The successful application of different excavation methods on the example of the Koralm tunnel lots KAT1 & KAT2

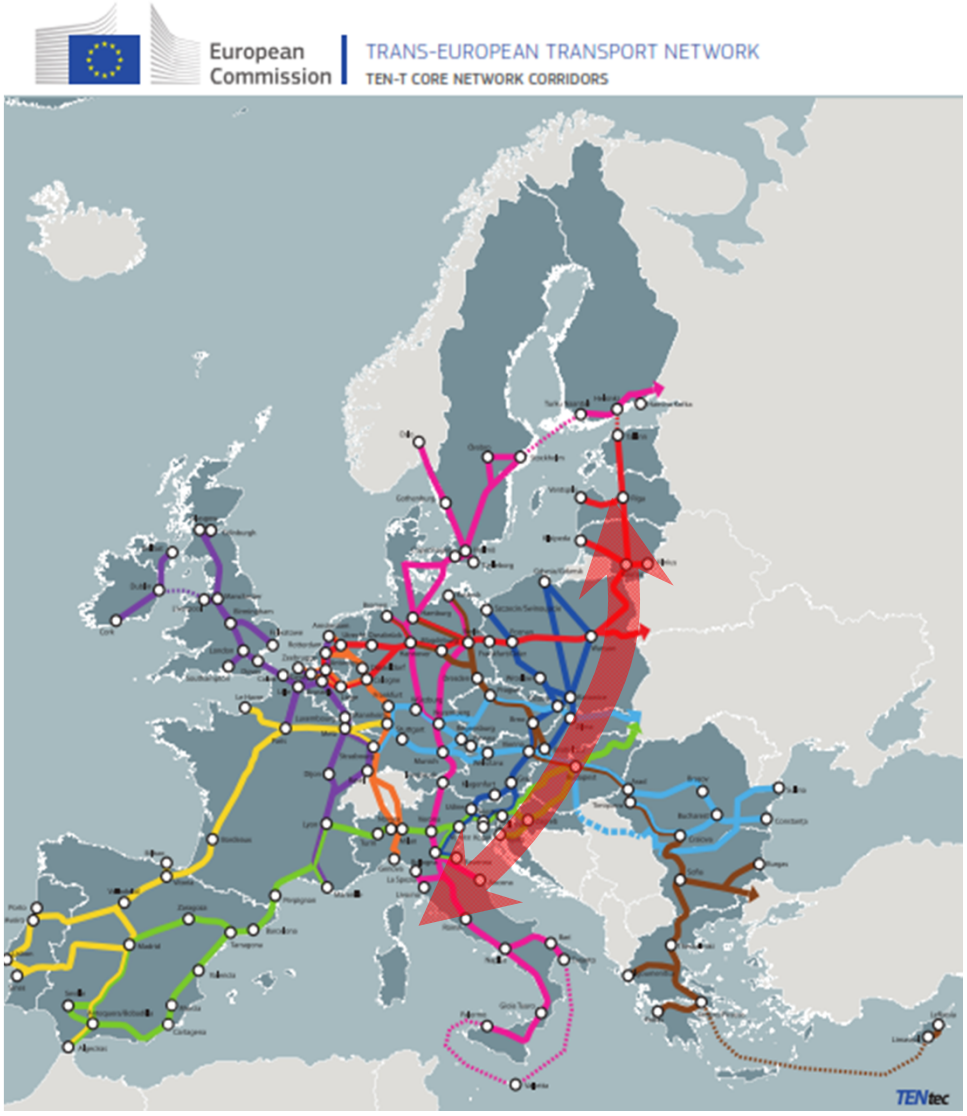
Hanns Wagner
OBB – Austrian Federal Railways

Koralm Railway as a part of the Baltic-Adriatic Axis

Key data:

