FUTURE CIRCULAR COLLIDER
Innovation Study

FCCNoW 2020 - MATEX Workshop

Management of matex as part of the environmental risk management process
Focus on excavation technologies

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General Conditions

Technical

- Tunnel advance method, length, -diameter
- Site organisation
- Material yield parameters
- Material analysis
- Processing technology

Geological

- Geological situation
- Chemistry/ mineralogy/ strength properties of excavated materials
- Customer specifications
- Processability

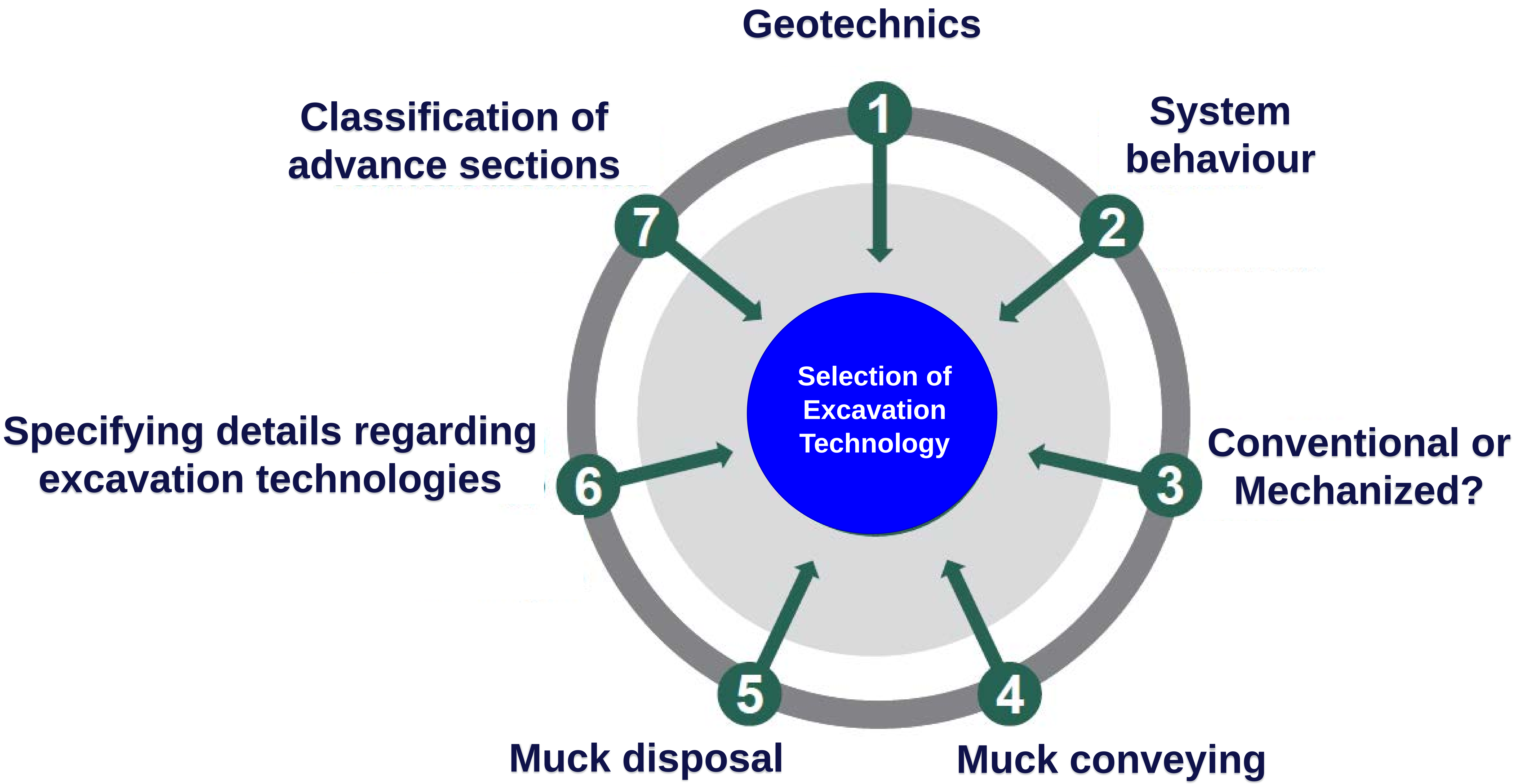
Legal

- Ownership
- Waste law
- End of waste character

