



**Tunnelling Asia' 2022**

Workshop on  
Observational Approach in Tunnelling: Evolvement,  
Issues and Challenge



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# **THE PECULIARITIES OF THE CONSTRUCTION OF THE INCLINED SHAFT FOR THE NEW RITOM PUMPED STORAGE HYDROPOWER PLANT**

by

**DANIELE BRONZETTI**

LOMBARDI ENGINEERING LIMITED, GIUBIASCO (SWITZERLAND)

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June 24<sup>th</sup> – 25<sup>th</sup> 2022, Mumbai, India



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**DANIELE BRONZETTI**

CO-AUTHORS: F. CIPPÀ, U. MÜLLER, G. SANGALLI, R. ZANOLI



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### TOPICS

- Introduction
- The machine
- Particularities of the project
- Geological and hydrogeological investigations
- Experience gained from the construction



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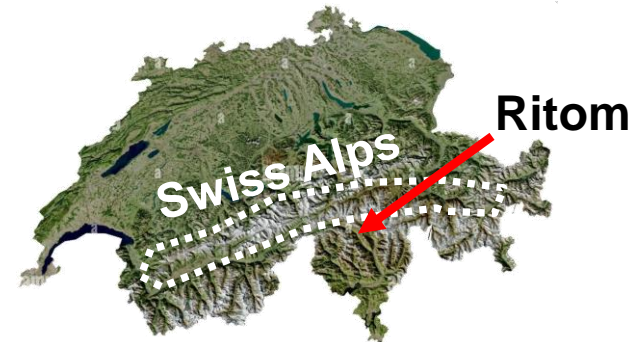


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### LOCATION



June 24<sup>th</sup> – 25<sup>th</sup> 2022, Mumbai, India



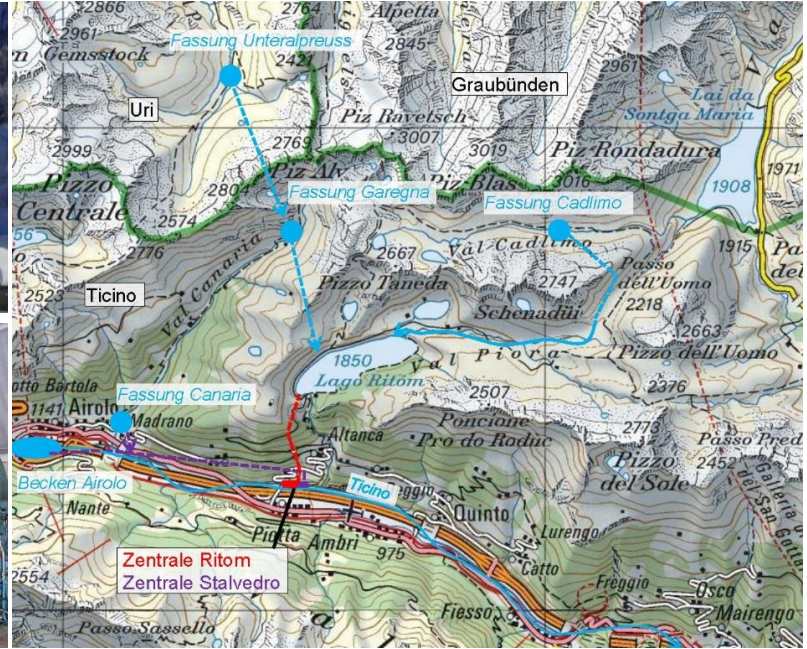
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### EXISTING POWER PLANT FROM THE 1920s





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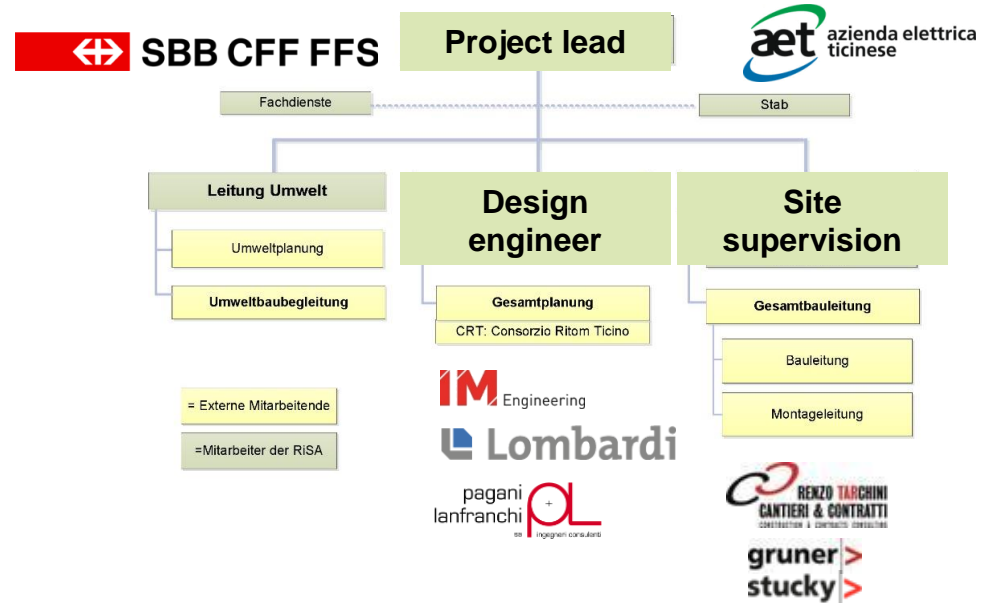
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### Client and project organization – “Renewal of the Ritom power plant”



Partner Company of  
Swiss Federal Railways (75%)  
Canton of Ticino / AET (25%)



