Main geotechnical issues and planned investigations for the design of ET Infrastructure in Sardinia

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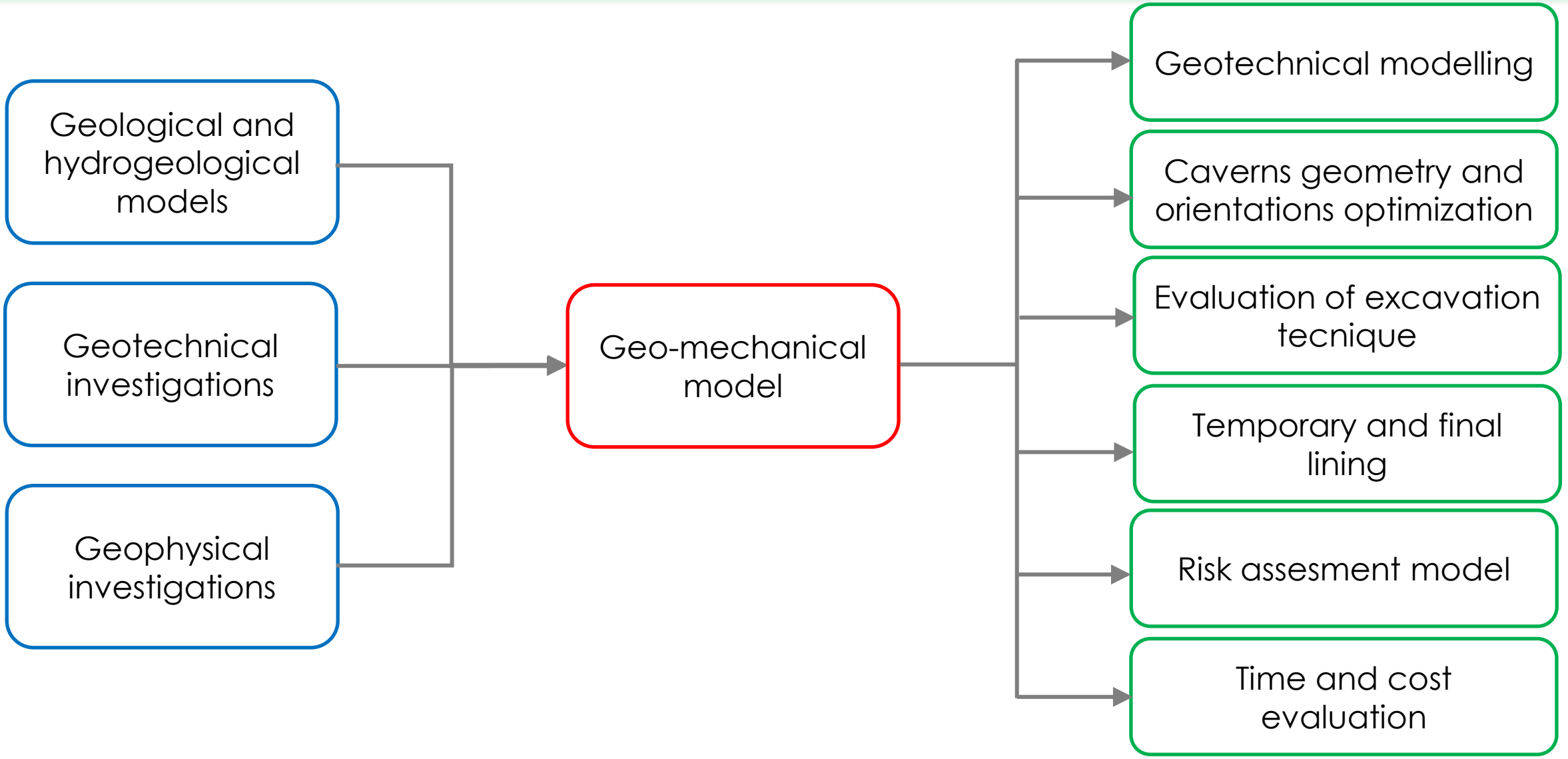
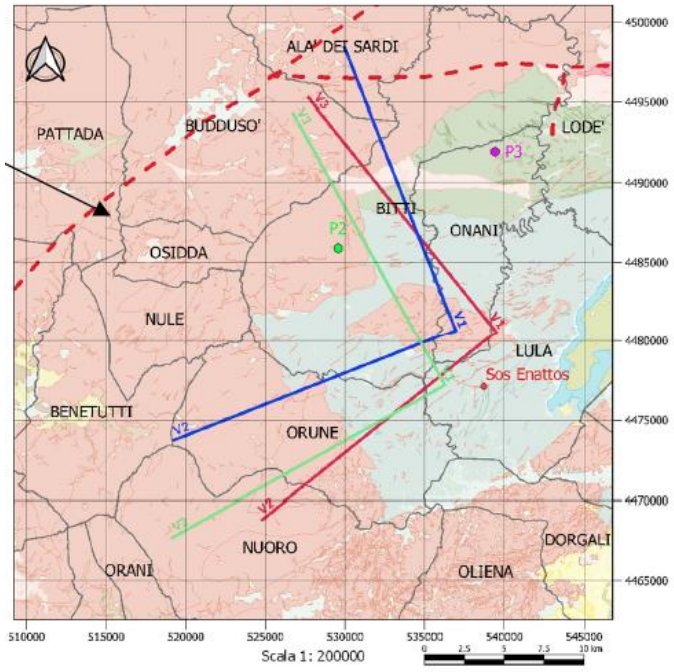
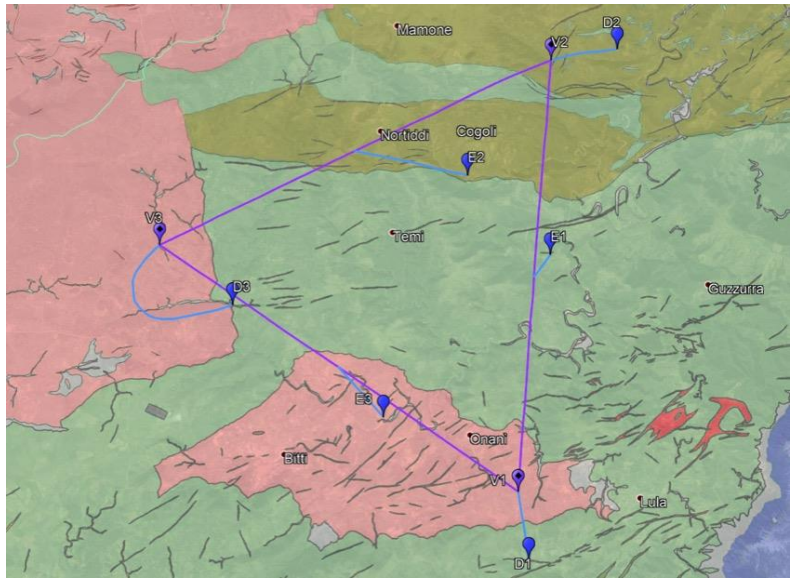
MAIN OBJECTIVES

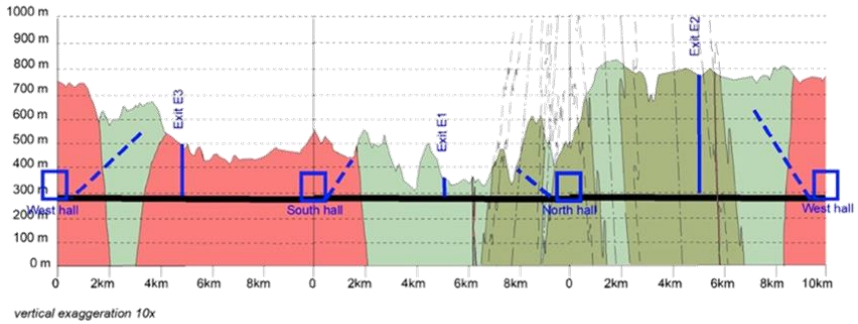


GEO-MECHANICAL MODEL

- Preliminary identification of the main **Geotechnical UNITS** along the tunnels alignment, at caverns, at tunnels/shafts access:
  - **G unit**: Granodiorites and monzogranites
  - **O unit**: Orthogneiss
  - **M units**: Micaschist