Economic

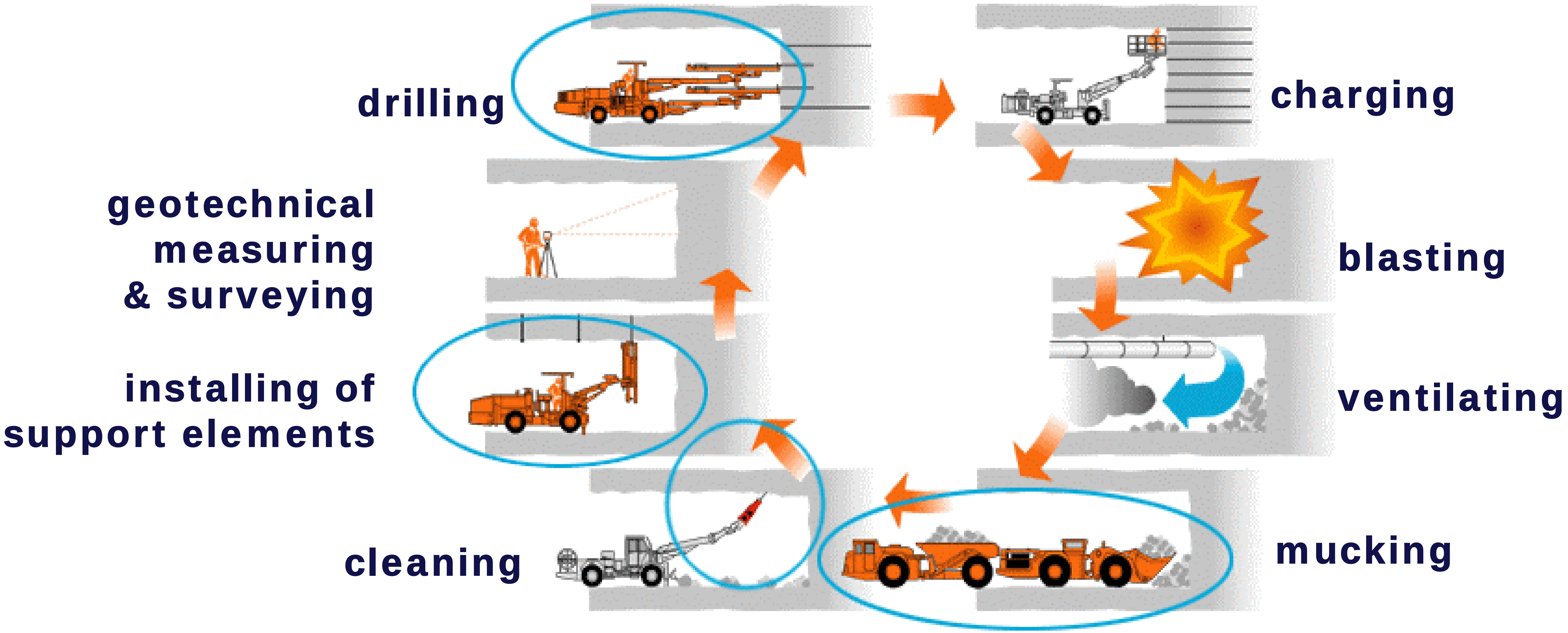
- Supply and demand
- Raw material price vs. landfilling costs
- Transport route/ -range to customers / landfills

Selection of Excavation Technology



Conventional Tunnelling

Conventional tunnelling is carried-out in a **cyclic process** of repeated steps of excavation followed by the **application of relevant primary support**, both of which **depend on existing ground conditions** and **ground behaviour**. An experienced team of tunnel workers (**miners**), assisted by standard and/or **special** plant and **equipment** executes each individual cycle of tunnel construction.