Building contractor  
Consorzio Marti-Ferrari Ritom

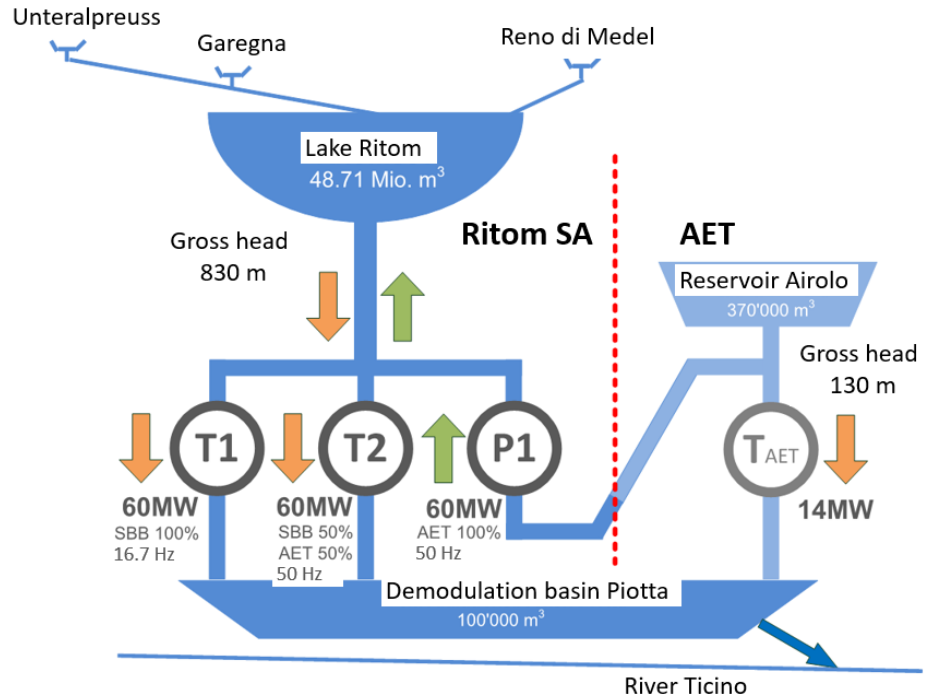
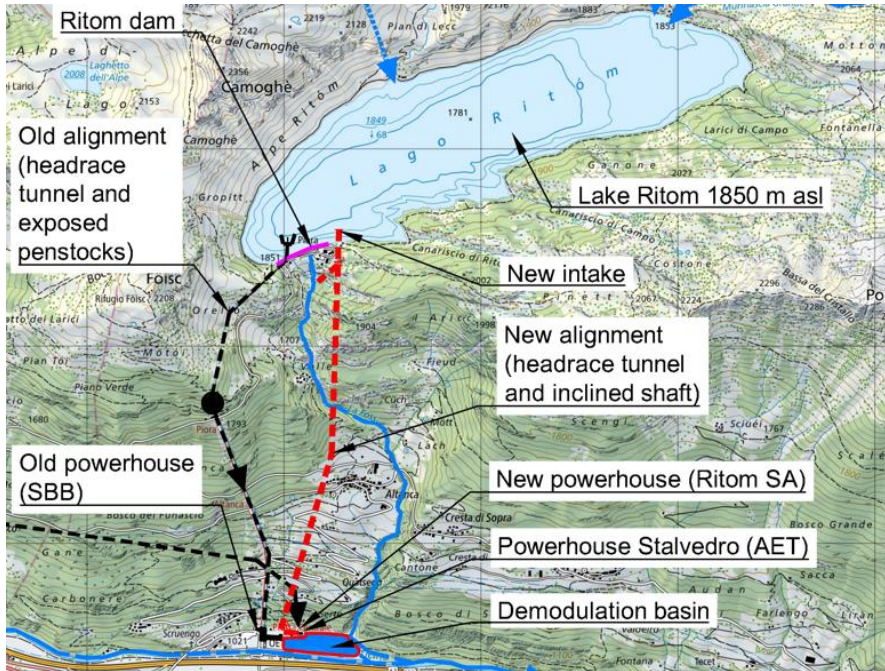


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### Hydraulic scheme of the new plant