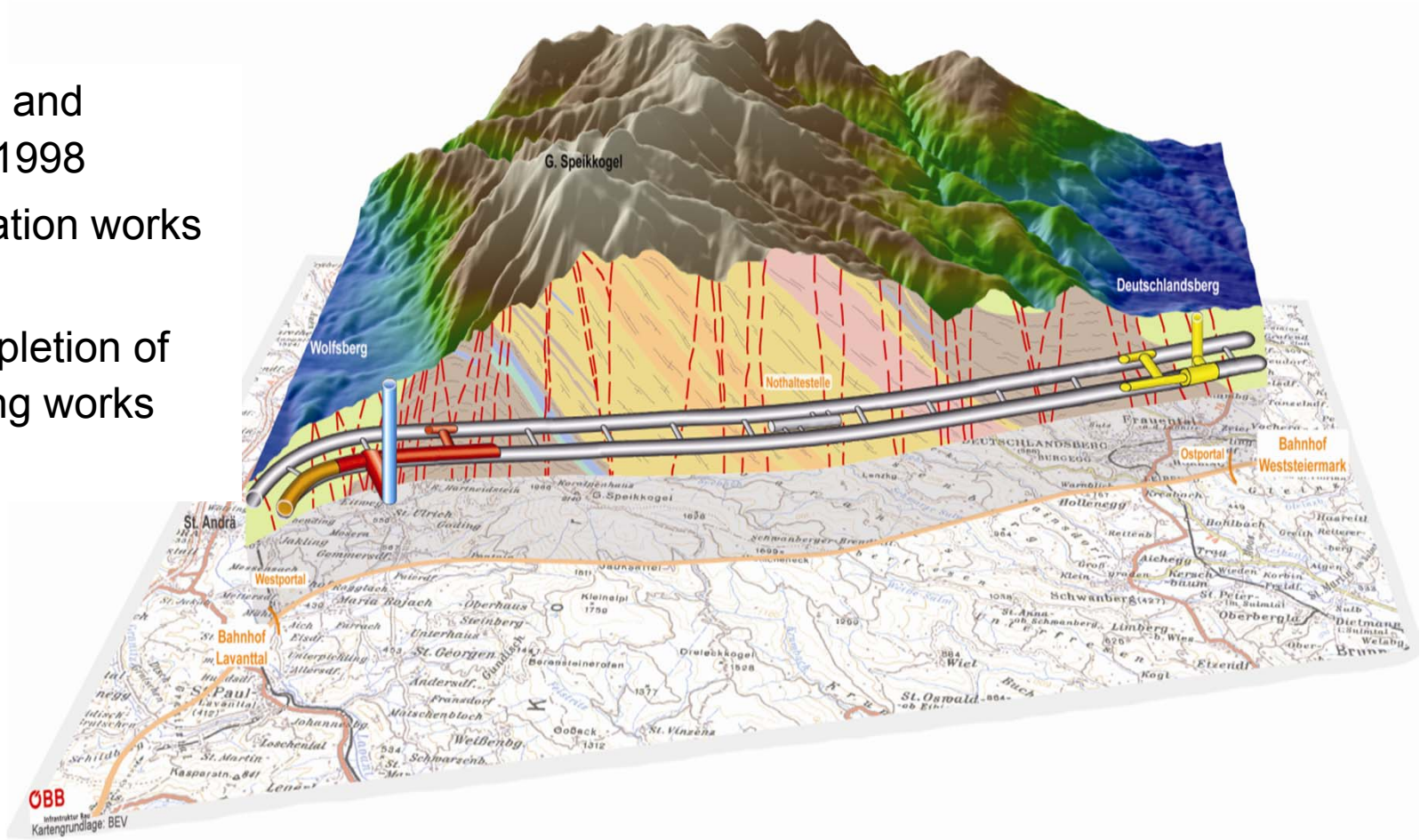
- 127 km overall length
- Travel speed up to 250 km/h
- Travel time Graz – Klagenfurt 45´
- Length Koralm tunnel 32,9 km
- Start of construction 1999
- Start of operation 2023
- At present ≈ 70% under operation or under construction
- Target costs 5,4 bn. EUR*
  - incl. Koralm tunnel 2,3 bn. EUR*