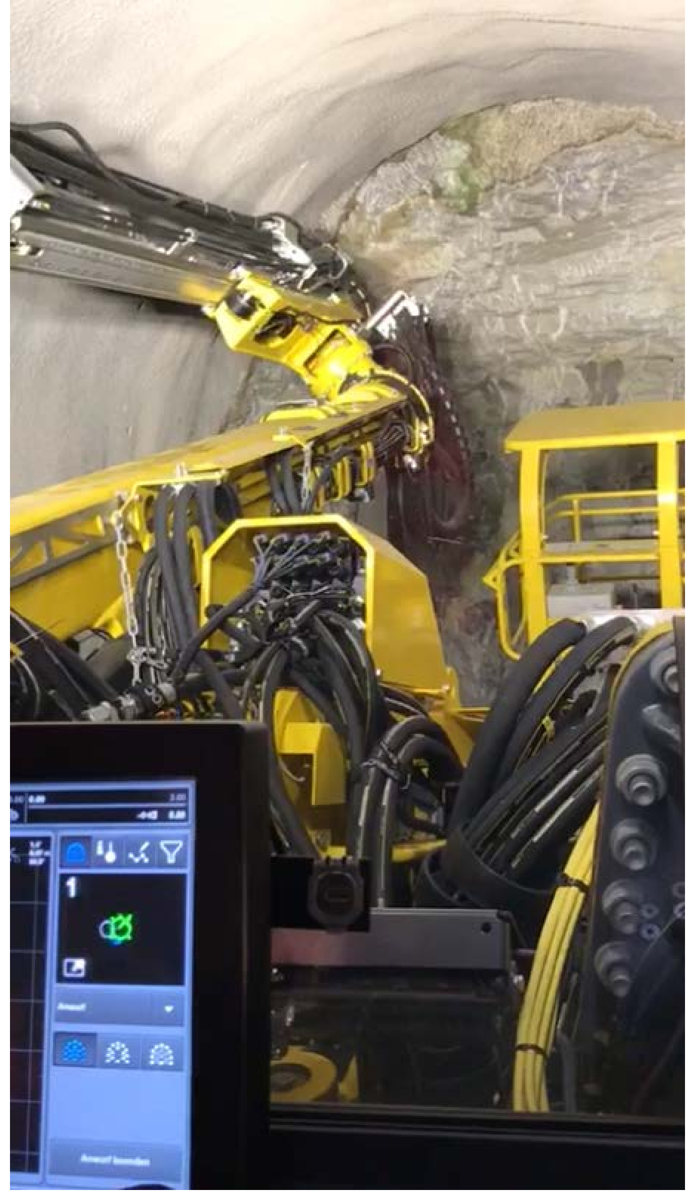
Conventional Tunnelling

… means the construction of underground openings

- of any shape
- with a cyclic construction process of:
  - o excavation of the full or the partial face,
  - o by using the drill and blast methods or
  - o mechanical excavators, except by full face TBM
- mucking excavated material from the face to the shaft or portal
- Placement of the primary support elements such as:
  - o steel ribs or lattice girders
  - o soil or rock bolts
  - o sprayed or cast in situ concrete, not reinforced or reinforced with wire mesh or fibres







Fotos: ZaB-Zentrum am Berg

Conventional Tunnelling

The Conventional Tunnelling Method encompasses the traditional drill and blast and the New Austrian Tunnelling Method (**NATM**) or sometimes referred to as the Sequential Excavation Method (**SEM**), or the Sprayed Concrete Method (**SCM**).

The conventional tunnelling method using standard equipment allows **access to the tunnel excavation face** at almost any time and is **very flexible** and **adaptable** for situations that require a change in the structural support system.

Instrumentation and **monitoring** of the behaviour of the ground during excavation is essential for successful tunnelling.

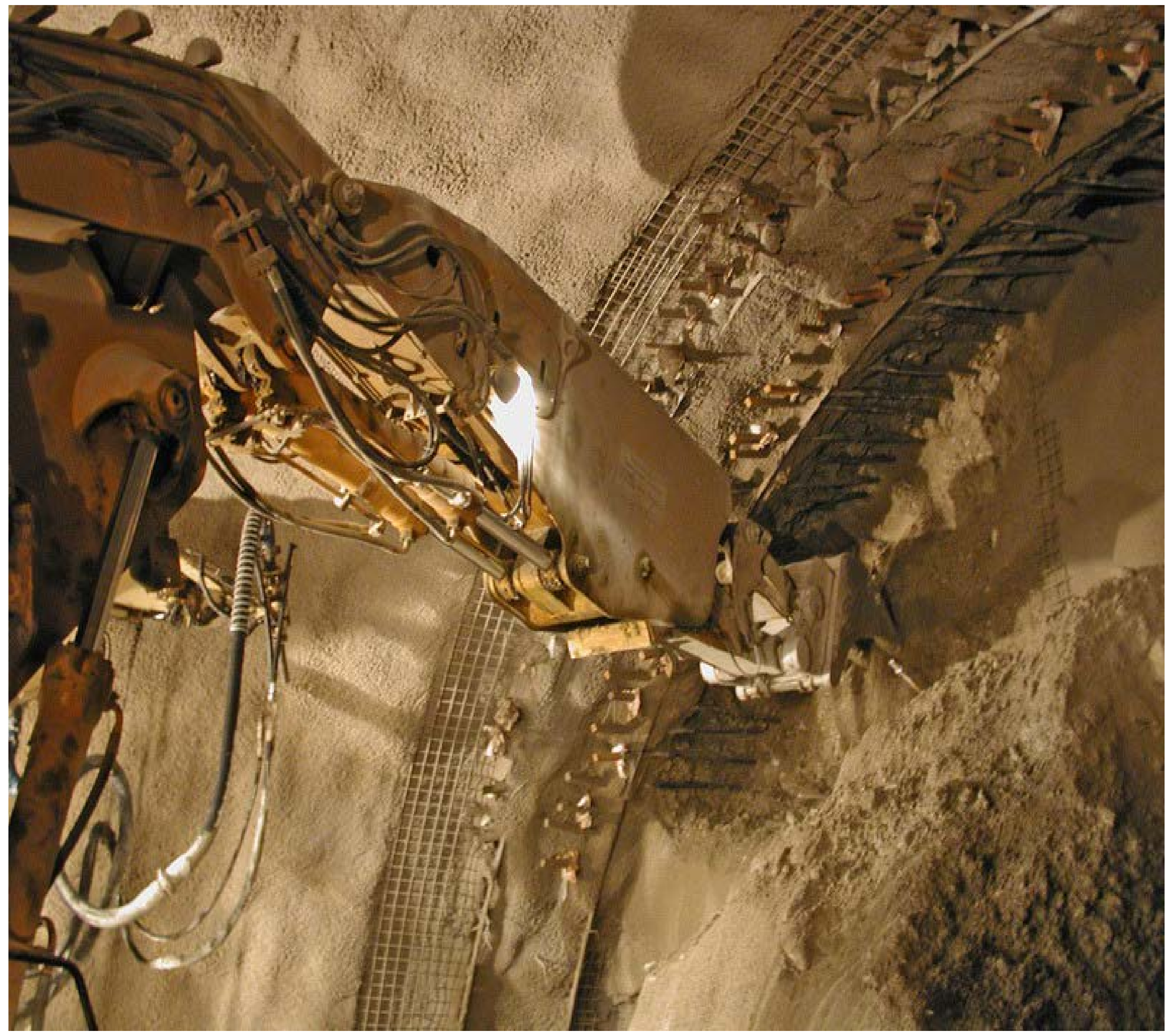
Supplementary **support system**, often referred to as **tool box**, can be implemented as required.