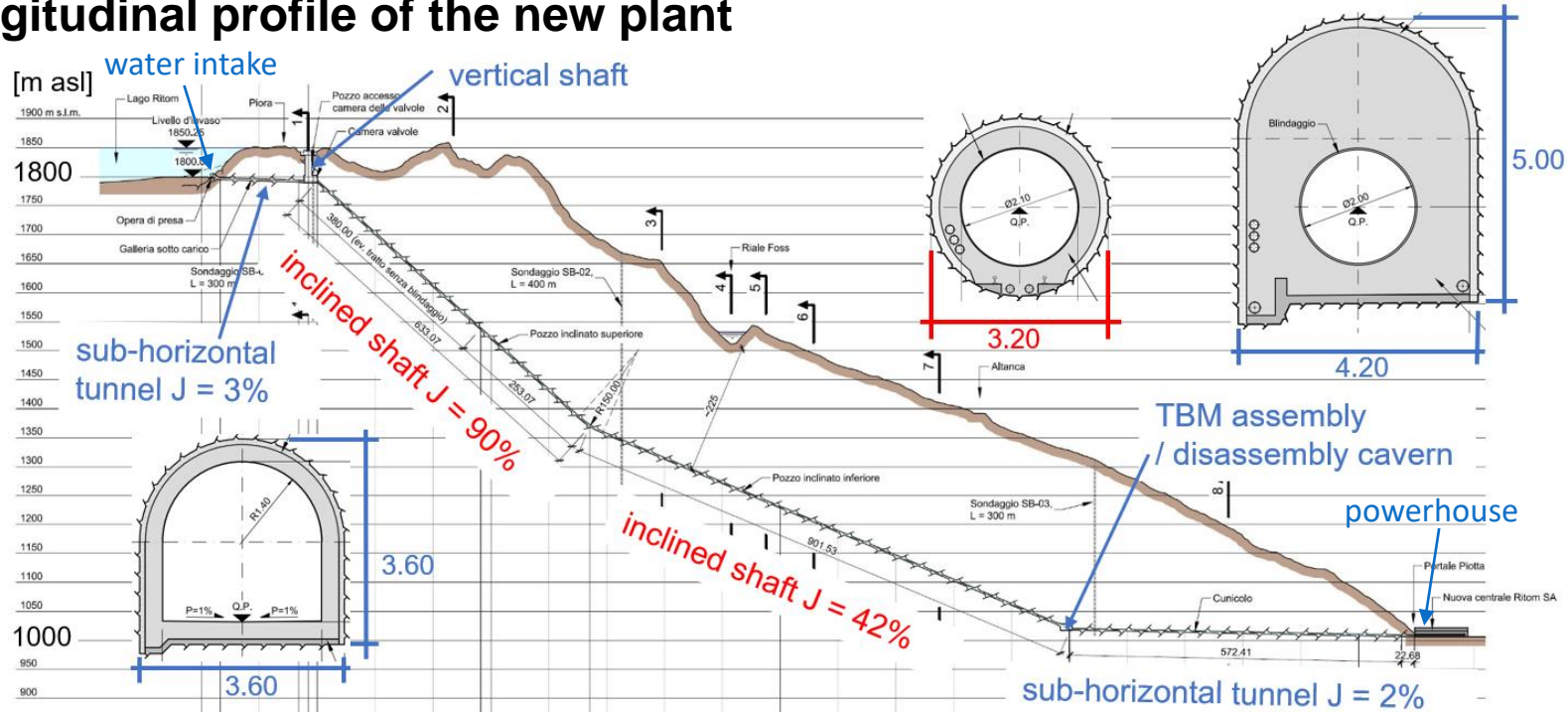


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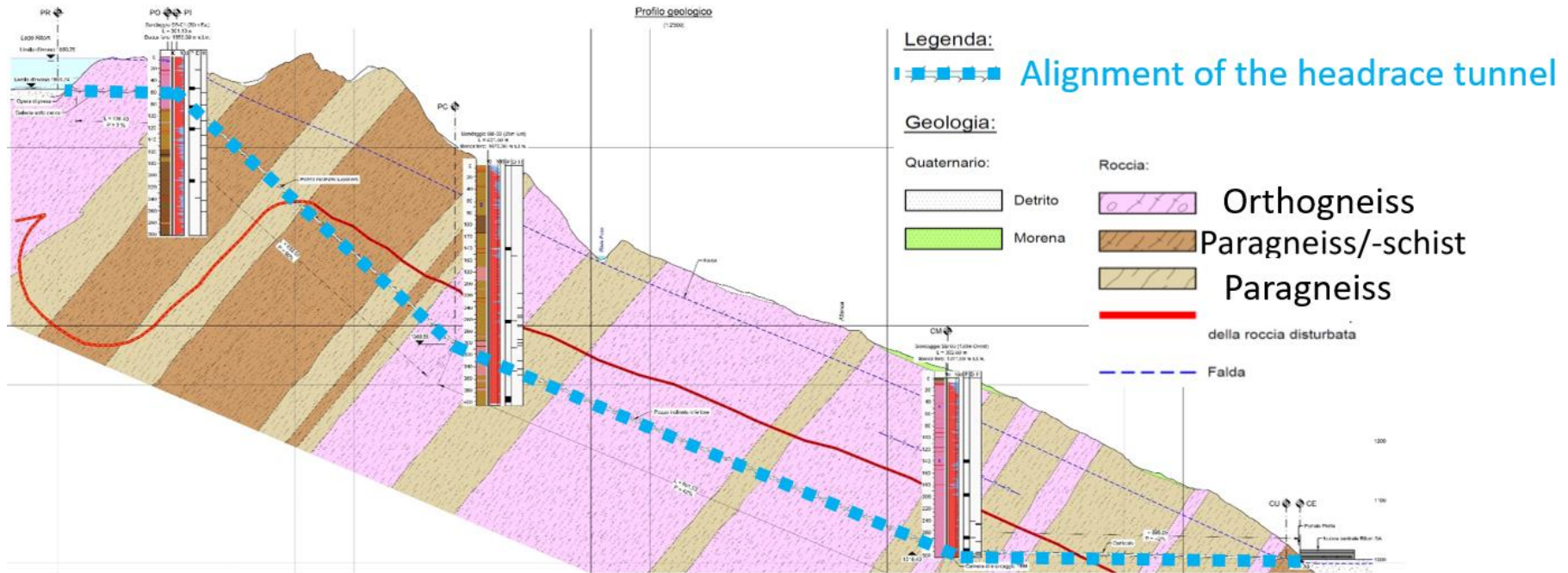
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### Longitudinal profile of the new plant



### Geology of the project area





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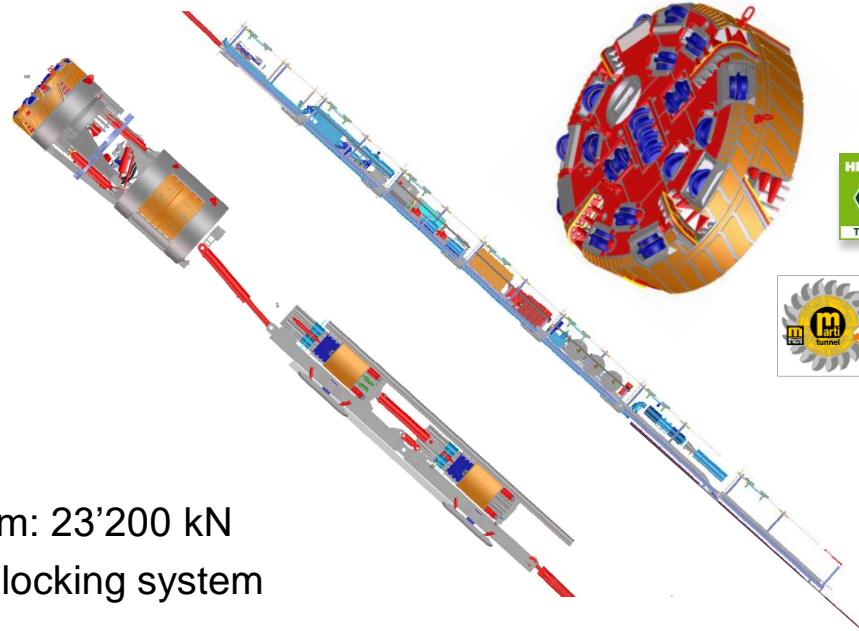
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### Hard Rock TBM (Gripper) with backfall locking system

- Total length: 98 m
- Total weight: 305 ton
- Excavation diameter: 3.230 m
- Number of disc cutters: 23 (14")
- Cutter head with backloading system
- Max. torque: 1'300 kNm
- Stroke length: 1.20 m
- Max. thrust force: 5'700 kN
- Max. gripping force TBM: 25'736 kN
- Max. gripping force backfall locking system: 23'200 kN
- Mechanically self-locking double backfall locking system
- Number of back-up gantries: 7





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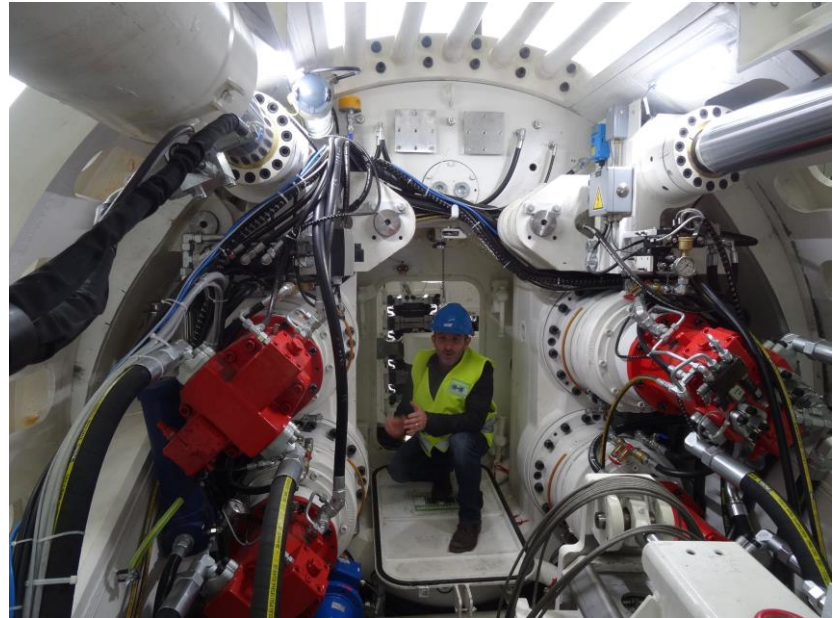
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### Hard Rock TBM (Gripper) with backfall locking system