*) status 01.2014



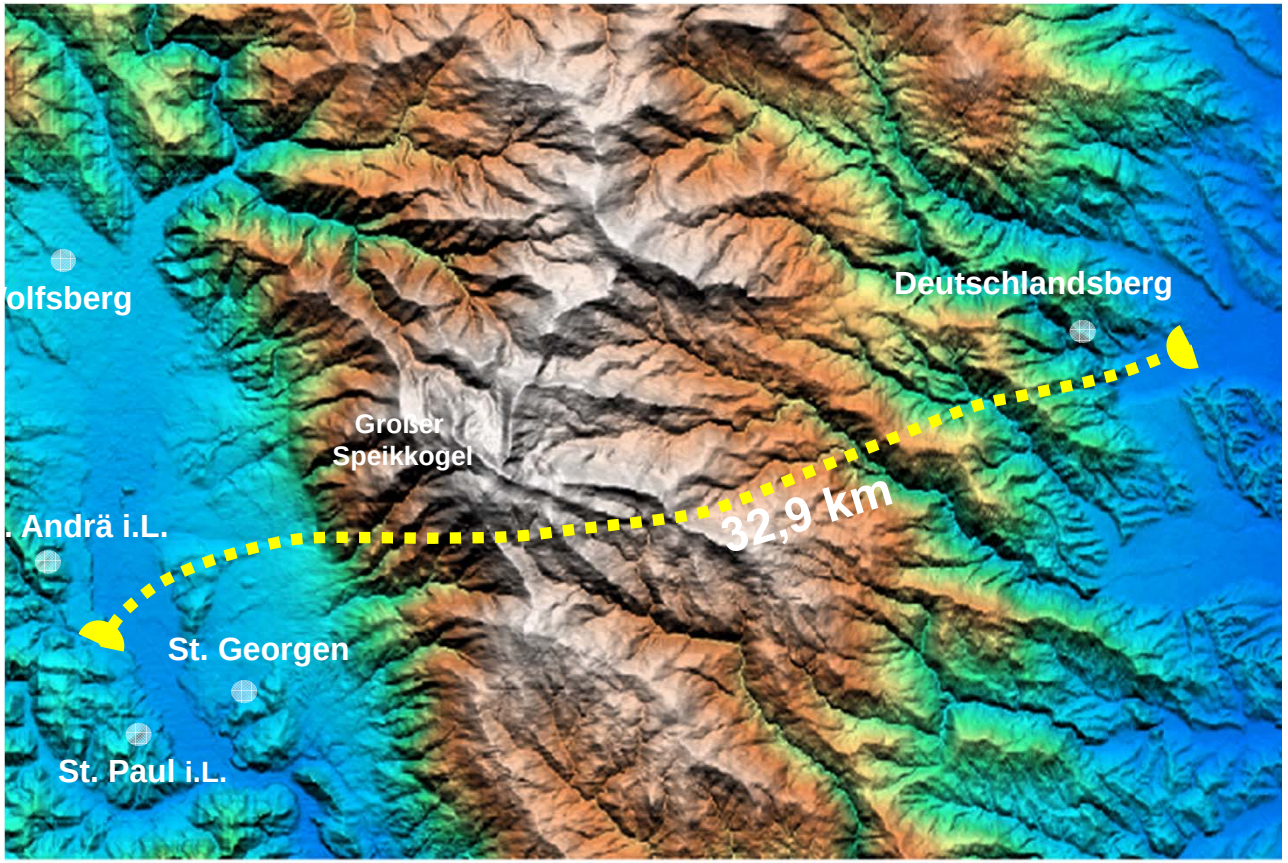
Koralm Tunnel - Project overview

- Start of design and exploration in 1998
- Start of excavation works in 2010
- Expected completion of civil engineering works 2019



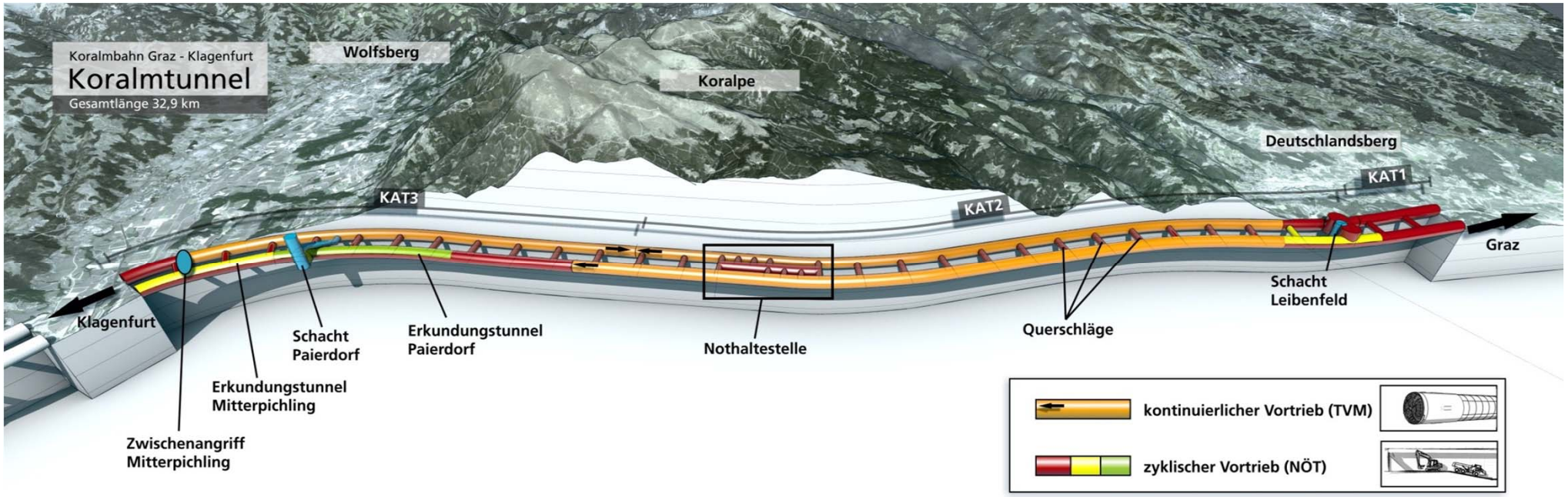
Koralm Tunnel – key data

- Tunnel length: 32,9 km
- Max. overburden 1.200 m
- Tunnel system: twin-tube – single-track tunnel
- Tunnel ∅i: 7,90 m
- Cross passages each 500 m
- Emergency stopping area approx. in the middle of the tunnel system