Foto: ITA-WG 14 & 19 report

Conventional Tunnelling

A standard set of equipment for the execution of a conventional tunnel drive may consist of the following items:

- **drilling jumbo** to drill holes for blasting, rock bolting, water and pressure relief, grouting, etc.
- **road-header** or **excavator** in cases where the ground is suitable for road-header excavation or blasting is not possible or economical
- Loader or excavator for loading excavated ground onto dump trucks
- Dump trucks for hauling excavated ground
- Set of shotcrete equipment for application of wet or dry shotcrete



Mechanized Tunnelling

- Mechanized Tunnelling utilizes a Tunnel Boring Machine (TBM).
- The excavation diameters for mechanized tunnelling range from approximately 400 mm for remote controlled utility tunnelling up to double-deck traffic tunnels with diameters beyond 17.5 m.
- TBMs could be equipped with a full face cutterhead or with partial face excavation from within a shield.
- Depending on the TBM design, mechanized tunnelling allows to maintain continuous active support onto the tunnel face during the excavation process if required such as the case for soft ground TBM.
- The tunnel face and excavation area can be completely isolated from the rear tunnel and working area, for example to maintain natural ground water levels, even higher than 10 bars, or to tunnel safely in contaminated or gassy ground.

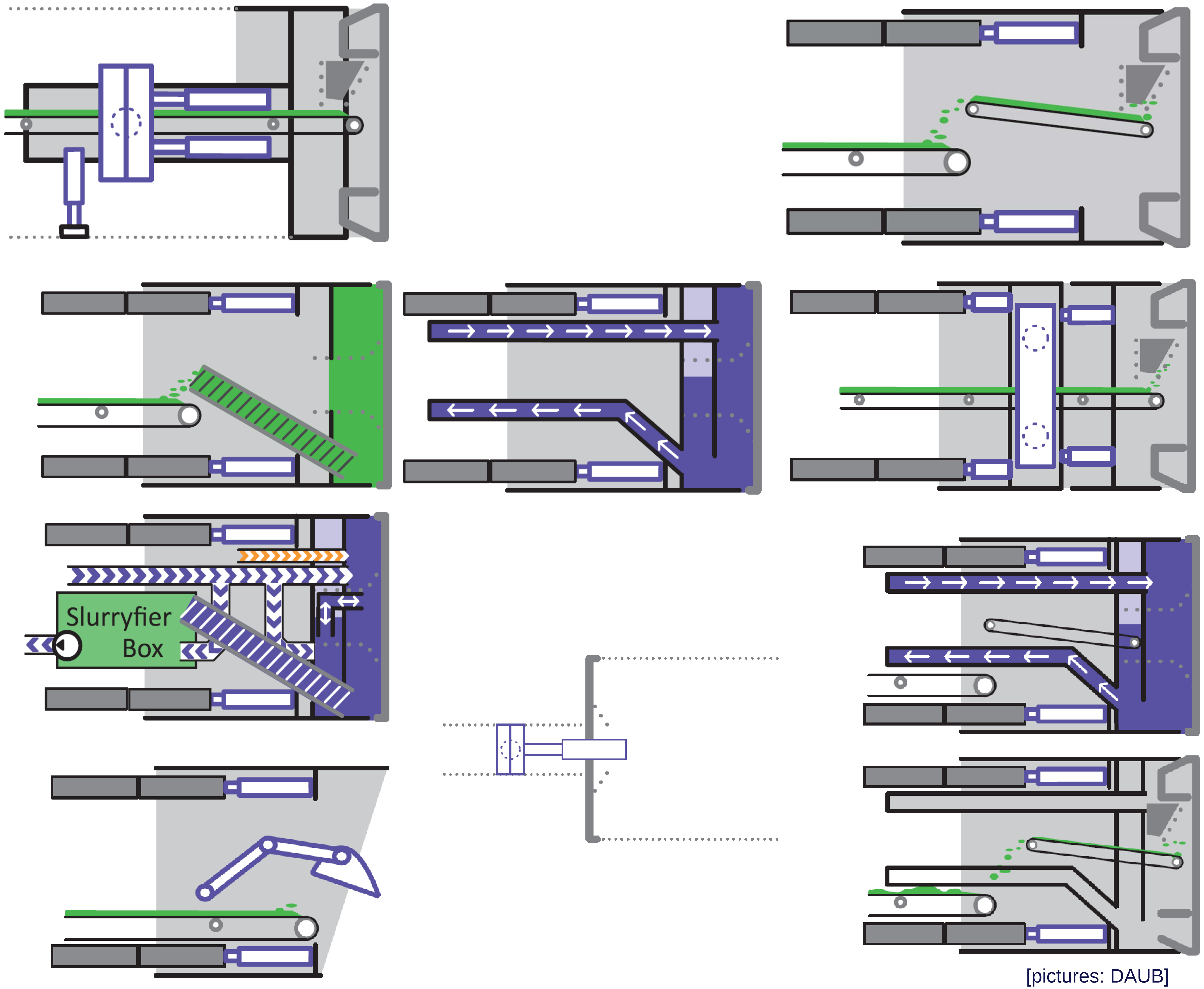
Lowering a TBM into the start shaft

TBM arrived at the portal with back-up still inside the tunnel

[Fotos: ITA-WG 14 & 19 report]

Mechanized Tunnelling

- Gripper **GRT**
- Single Shield **OPS**
- Double Shield **DOS**
- Slurry Shield **SLS**
- Earth Pressure Balance Shield **EPB**
- Variable-Density-Shield VD **VDS**
- Hybrid Shield **HYS**
- Extension TBM **XTS**
- Excavator Shield **EXS**
- Roadheader Shield **RHS**



[pictures: DAUB]

Excavation by conventional tunnelling

- By blasting, soluble parts of nitrate (NO3-), nitrite (NO2-) and ammonium (NH4 +) are introduced into the excavated material.
- In modern blasting, today mainly explosives based on ammonium nitrate (NH4NO3) are used.
- The excavated material can be contaminated by the settling of explosive clouds or by residues of unreacted explosives.

Empirical values are as follows:

- Nitrate (NO3-): 6.0 to 15.0 g/t excavation
- Nitrite (NO2-): 1.0 to 2.4 g/t excavation
- Ammonium (NH4 +): 0.2 to 3.3 g/t excavation
- high pH value due to grout and shotcrete

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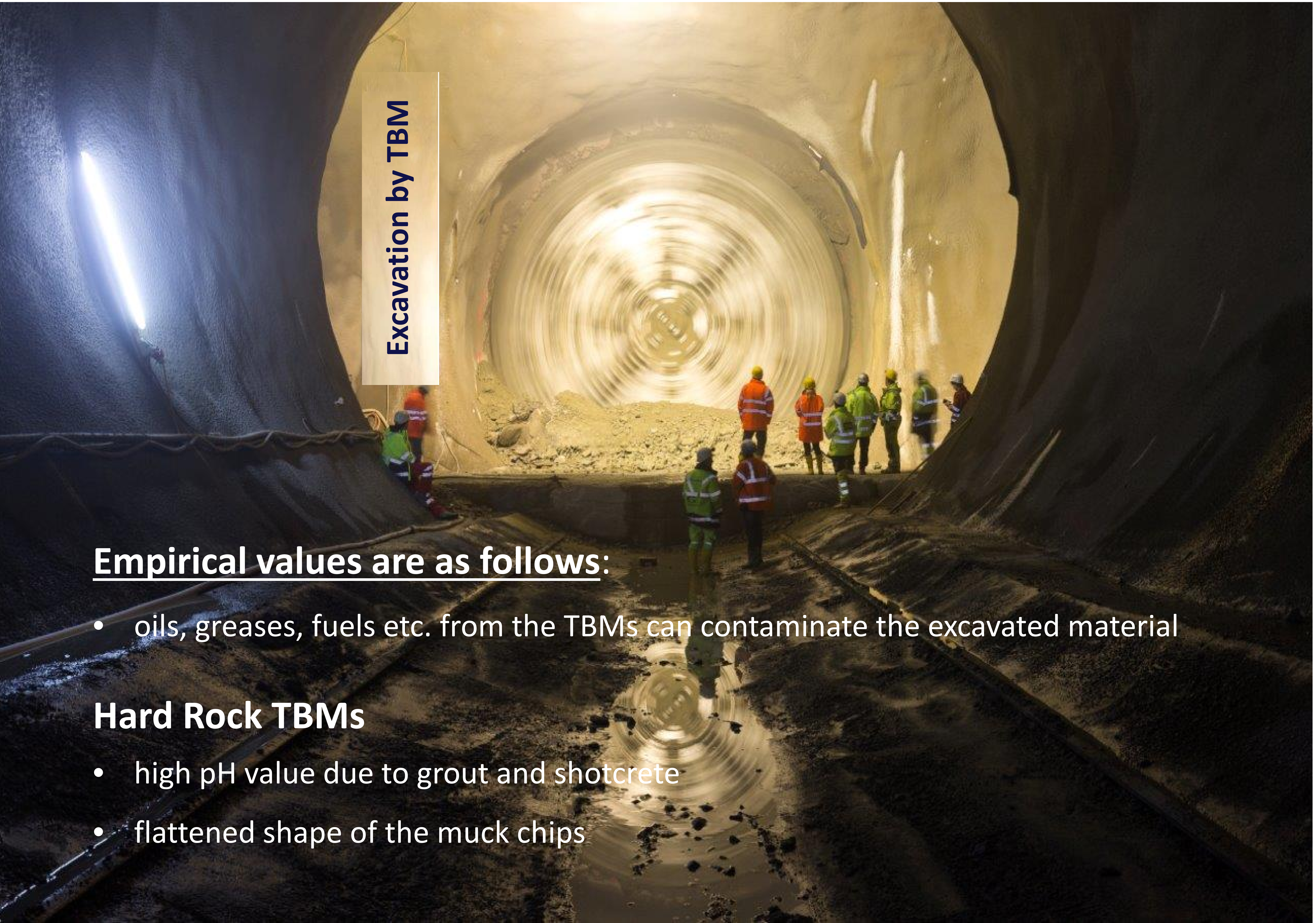