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GEO-MECHANICAL MODEL

INTACT ROCK

- Estimation, for each unit, of the physical and mechanical properties (strength, deformability) of the intact rock:
  - Unit weight of rock [kN/m^3]
  - Uniaxial compressive strength [MPa]
  - Triaxial strength [MPa]
  - Tensile strength [MPa]
  - Young's modulus [GPa] and Poissons ratio

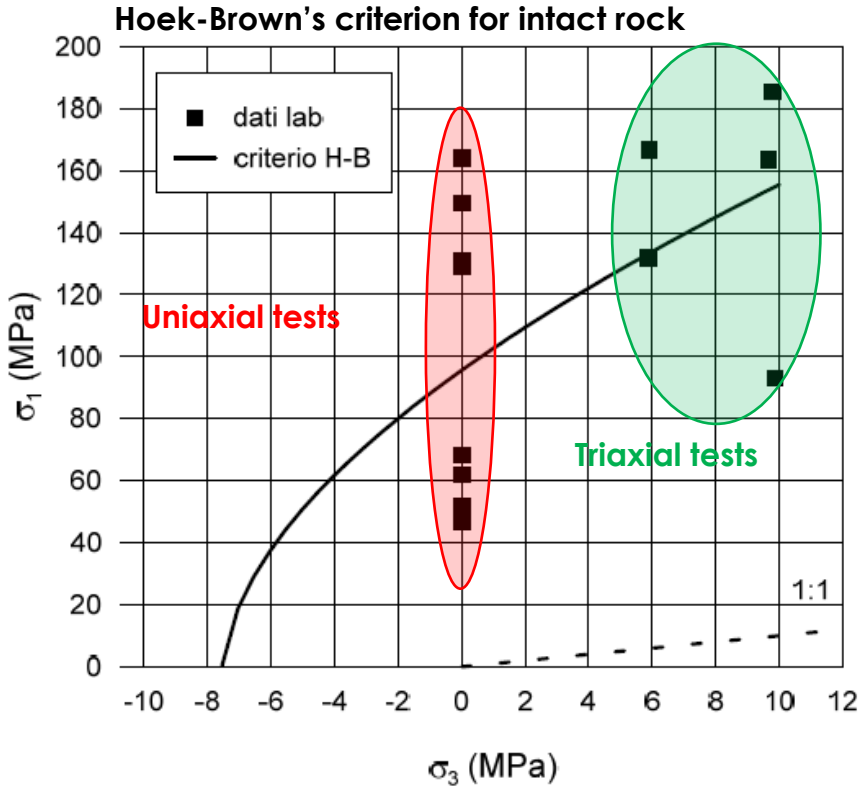
Laboratory tests on cores

- Evaluation of the strength and deformability in the different directions especially for the metamorphic rocks.
- Evaluation of peak and residual parameters
- Evaluation of sub-unit in function for example of the expected degree of alteration in different area

GEO-MECHANICAL MODEL

INTACT ROCK
M Unit

Geomechanical characterization from SAR-GRAV investigation campaign



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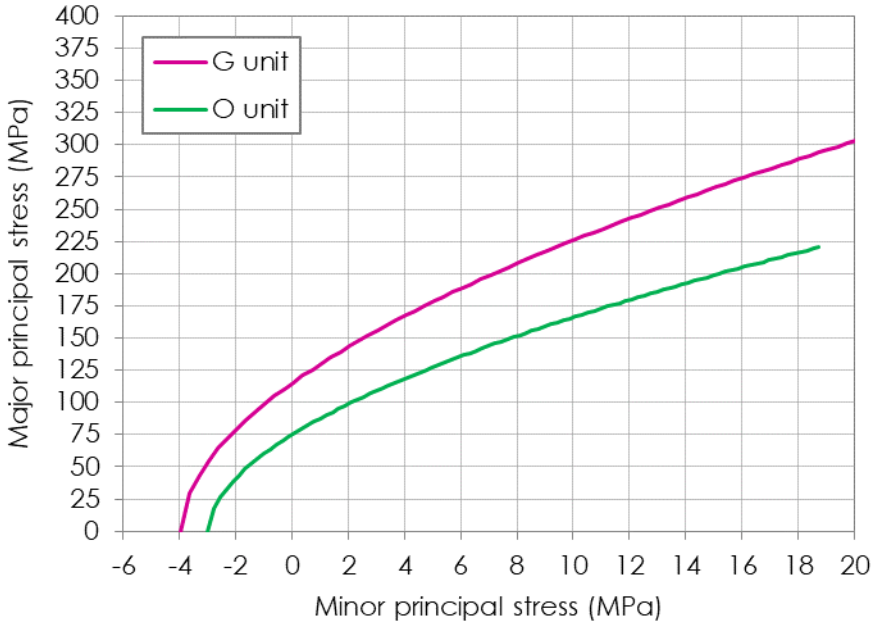
O and G Units

From uniaxial tests and bibliography references (very preliminary estimation)



GEO-MECHANICAL MODEL

DISCONTINUITIES

- Estimation of the properties of the discontinuities:
  - Orientation, spacing, persistence, aperture, roughness, infilling, weathering, etc.
  - Shear strength
  - Deformability

Geostructural surveys, borehole logs analysis, laboratory tests

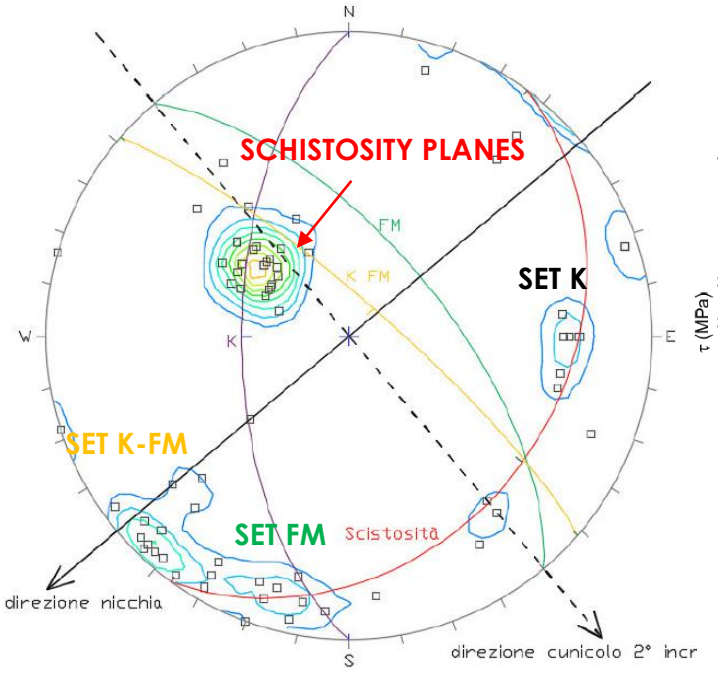
- Evaluation of small-medium scale joints system and large-scale structures (for example regional faults)