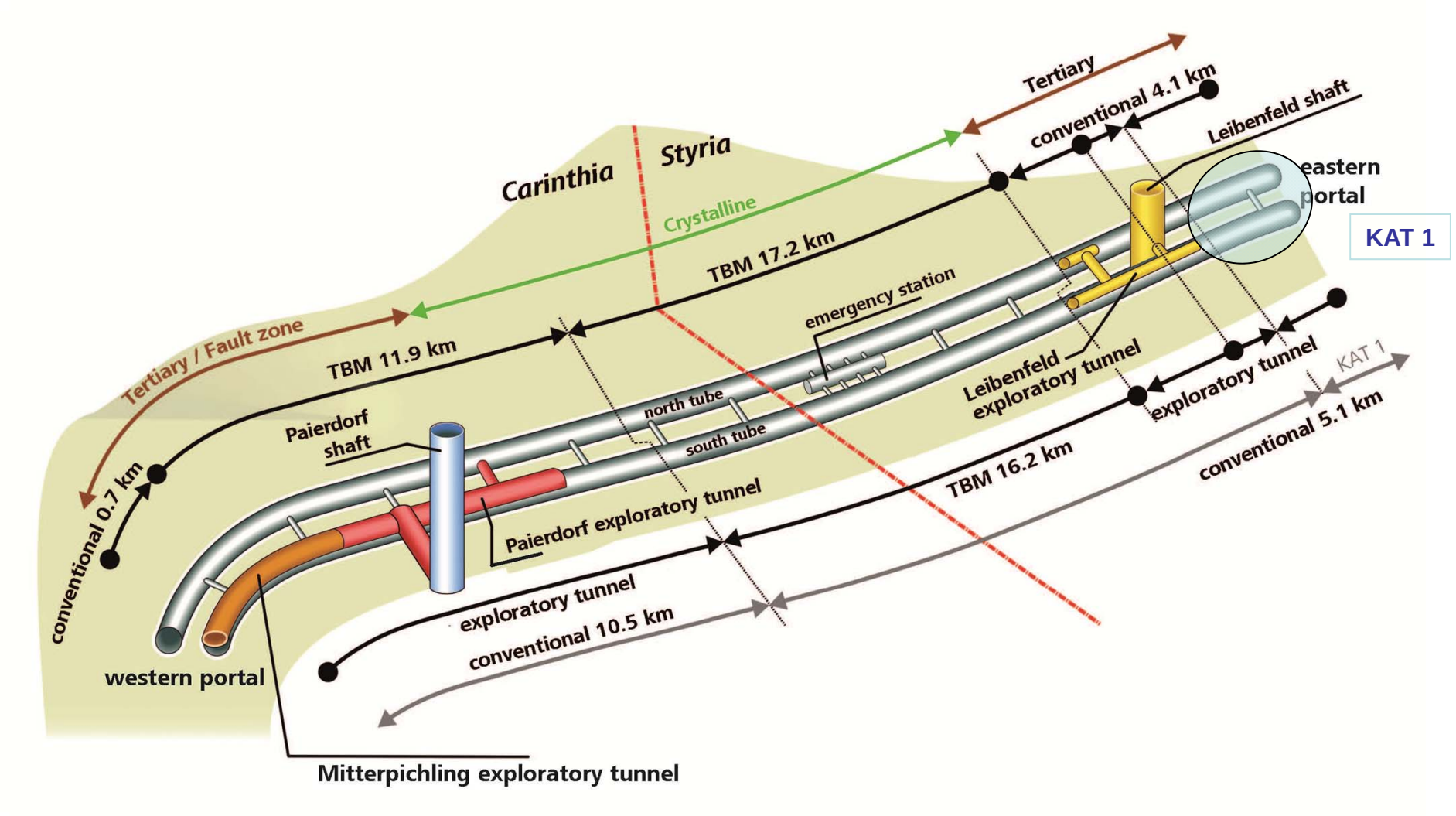


Koralmtunnel - Overview

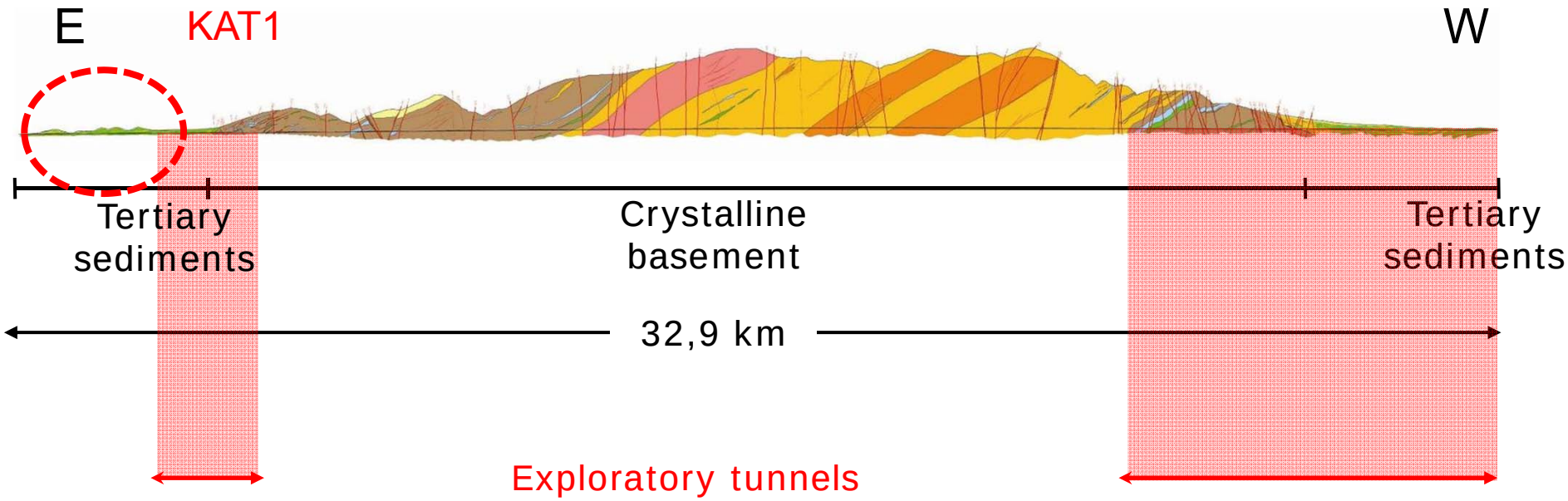
- Length 32,9 km
- 3 contract sections (KAT 1, KAT 2, KAT 3)