TBM commissioning by the manufacturer Herrenknecht AG in Gernamy – October 2019

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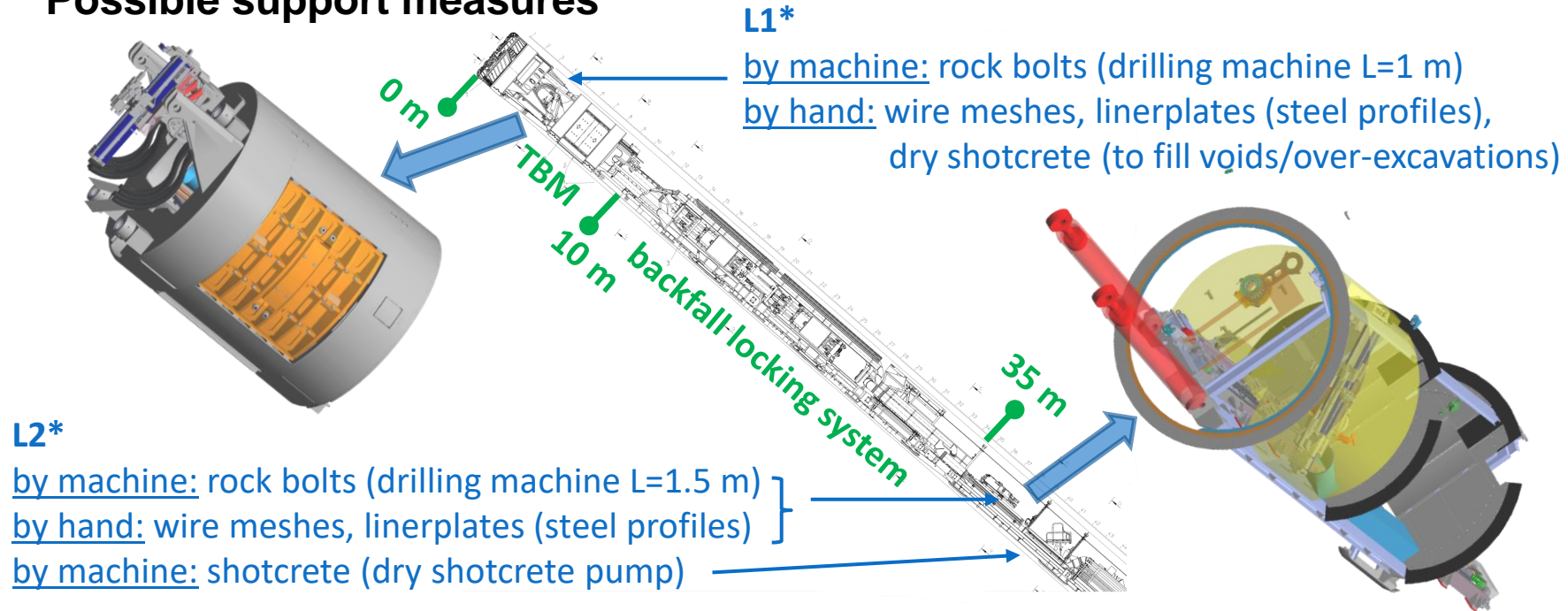


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## Possible support measures





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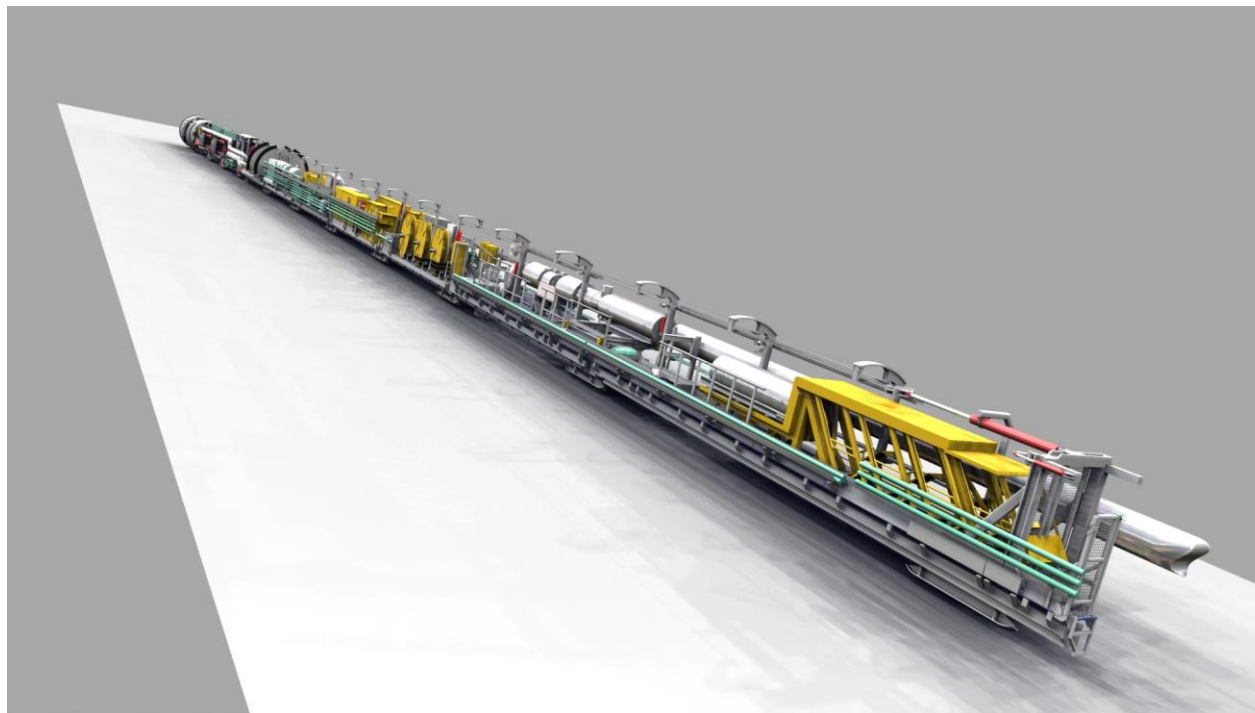
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### 3D Animation





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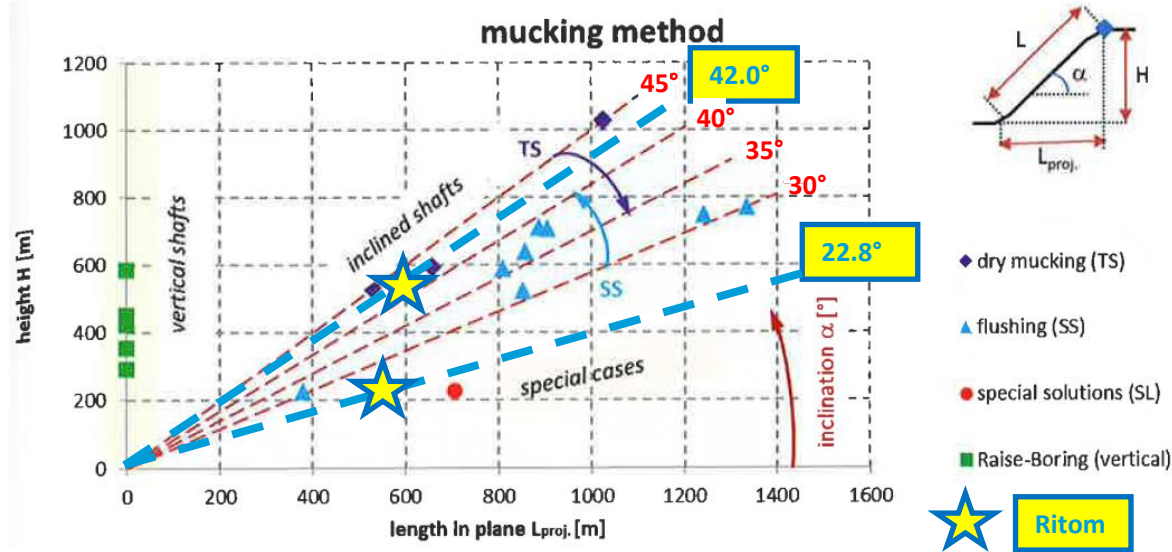