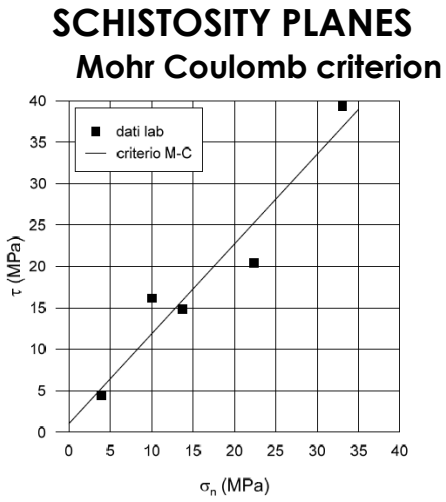
GEO-MECHANICAL MODEL

DISCONTINUITIES

M Unit

Geomechanical characterization from SAR-GRAV investigation campaign





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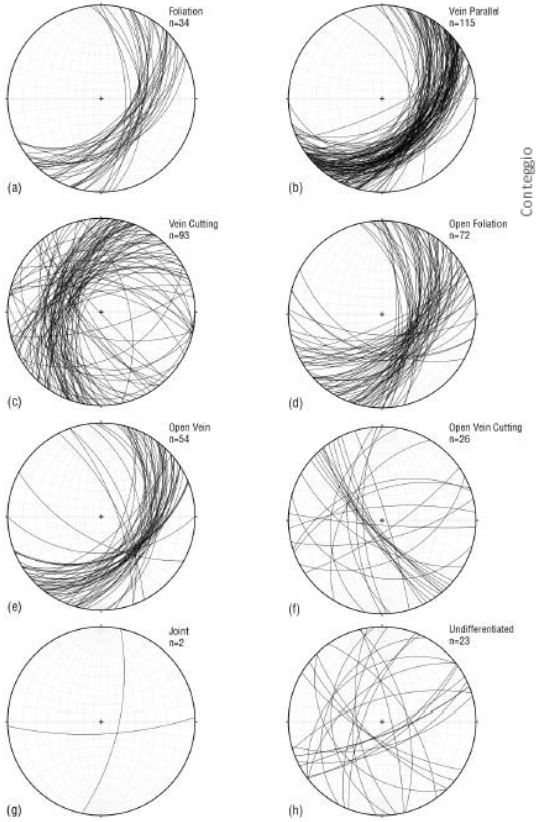
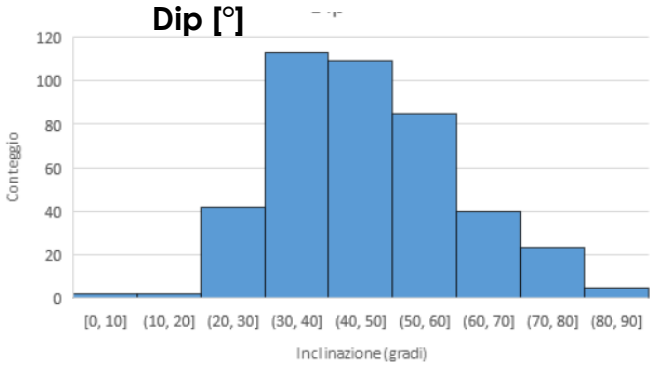
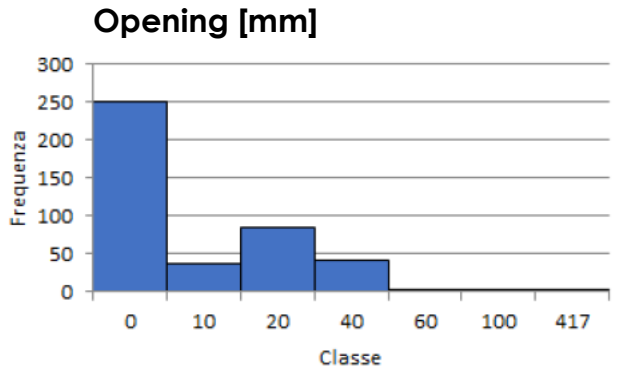
O Units

From P3 boreholes logs







GEOexplorer

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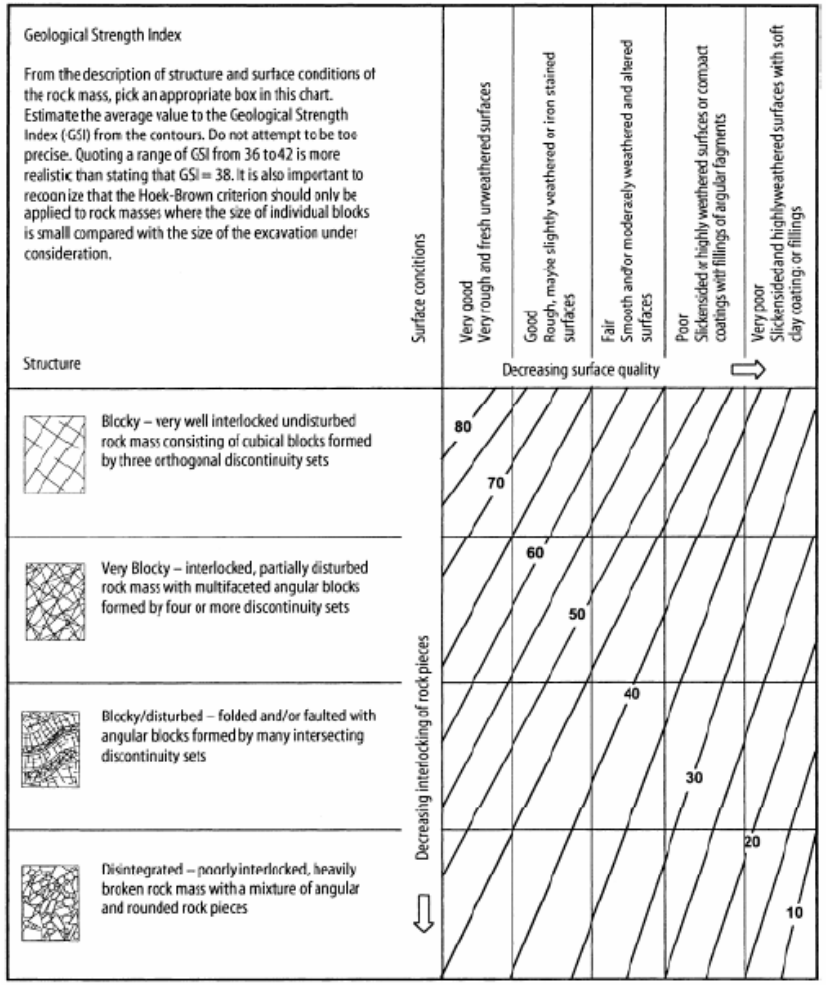
GEO-MECHANICAL MODEL

ROCK MASS

- Estimation of the properties of the rock mass behavior:
  - Definition of rock mass quality classes (GSI, RMR) to be utilized in the geotechnical modelling and for the definition of the types of supports and lining.
  - Estimation of rock mass mechanical properties for each unit and for the different classes

	Classe e qualità	Indice *RMR*
1	Ottima (Very good)	100 ÷ 81
2	Buona (Good)	80 ÷ 61
3	Discreta (Fair)	60 ÷ 41
4	Scadente (Poor)	40 ÷ 21
5	Molto scadente (Very poor)	≤ 20

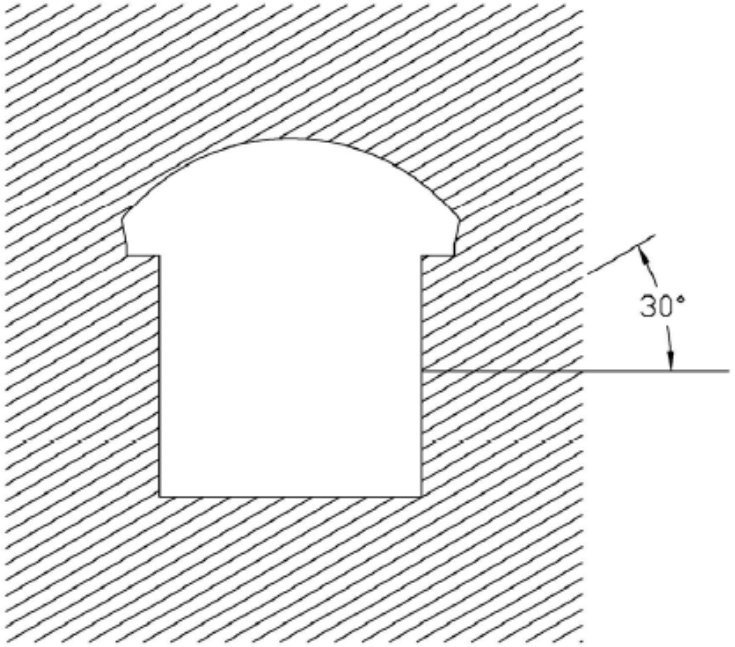


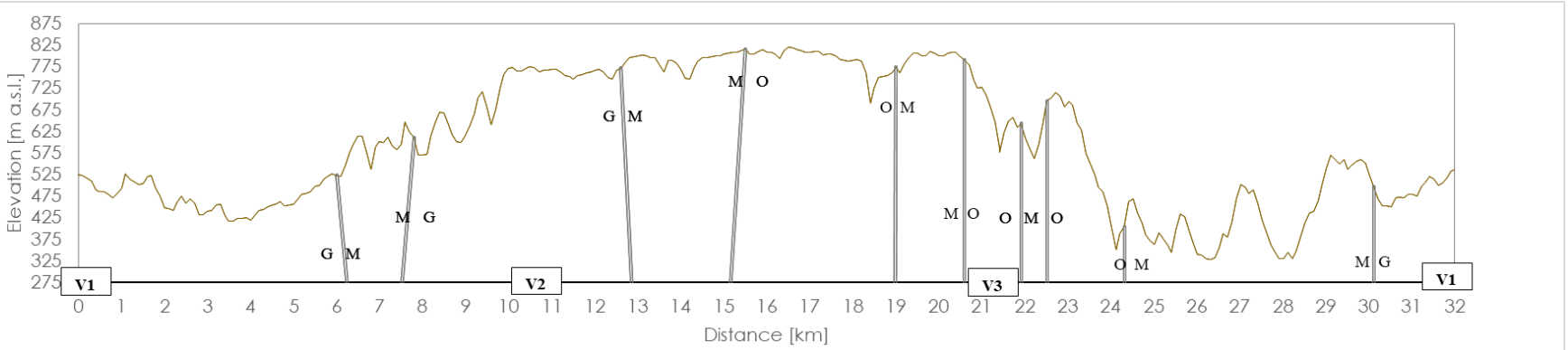
GEO-MECHANICAL MODEL

ROCK MASS

- Selection of the rock mass model (for example continuous homogeneous model with schistosity planes explicitly modelled)
- Estimation (also by statistical analysis) of the rock quality class distribution along infrastructures alignment
- Estimation of in-situ stress state