Koralm Tunnel – construction section KAT 1



Geological framework KAT 1



- **Silt-, clay- and sandstones**

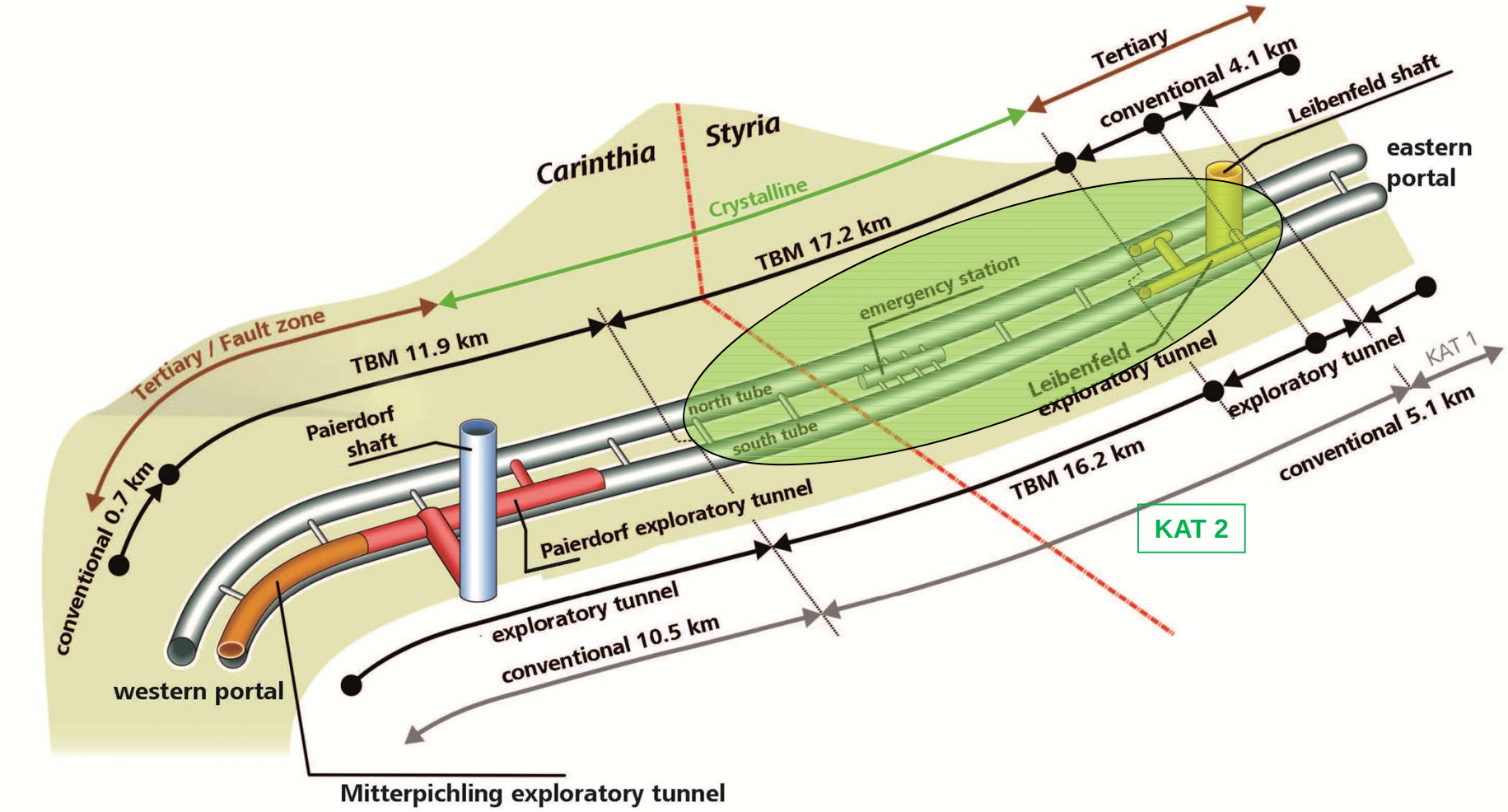
Koralm Tunnel – Lot KAT 1

- NATM tunneling with 2 x 2.6 km length
- 5 cross sections
- Tunnel advance finished in 2012
- Inner lining is completed