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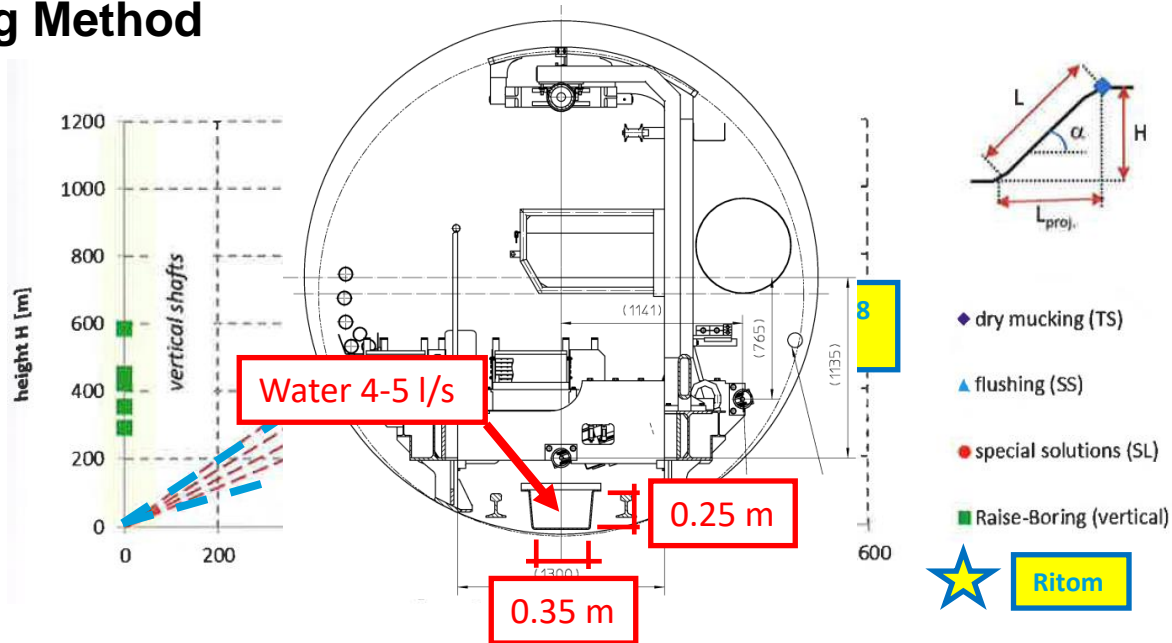


### Mucking Method



Source: Vigl A., Systemlösungen für Kraftabstiege von Hochdruck-Wasserkraftanlagen, Geomechanics and Tunneling (2015)

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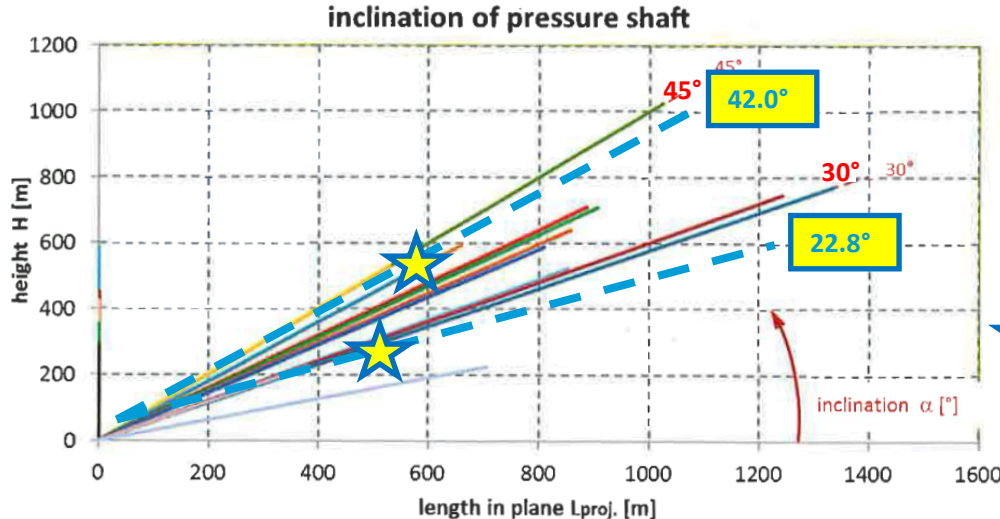


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### Steep shaft



- |                |                  |                |
|----------------|------------------|----------------|
| Uttendorf      | Feldsee II       | Nant de Drance |
| Palomino       | Vianden          | Kaprun         |
| Limberg II     | Zillergründl     | Reisseck II    |
| Kopswerk II    | Vermuntwerk      | Bannalp        |
| Gerlos         | KW Innertkirchen | Kaunertal      |
| Parpati I + II | KW Mutt; Zermatt | KW Kaiserstuhl |

★ Ritom

Source: Vigl A.,  
Systemlösungen für  
Kraftabstiege von  
Hochdruck-  
Wasserkraftanlagen,  
Geomechanics and  
Tunneling (2015)



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## Heavy water inflow in the lower sub-horizontal tunnel

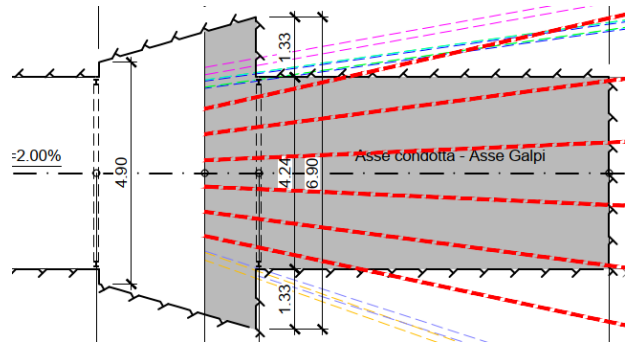


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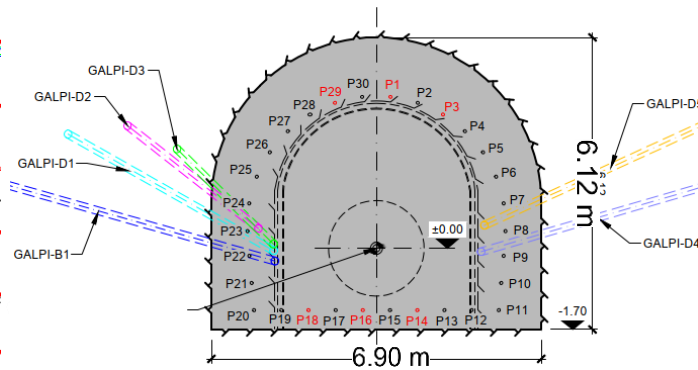
### Heavy water inflow in the lower sub-horizontal tunnel