Excavation by TBM

<u>Empirical values are as follows</u>:

- oils, greases, fuels etc. from the TBMs can contaminate the excavated material

Hard Rock TBMs

- high pH value due to grout and shotcrete
- flattened shape of the muck chips

Excavation by TBM

Slurry TBMs:

- main problems are additives added during the excavation process
- bentonite and chemical mixtures
- In coarse-grained soils, with increasing permeability, highly viscous suspensions or high-density slurries are usually suitable; density range 1,4 bis 1,8 t/m³
- anthropogenic pollution (conditioning agents, loss of grease lubrication, hydrocarbons in the TBM excavated material, etc.)
- secondary treatment necessary (e.g. drying, segregation of chemical additives, sieving)

Excavation by TBM

EPB TBMs:

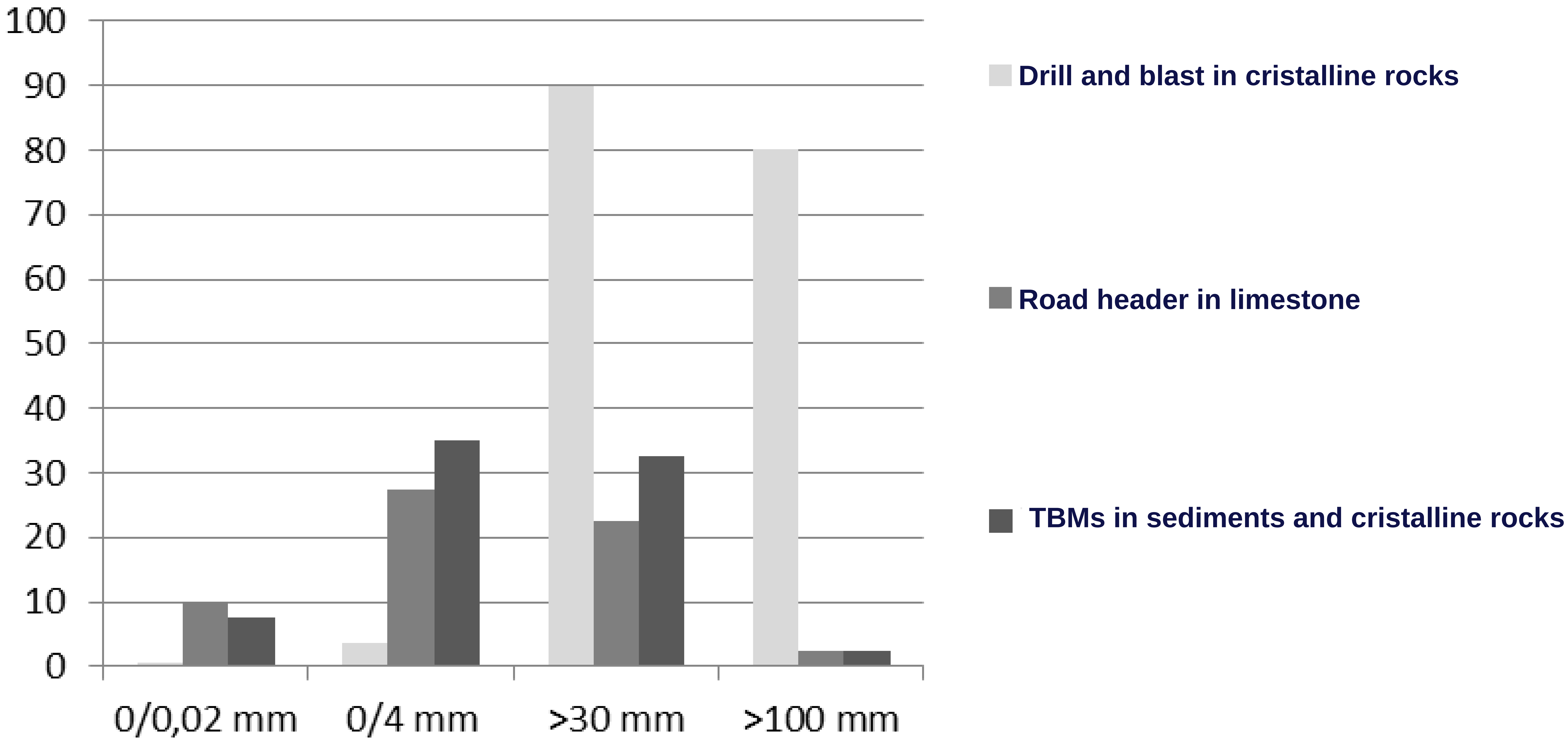
- in coarse-grained or mixed-grained loose rock, surfactant foams are usually added together with polymers or fine material suspensions, main problems are the tensides
- in fine-grained loose rock, polymer, bentonite and clay suspensions are used; main problems are the tensides
- The concentration of the conditioning agents is estimated on the basis of experience, the characteristic values of the subsoil and the results of tests.
- As an effect of the use of surfactants, an increased content of DOC (dissolved organic carbon) in the excavated material can be found.