Geomechanical model of SAR-GRAV project

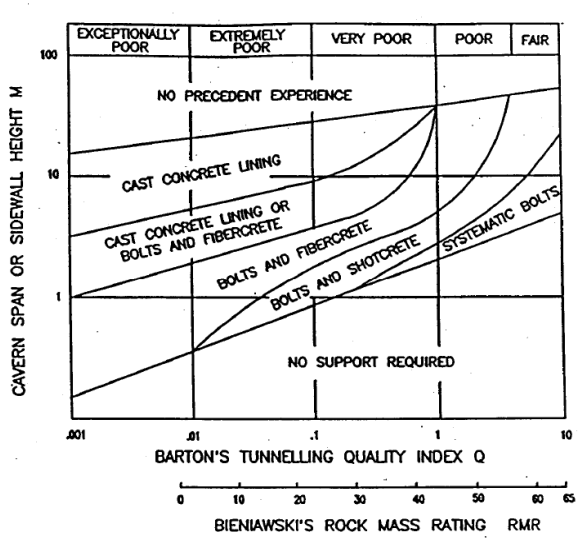


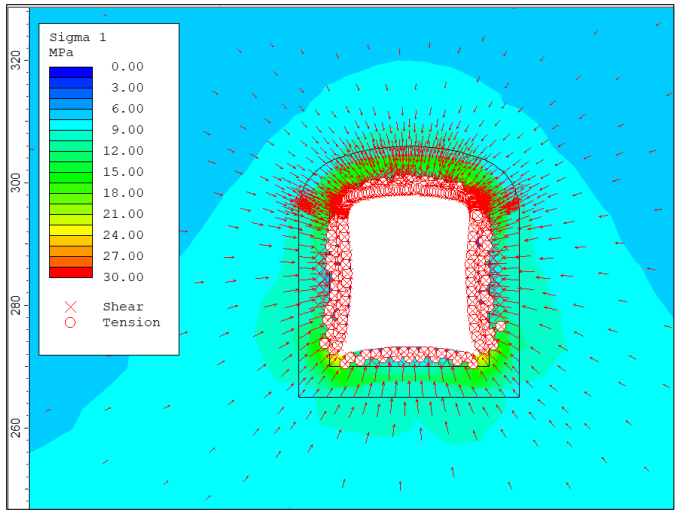


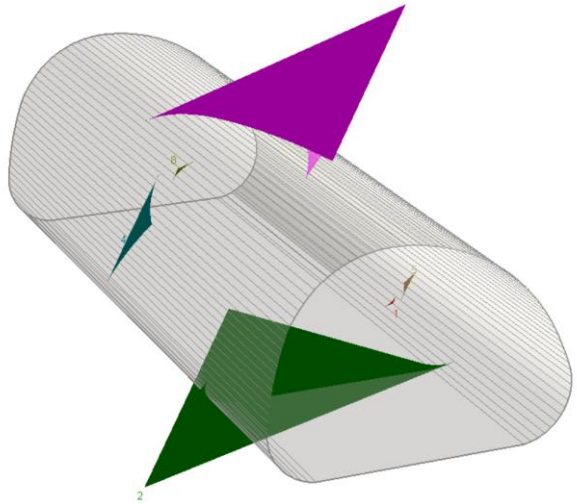
GEOTECHNICAL MODELLING

Geotechnical modeling with increasing degree of detail:

- bibliography and experience (in progress)
- two-dimensional modelling both with continuous homogeneous model and discontinuity model (in progress)

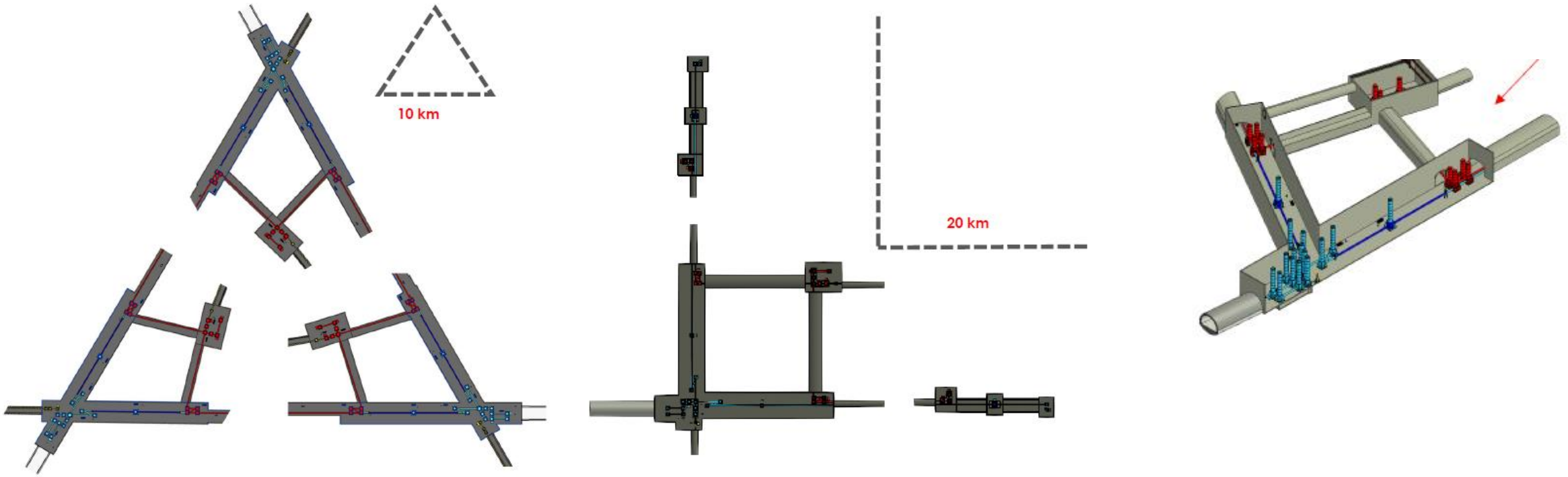






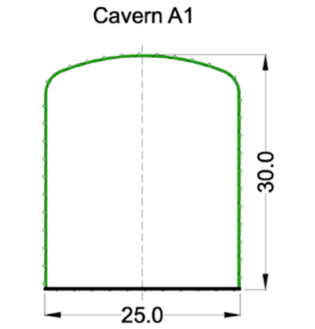
GEOTECHNICAL MODELLING

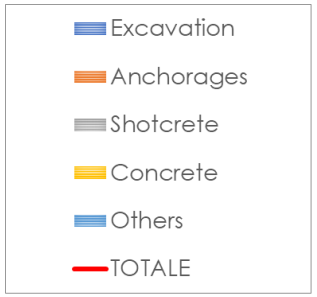
- Three-dimensional modelling, for example to study the interference of caverns at ET vertex

