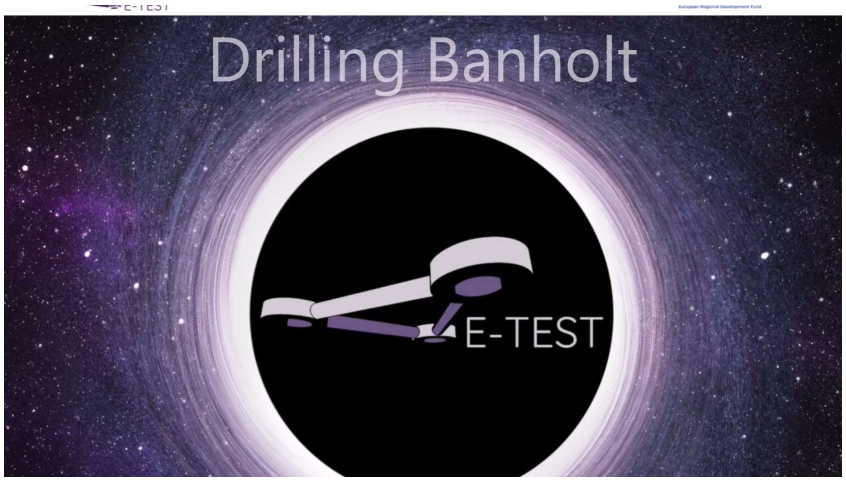
Drilling Banholt

- Started at 9th of August
- Passed Cretaceous: Karstified lithologies and Sands of Vaals
- Drilling currently at a depth of 137 m



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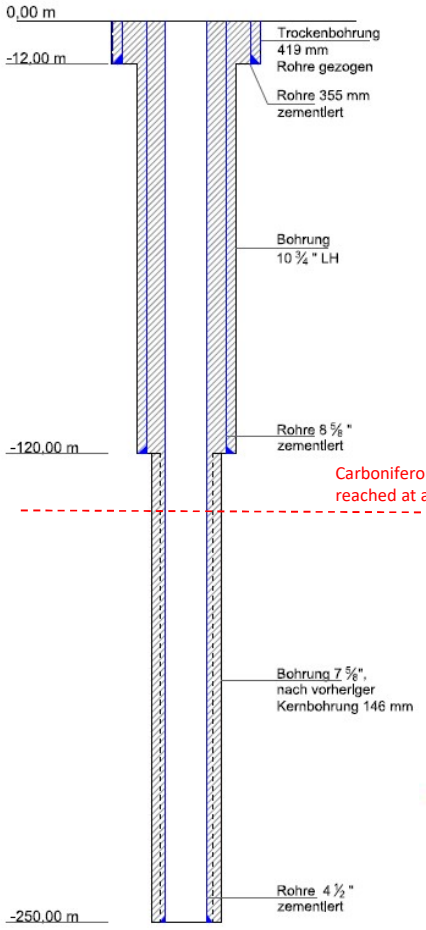
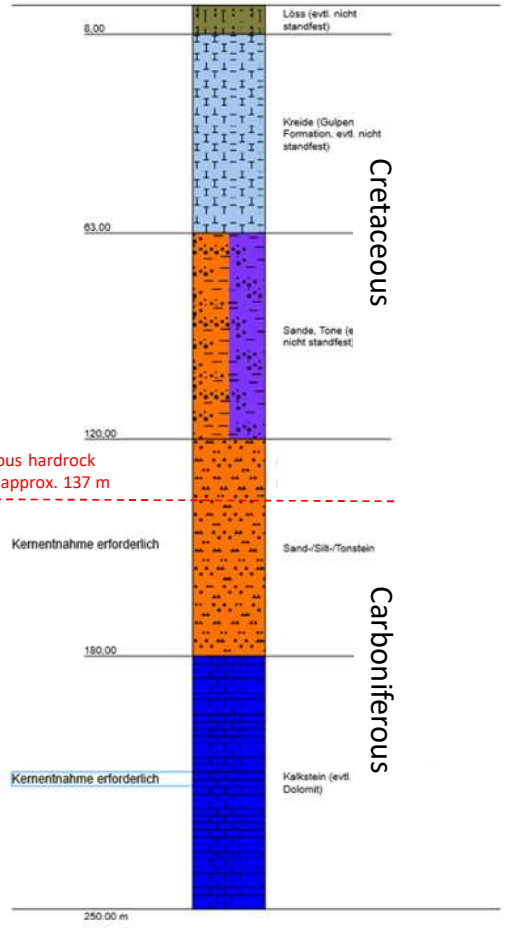
Technical concept	Geological forecast