- Contractor Wayss & Freytag
- Contract worth 100 Mio Euro

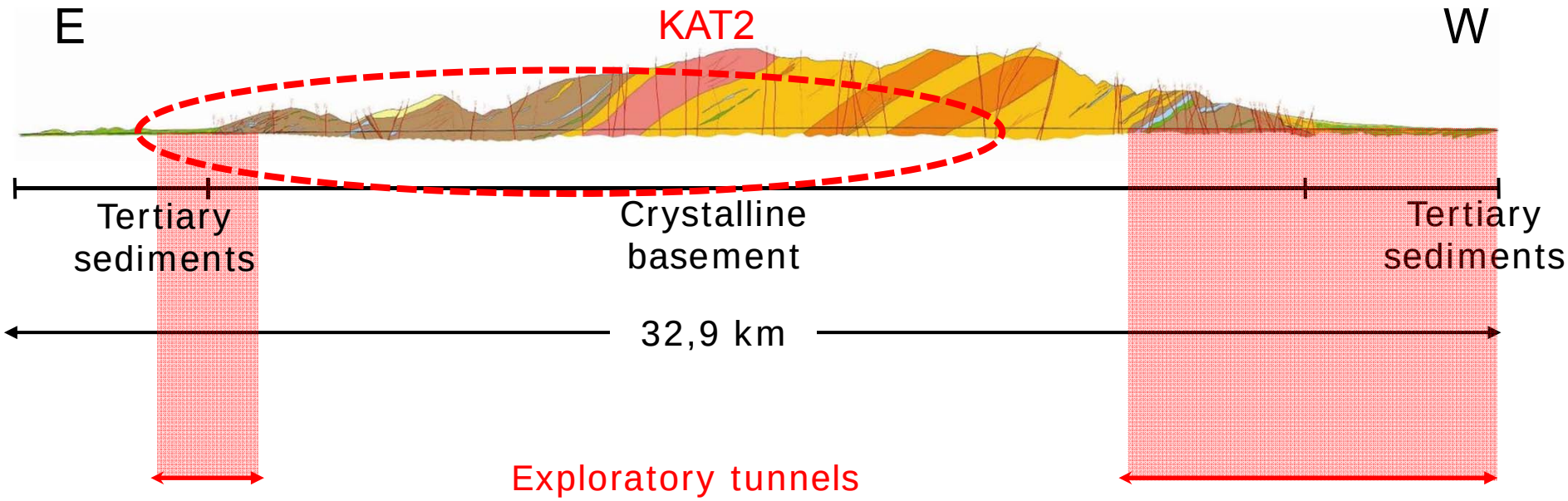
Koralm Tunnel – Lot KAT 1

- Neogenous formations
- Short advance length
- Shallow overburden of less than 10 m
- Advance under pipe roof
- Limits of establishing the construction site near portal