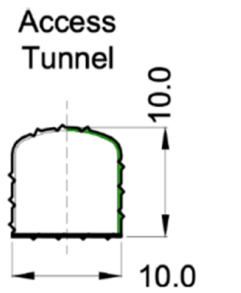


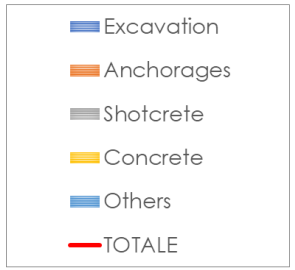
PRELIMINARY TIME AND COST EVALUATION

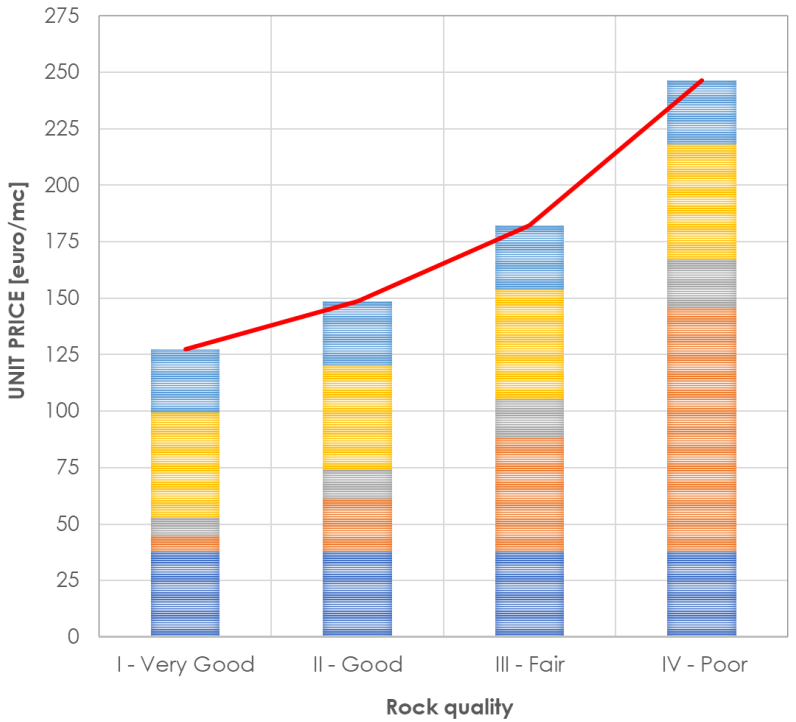
- Preliminary geotechnical stability in order to estimate the infrastructure costs useful for the selection of the optimal configuration and localization of the works.







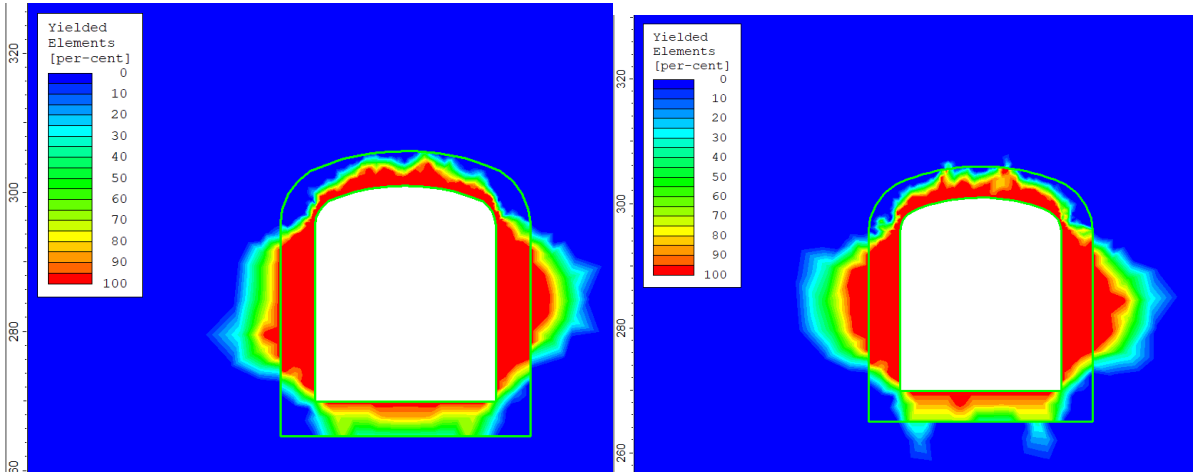




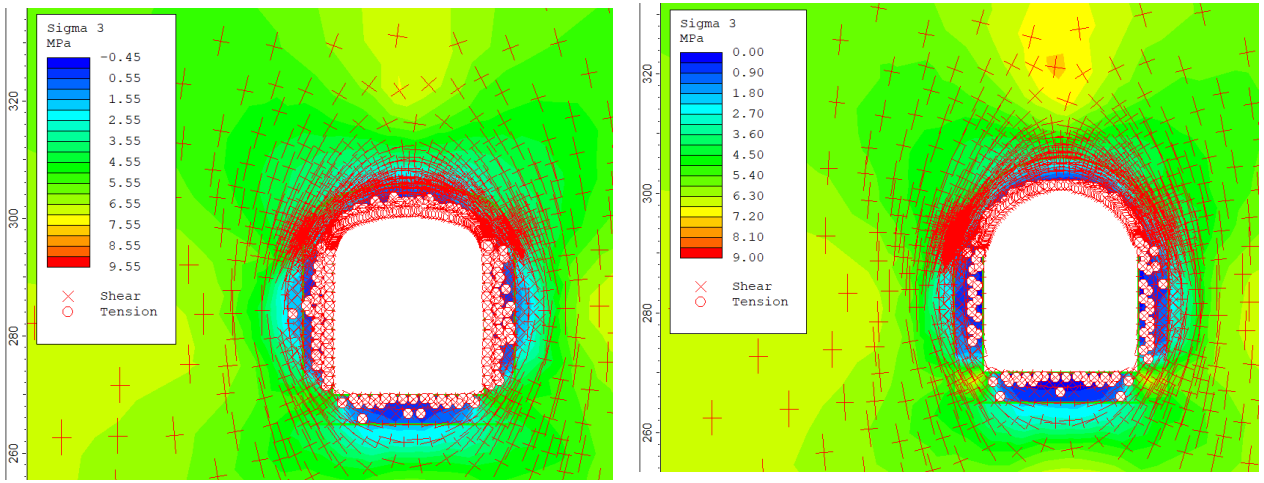
CAVERNS GEOMETRY AND ORIENTATIONS OPTIMIZATION

- Study the influence of rock mass stress state on cavern orientation
- Cavern dimension and geometry (for example wall and vault shape)

Main cavern, Unit G3
different assumption of stress state



Main cavern, Unit G3
different vault shape

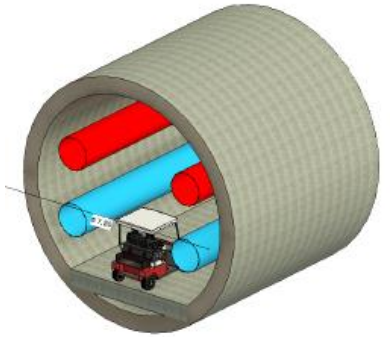


EVALUATION OF EXCAVATION TECNIQUE

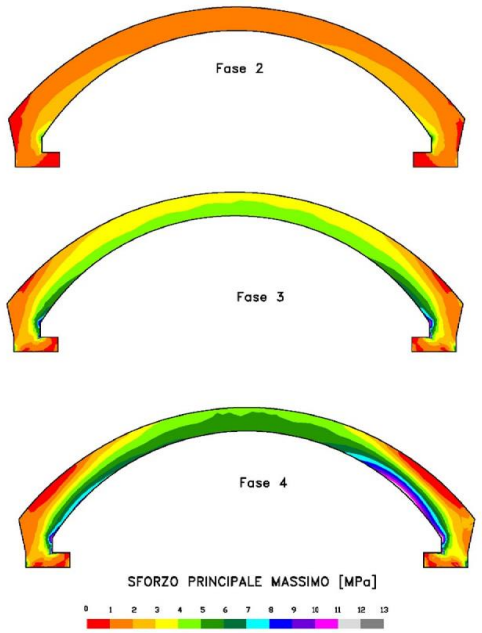
- Main tunnels lining (TBM excavation):
  - Open or Shielded tunnel boring machine
  - Number of boring machine (time and cost estimation)
  - Study the interference with local tunnel enlargement (service cavern, emergency exit)
- Shaft lining: D&B, raise boring
- Access and service tunnel: D&B
- Caverns (D&B):
  - Optimize excavation steps for the single cavern and in relation to the interference between the different caverns at vertex

TEMPORARY SUPPORTS AND FINAL LINING DESIGN

- Main tunnels lining (TBM excavation):
  - Segmental lining, shotcrete lining, etc.
  - Waterproofing and drainage system