#### Investigation boreholes:

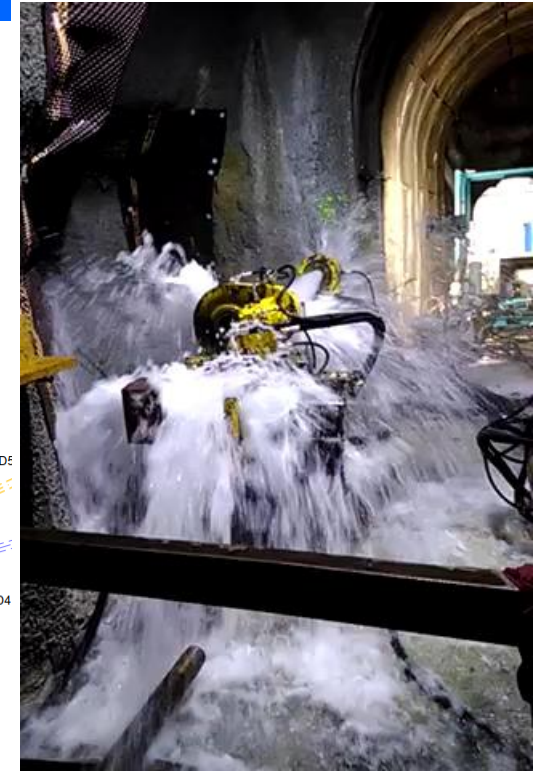
- 1 borehole of  $L = 146$  m,  $\varnothing 96$  mm till the TBM assembly cavern
- 5 shorter borehols (ca.  $L = 30$  m,  $\varnothing 96$  mm) into the fault zone
- Ca. 80 m of fractured rock with  $> 100$  l/s water inflow



Plan view

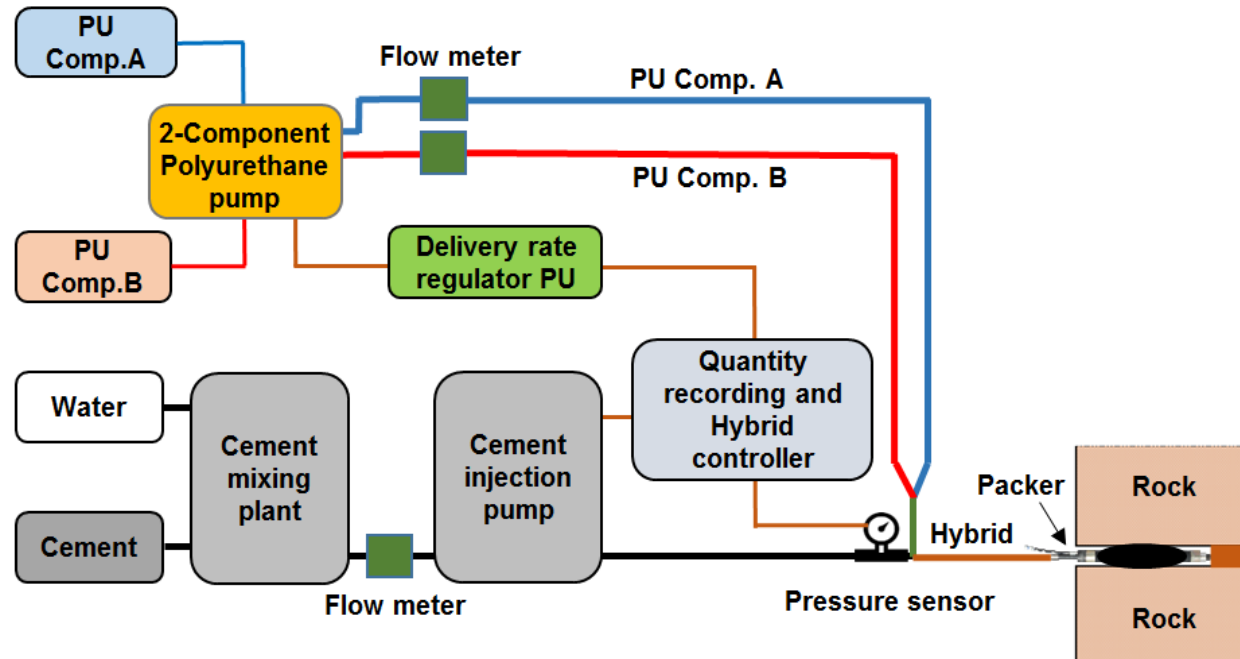


Cross section



### Heavy water inflow in the lower sub-horizontal tunnel

«Hybrid injections»

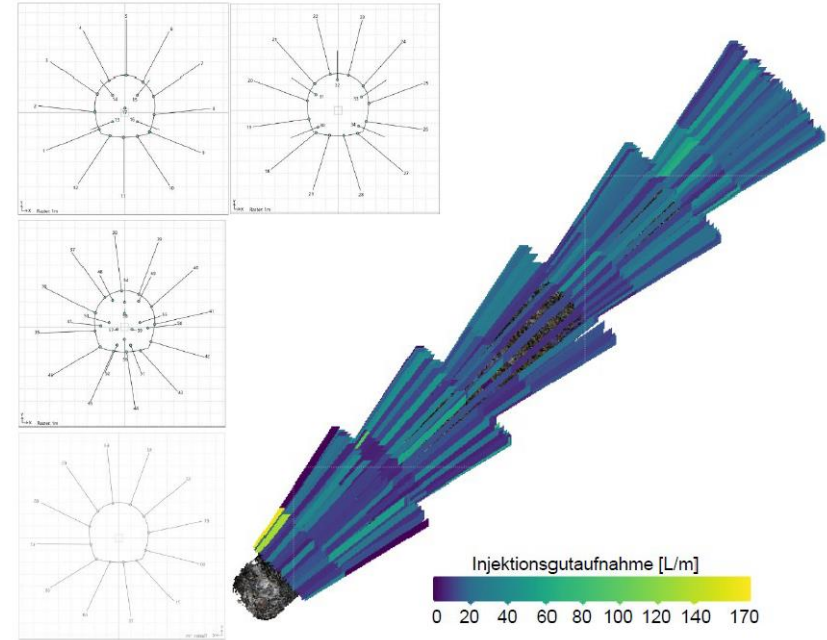




## Heavy water inflow in the lower sub-horizontal tunnel

### Grouting screens («hybrid injections»):

- 5 grouting umbrellas behind the excavation face
- Boreholes diameter = 64 mm, length = 20 m, overlap = 5 m







## New investigations with additional exploratory drillings



Exploratory drilling SB-05 in Piora  
Inclined drilling L = 750 m for an  
exact determination of the  
geological and hydrogeological  
conditions in the inclined shaft