Koralm Tunnel – contract section KAT 2



Geological framework KAT 2



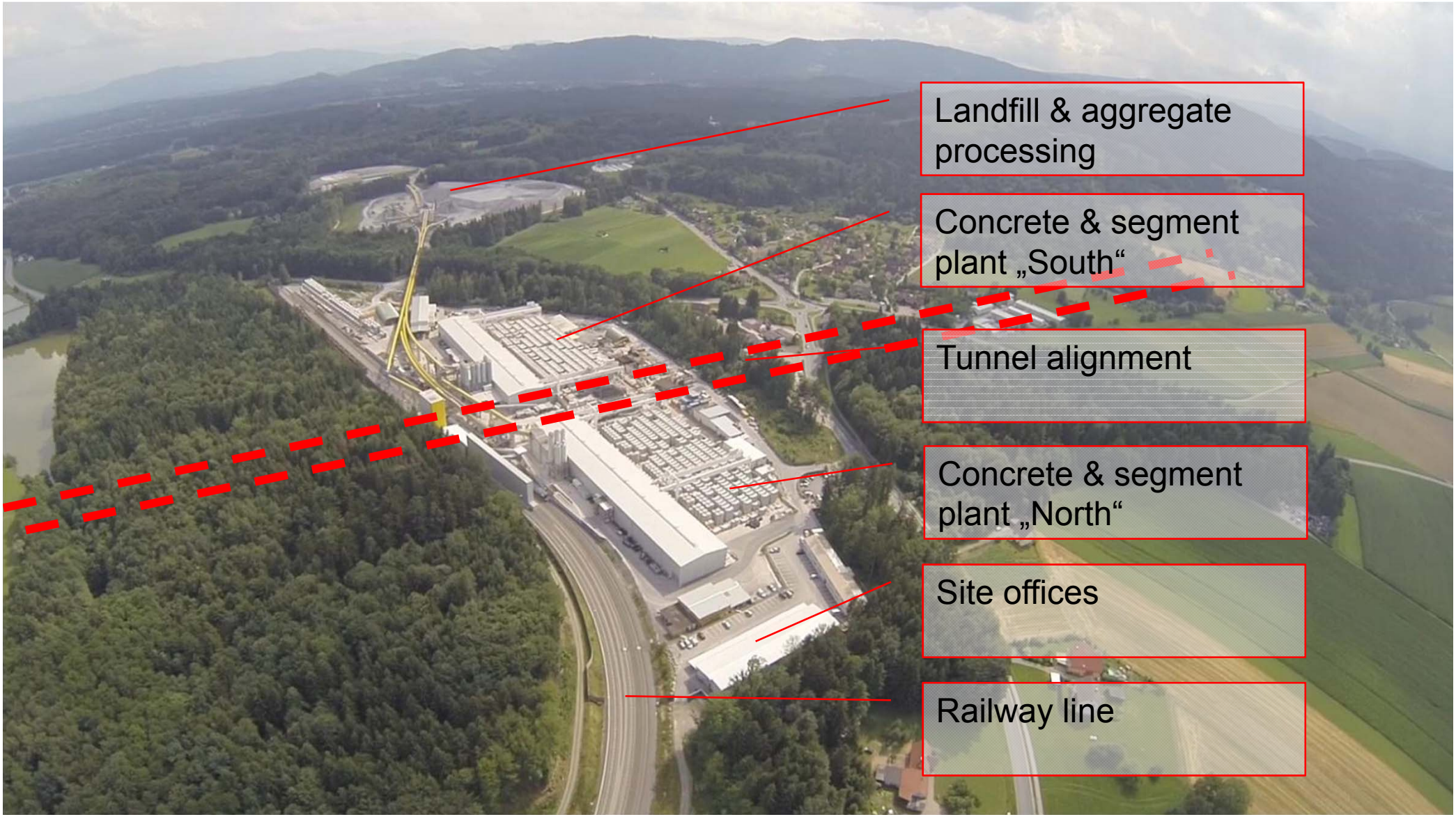
- **Gneis (dominating), mica shists, marbles, amphibolites, eclogites, quartzites and pegmatites**