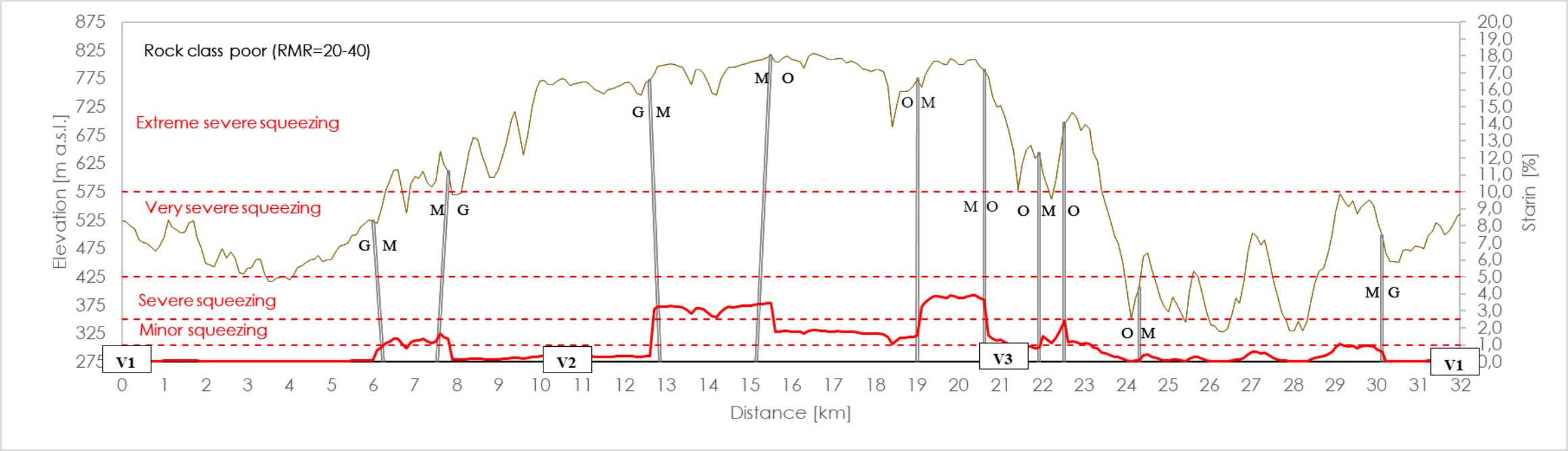


- Cavern lining:
  - Implementation or not of concrete vault
  - Active or passive anchorage, shotcrete or concrete lining
  - Waterproofing and drainage system

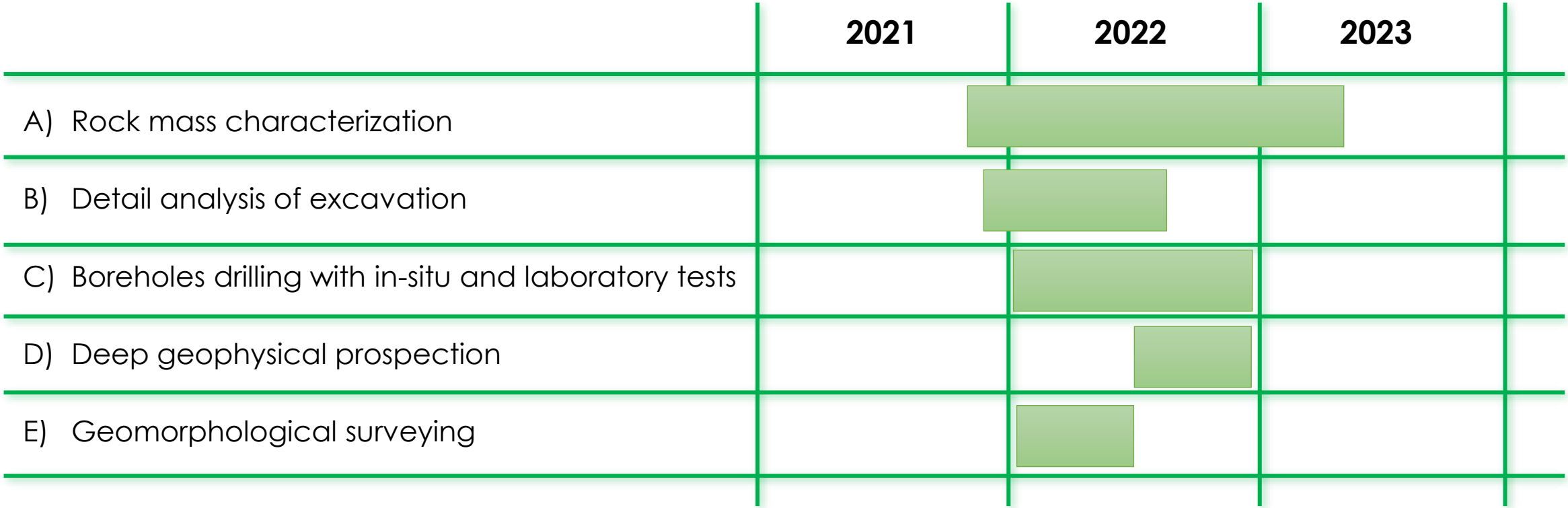


RISK ASSESMENT MODEL

Construction of risk assessment model and definition of the countermeasures, considering all the potential risk of tunnel constructions (face stability, squeezing, important water flow, areas with very low mechanical properties, etc.)



GEOTECHNICAL INVESTIGATION PROGRAM

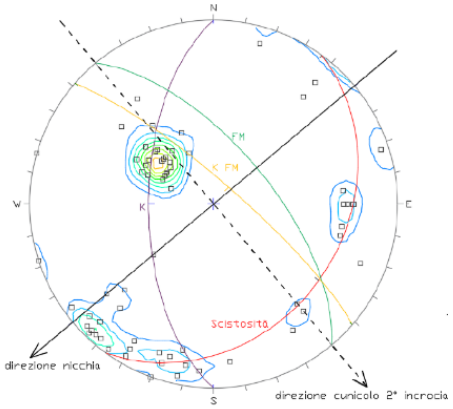


GEOTECHNICAL INVESTIGATION PROGRAM

A) Rock mass characterization

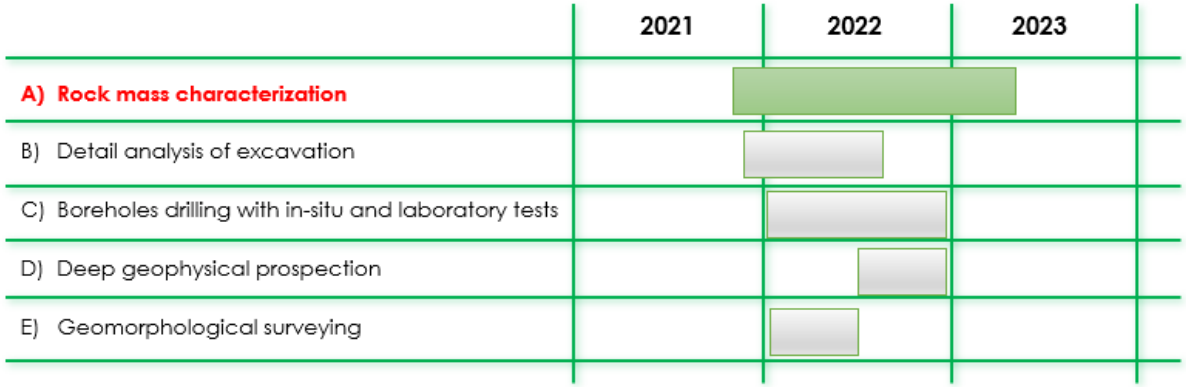
FIRST PHASE:

- Geo-structural surveys;
- Collection of samples for laboratory tests;
- Laboratory tests (density, waves measurements, UCS, triaxial tests, deformability tests, indirect tensile tests, etc.)
- Geo-mechanical model of different units



SECOND PHASE:

- Update of the geo-mechanical model on the basis on the information collected during the boreholes excavation (see next slide).