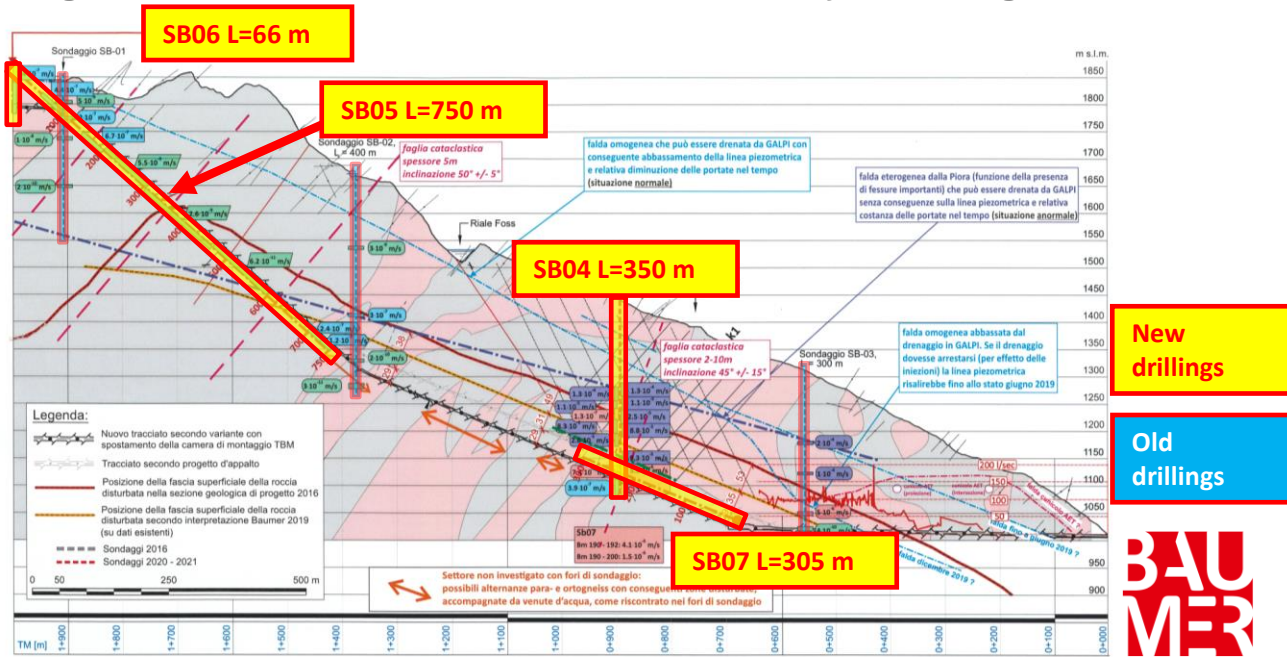


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### New investigations with additional exploratory drillings





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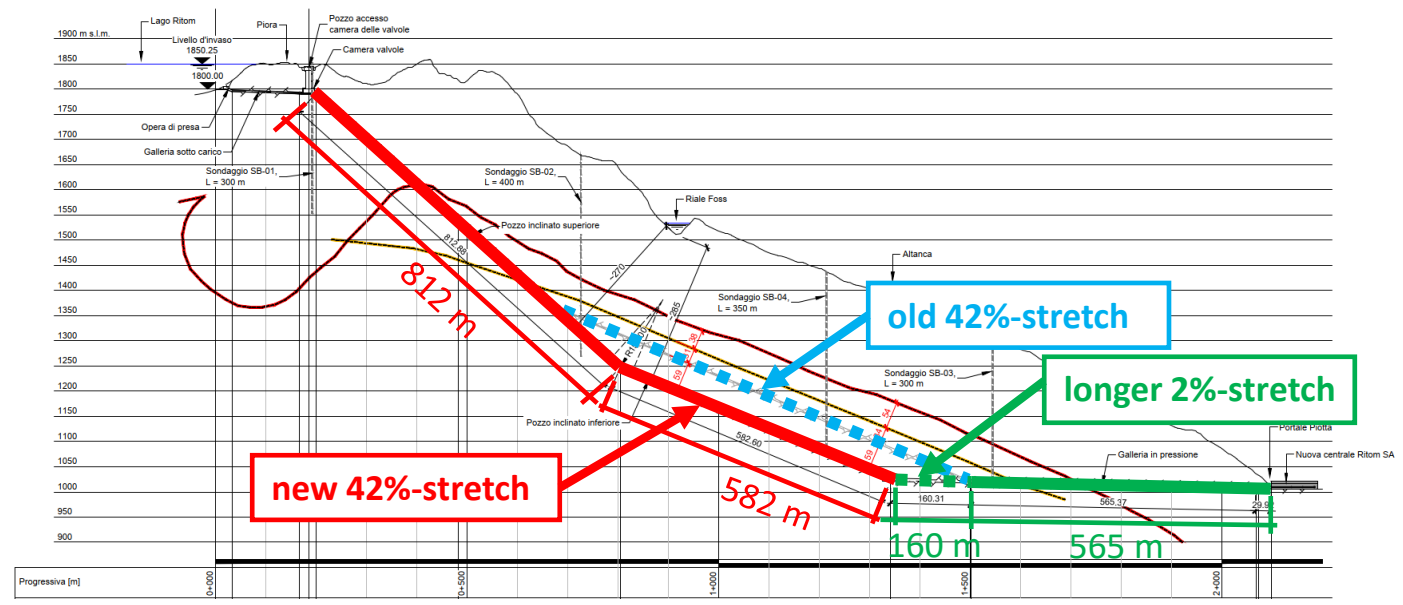


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### New layout





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### Mucking

- Sporadic clogging
- High abrasion
- Maintenance



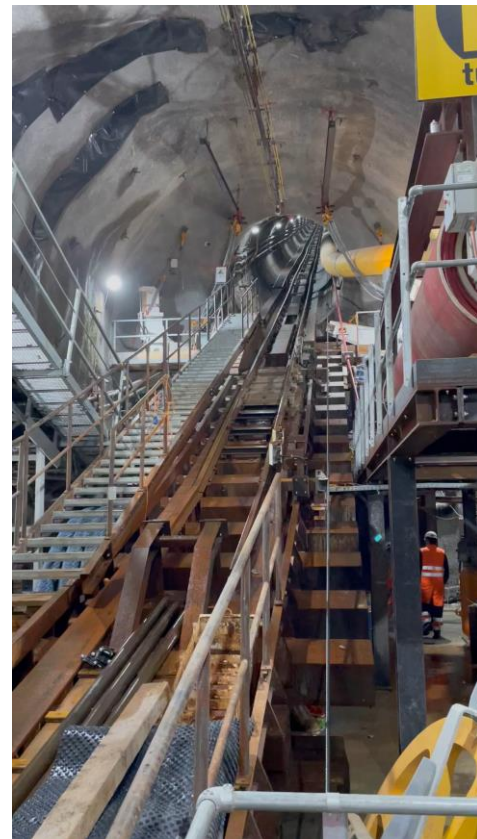
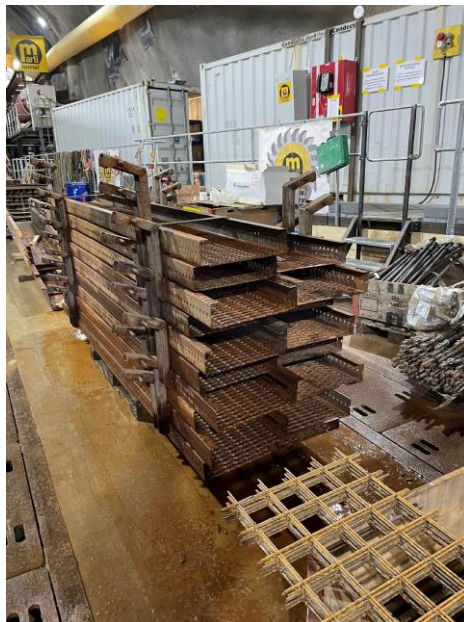
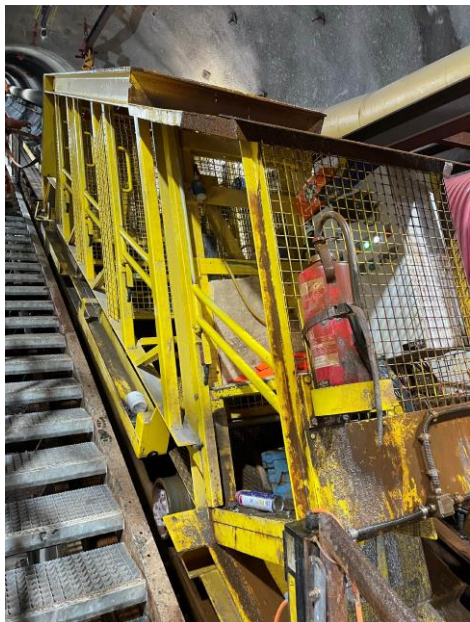