(Daldrup & Söhne AG, 2021)



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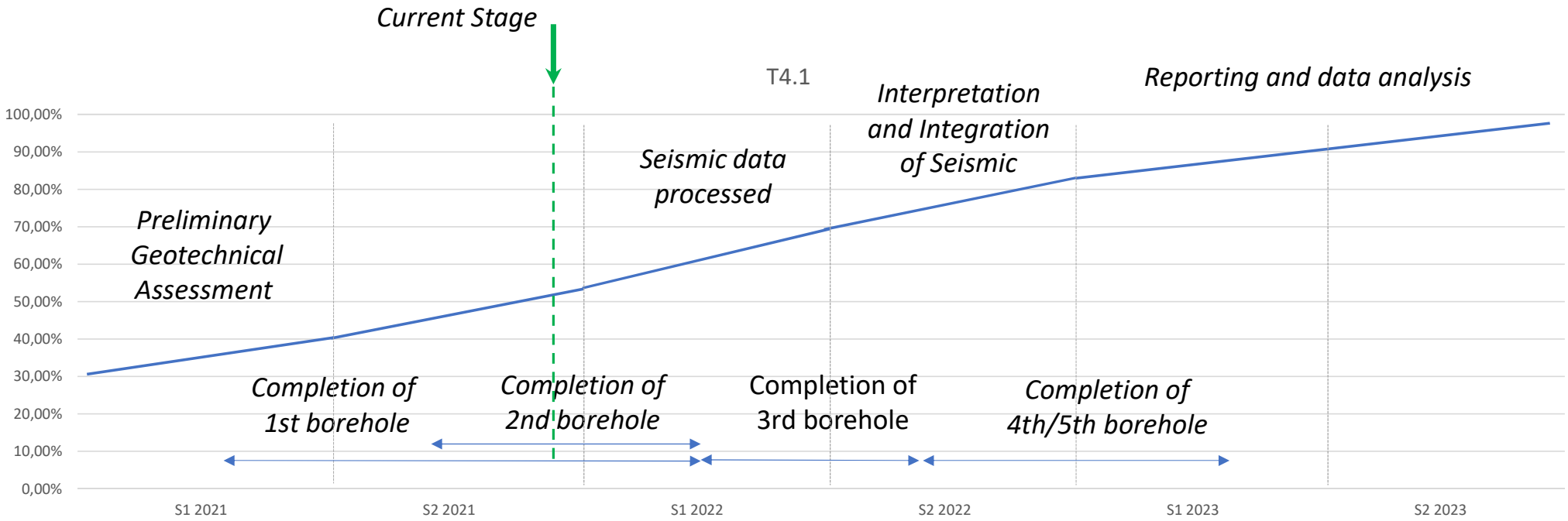
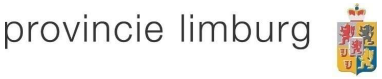
Geological Challenges during Field Work and Drilling

- Complex distribution of rock type in EMR region
  - Prediction of rocks in the subsurface in one specific location is difficult
- Understanding of fracture network is difficult
  - Water circulates in open fractures
- Technical problems during drilling
  - Fluid losses and additional cementation needed
- Access to outcrops
  - Closed borders due to COVID
  - Bringing equipment to outcrops

Preliminary Forecast of T4.1 Cross-border Open Geological Model



E-TEST is co-funded by the Regions:



E-TEST is also co-funded by the own-funding of all Partners:

E-TEST partners

NMWP.
The Innovation Engineers.

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