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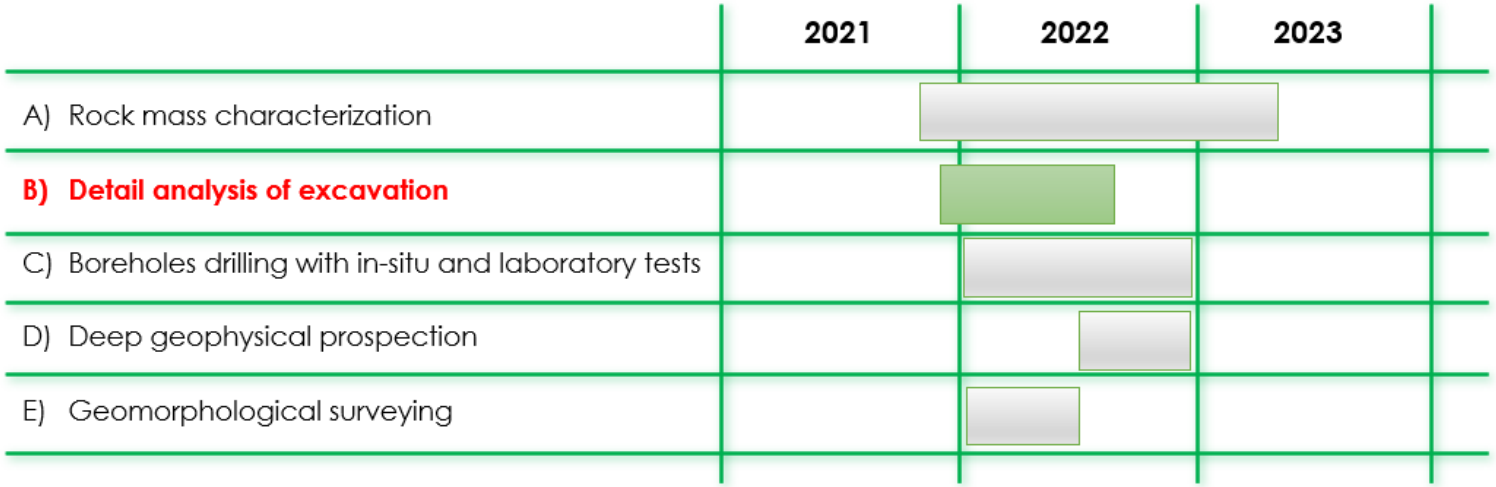
Geotechnical INVESTIGATION PROGRAM

B) Specialist study for the analysis of mechanical excavation (TBM)

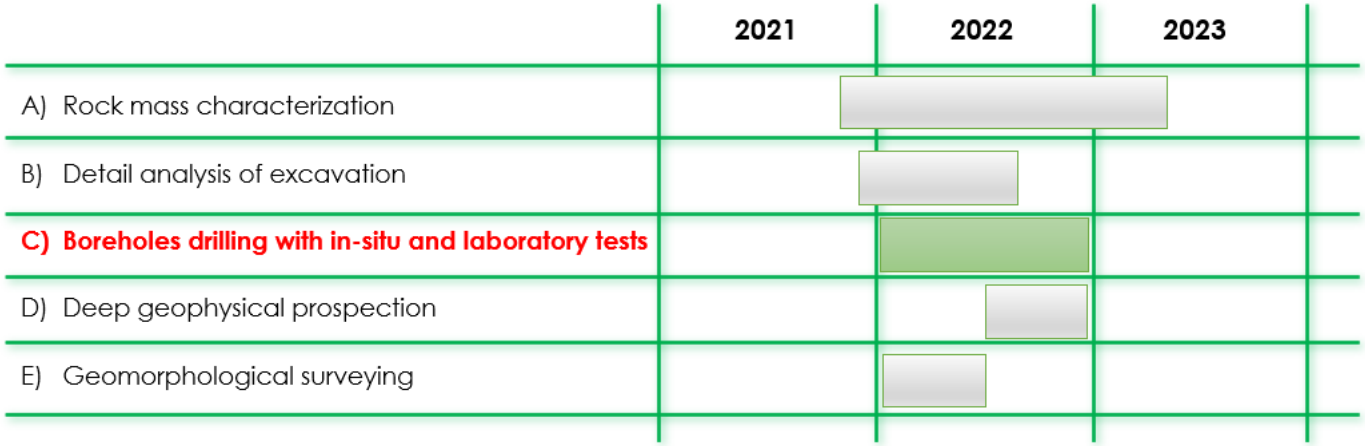
- Open or Shielded tunnel boring machine
- Number of boring machine (time and cost estimation)
- Study the interference with local tunnel enlargement (service cavern, emergency exit)