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### Carefully well-planned logistics



- Organisation and planning of the activities (time-consuming access)



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### Carefully well-planned logistics



- Cable car to move the material/equipment through the TBM



## Experienced team in narrow space conditions

- Access via the backfall locking system







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### Experienced team in narrow space conditions

- Access to L1\*  
(just behind the  
cutter head)





### Experienced team in narrow space conditions



- Mounting of linerplates by hand behind the cutter head



### Experienced team in narrow space conditions

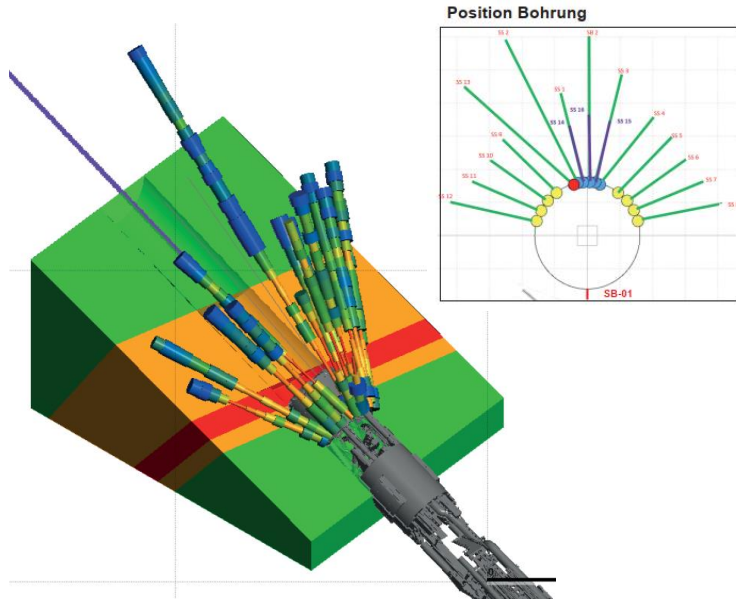


- Drilling machine in L1\*



- Drilling machine in L2\*

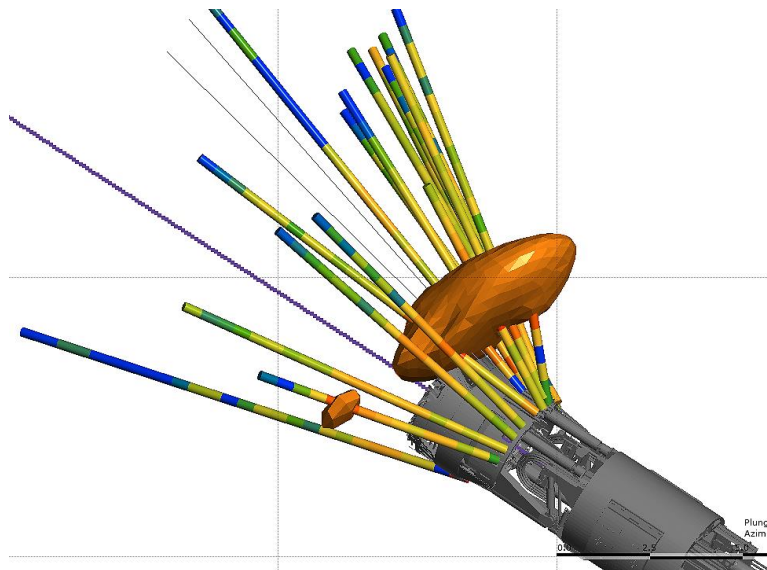
### Treatment of a fault zone



- Short boreholes performed behind the cutter head to investigate and to treat a weak zone



### Treatment of a fault zone



- Cement grout through 16 boreholes of  $\text{\O} 124$  mm and self-drilling bolts umbrella R38/19 mm



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### Dismounting of the TBM cutter head



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## Redescent of the TBM and finishing works



- Water conveyance with wire meshes/shotcrete and “cleaning” of the profile



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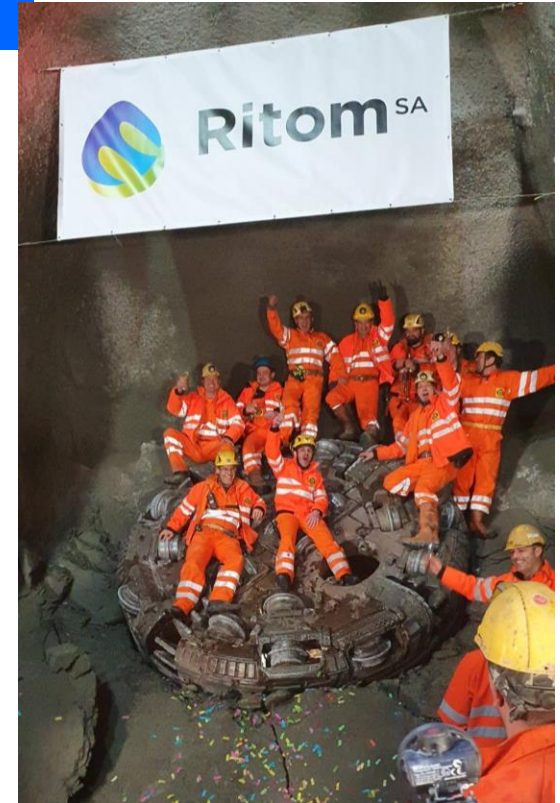
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### Schedule and timing

- Assembly of the machine in the cavern: 7 weeks
- Excavation of the inclined shaft: 11 months (10.3.-23.2.2022)
- Redescent of the machine (incl. finishing works): 8 weeks
- Disassembly of the machine in the cavern: 3 weeks







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Thank you for your attention