Excavation by TBM

EPB TBMs:

- As the soil conditioner is injected ahead of the cutter, the working chamber and/or screw conveyer, the excavated soil might be contaminated from the conditioning product.
- The conditioning agents can be divided into different categories. These include water hazard classes, degradability and the toxicological limit values organisms.
- Due to the large number of conditioning agents, the composition of loose rock soils and their properties, a general classification of conditioned soils is not possible.
- It must be considered on a case-by-case basis which limit values are complied with and how the conditioned material is treated further.
- Relevant treatment of EPB-TBM excavated soil is drying/stockpiling, washing and grain size separation before use, which are important issues for the management of soil extracted.

Grain Size Distribution depending on the excavation method



Excavation method: Conventional or TBM?

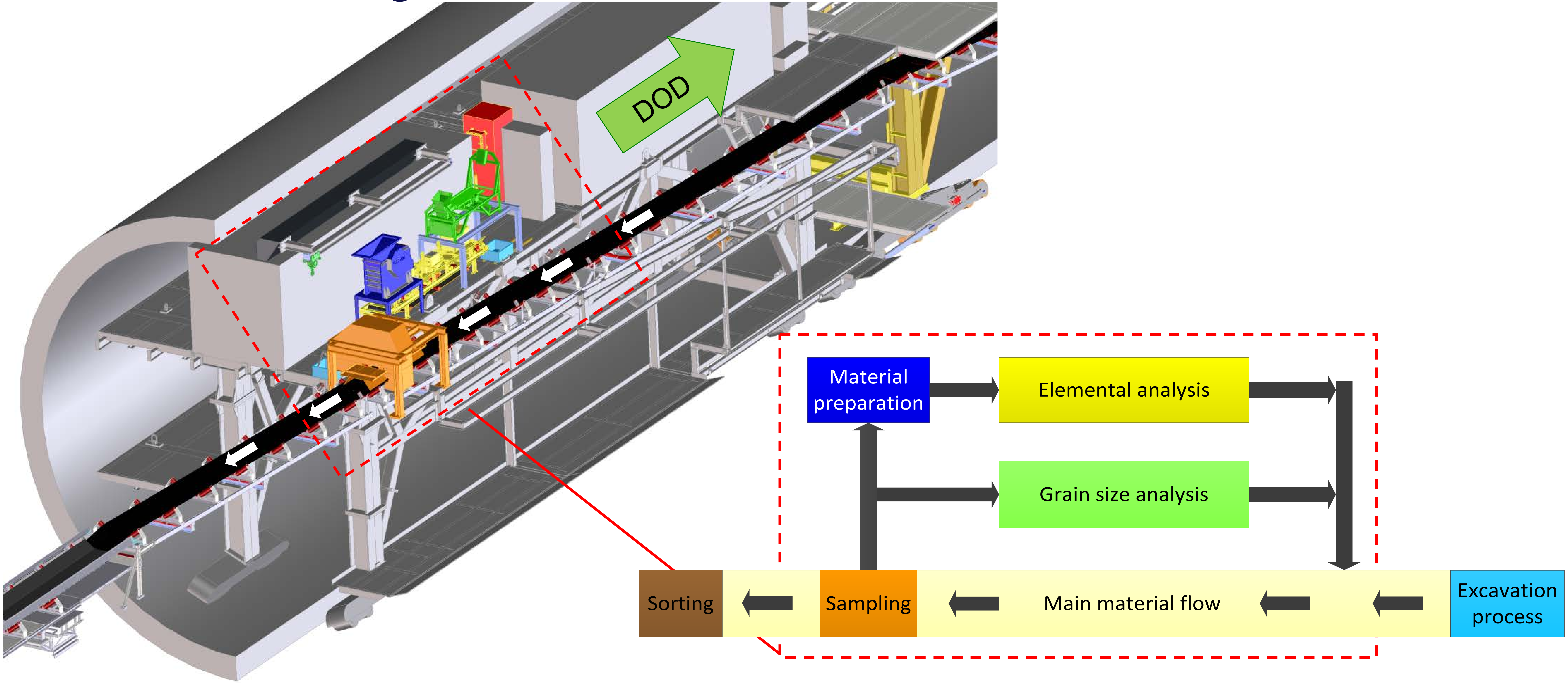
Indeed, it is decisive from the environmental point of view!