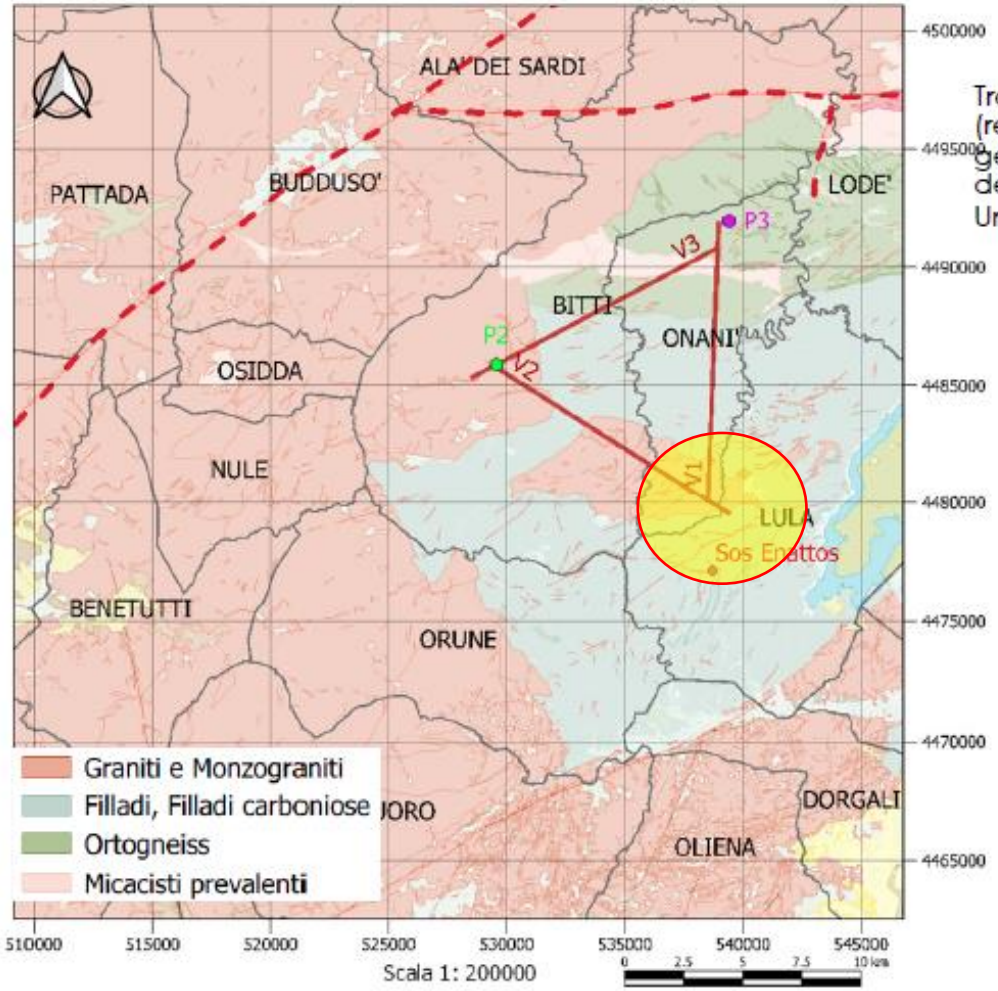
GEOTECHNICAL INVESTIGATION PROGRAM

C) Boreholes drilling with in-situ and laboratory tests

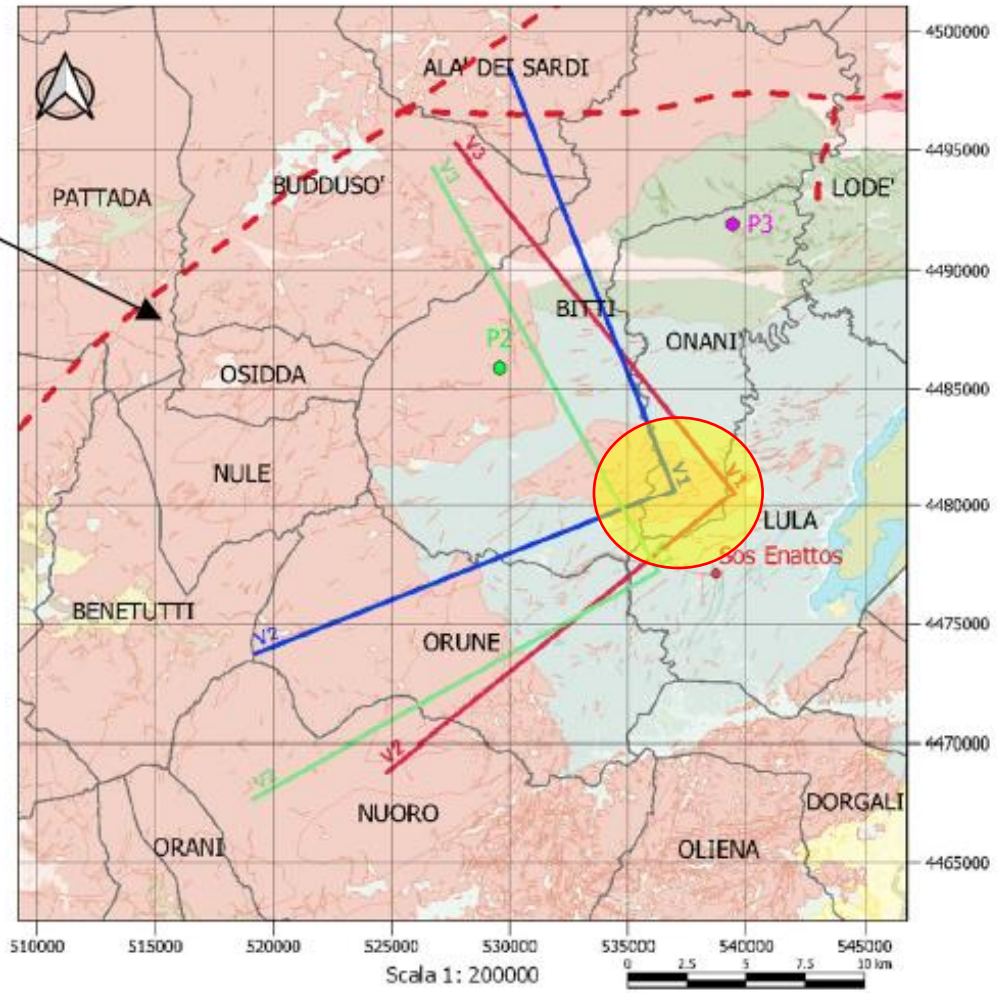
- Execution of n. 2 boreholes with core recovery up to depth of about 250 m from ground level
- Water tests on boreholes
- Geophysical logs and acoustic camera BHTV
- Cores collection for laboratory tests
- Laboratory tests (density, waves measurements, UCS, triaxial tests, deformability tests, indirect tensile tests, etc.)



GEOTECHNICAL INVESTIGATION PROGRAM



Tracciato faglie (redazione studio geologico di dettaglio in corso, Univ. Di Sassari)



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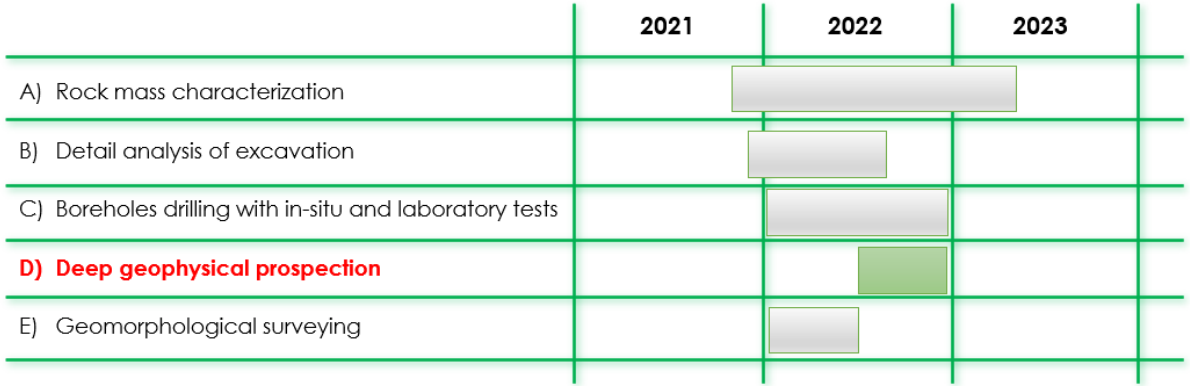
GEOTECHNICAL INVESTIGATION PROGRAM

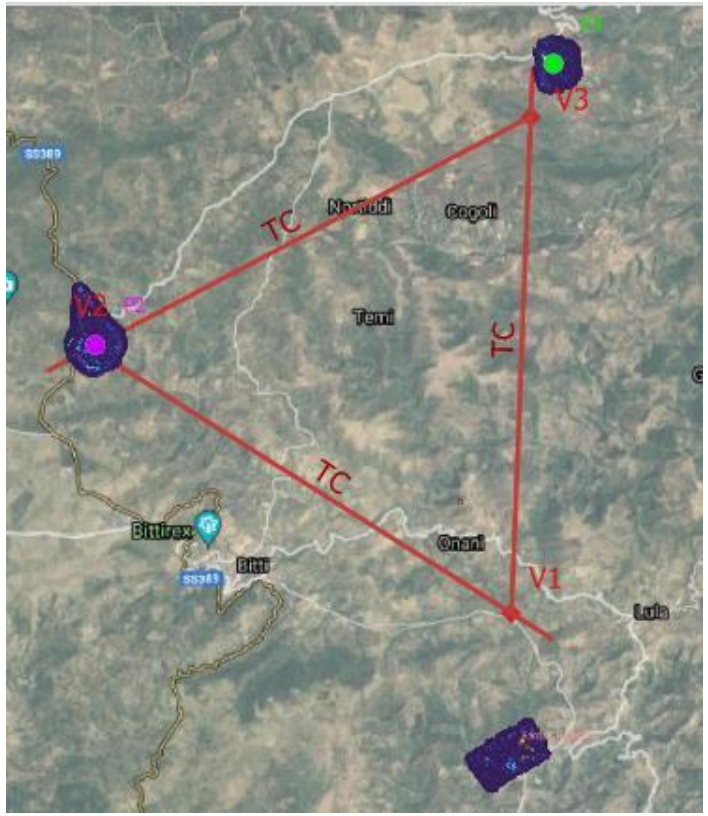
D) Execution of deep geophysical prospection to obtain information for 3D geological and geotechnical models.

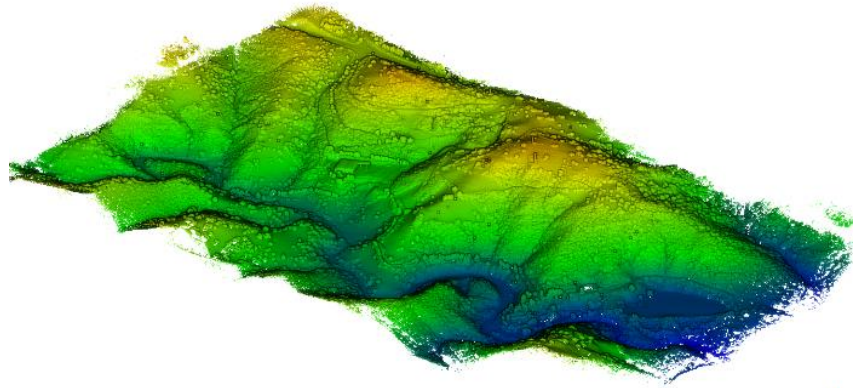
It is planned to carry out at lest two orthogonal profiles in correspondence of the two boreholes described in the previous slide in order to have the possibility of calibrate the results of geophysics in function of the information acquired from the borehole excavation



GEOTECHNICAL INVESTIGATION PROGRAM

E) Execution of UAV surveying in areas of interest such as access/emergency exit portals, shaft exits, surface infrastructure zones, etc., in support to geostructural characterization.





	2021	2022	2023
A) Rock mass characterization			
B) Detail analysis of excavation			
C) Boreholes drilling with in-situ and laboratory tests			
D) Deep geophysical prospection			
E) Geomorphological surveying			

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