Auxiliary construction methods

- Especially when driving in loose rock, it may be necessary to strengthen the soil by means of auxiliary construction measures in advance of the driving work.
- The jet grouting process (DSV) is a frequently used process.
- In this process, a cement-based binding agent is used under high pressure.
- Since larger amounts of binding agents are usually used than the soil can absorb, there is at the same time a backflow along the drill rod. The return is made up of soil components and the binder suspension introduced.
- Due to the high proportion of binding agents, the return flow is collected and disposed of after the components have been separated.
- It has to be pointed out that the suspension used sometimes contains heavy metals (especially chromium VI).

- **Mixing with the excavated material should be avoided as good as possible!**

Quality assurance by Online material analysis, classification and in-stream sorting



[DRAGON]

Construction Organisation

Example: Processing plant at Amsteg

The possibility of using the tunnel spoil coming both from conventional and mechanical tunneling will have a great influence on the logistics, environmental and economic aspects of the FCC tunnel project.

1. Zugangsstollen in den Berg
2. Baustellen-Bahnhof
3. Betonwerk
4. Förderband mit Ausbruchmaterial
5. Kieswerk
6. Siloanlage/Bahnverlad
7. Kläranlage
8. Rohmateriallager Grund

Austria	Semmering	12,800	Albitegneiss	34	Concrete and Aggregates and Embankment
			Amphibolite	10	
			Dolomite and marble	13	
			Phyllitic schist	10	Landfill
			Micashale + Phyllitic Material	33	
Germany	Fidler Tunnel	4,700	Siltstone + Clay	20	
			Gypsum and Anhydrite	40	Plaster
			Sandstone + Marl	25	
			Sandstone + Limestone	15	Concrete aggregates
	Bossler Tunnel	4,700	Opalineousstone	40	Bricks
			Sandstone	35	Silica bricks
			Sandstone + Siltstone	20	Cement
				5	
France	LTF Maurienne Ambin Base Tunnel	31,000	Quartzite	3	Concrete aggregates and embankment
			Limestone	2	
			Gneiss + Micashale	22	
			Sandstone	18	
			Permian Micashale	22	Landfill
			Gypsum + Anhydrite	6	Cement
			Shale, Carbon	21	Landfill
Italy	LTF La Maddalena	600	Paragneiss	27	Landfill
			Micashale	63	Concrete aggregate
France	Gavet	650	Amphibole	95	Road pavement and aggregates
			Gneiss		
			Leptynite	5	Landfill
Switzerland	Les Farettes	135	Limestone	75	Concrete aggregates
			Marlly limestone	25	Landfill
United Kingdom	Crossrail	6,000	Clay	20	Landfill
			Marls	45	
			Sand and Gravel	35	
Switzerland	Nant de Drance	4,600	Granite	22	Concrete aggregates
			Gneiss		
			Micashale	78	Landfill
			Metagrawacke		
Austria	Koralm Tunnel	14,800	Gneiss/Schiefergneis	35	Concrete aggregates embankment and outside use
			Amphibolite	3	
			Marble	5	
			Micashale	25	
			Sandstone/Schlufstein	32	Landfill

Examples, where re-use of tunnel excavation material was working well

The use of excavated rock in the project itself or projects in close vicinity will be of great benefit to the environment and also reduce the CO_2 footprint related to transport of tunnel muck.

Thank you for your attention!

Questions?