Koralm Tunnel – Lot KAT 2

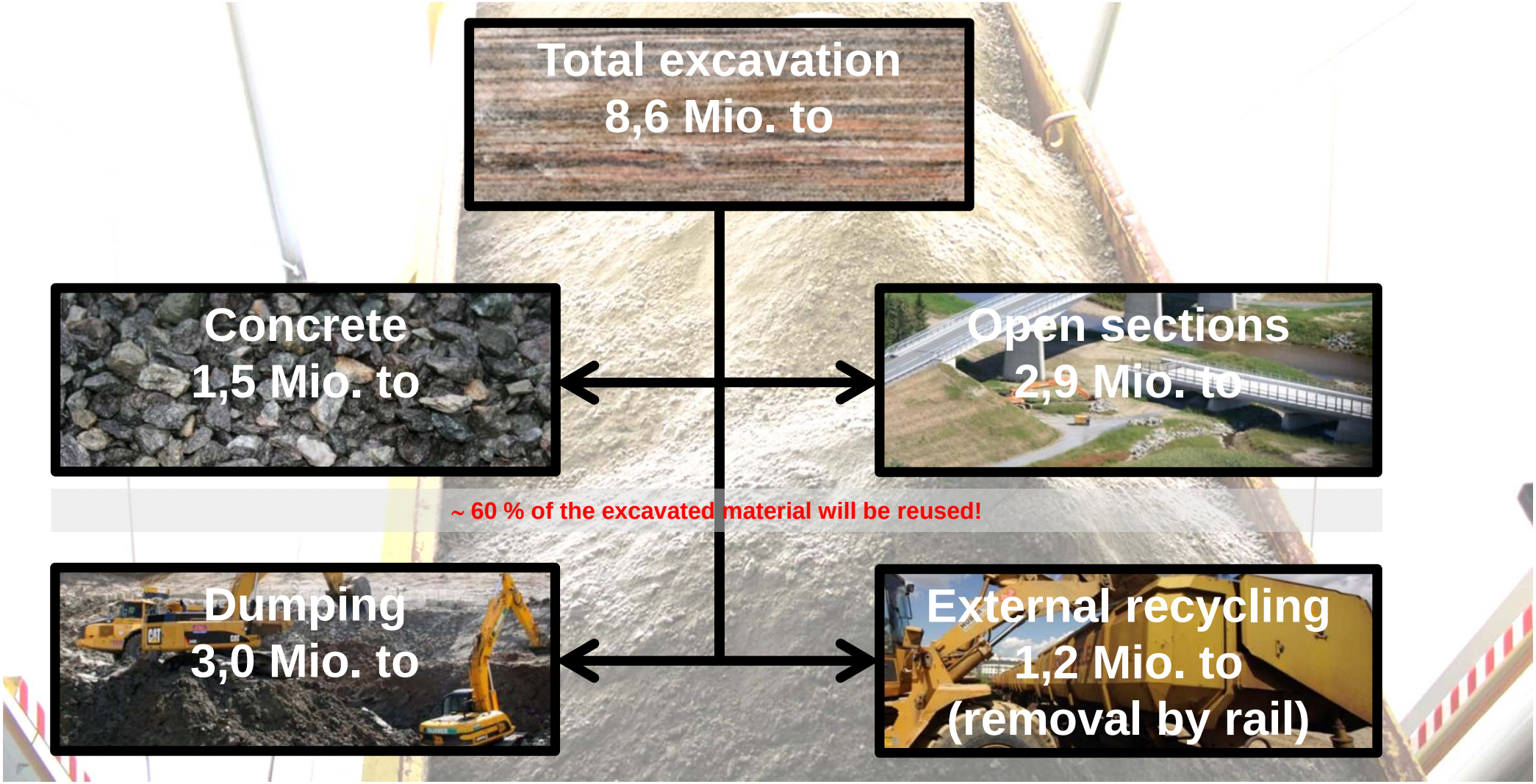
- Tunnel length 20 resp. 18 km
- 40 cross sections
- Emergency stopping area (900 m)
- 9 km open section
- Total of 45 km tunnel excavation
- Conventional (NATM) and continuous (TBM-DS) tunnel drives
- Duration: 2.950 Tage
- Contractor Strabag and Jägerbau
- Contract worth 570 Mio. €

Project Video KAT 2

Site installation KAT 2

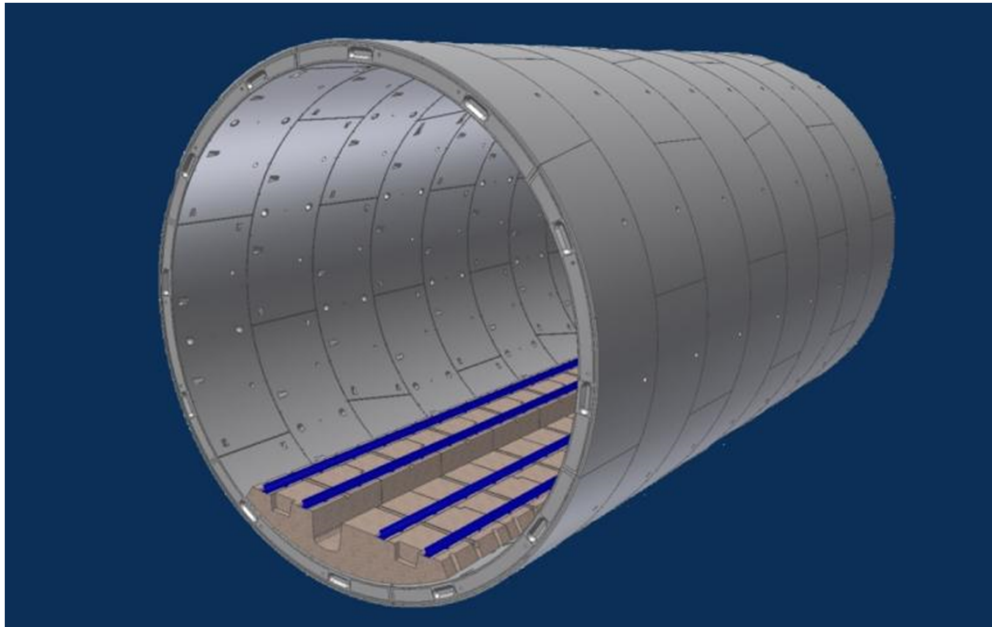


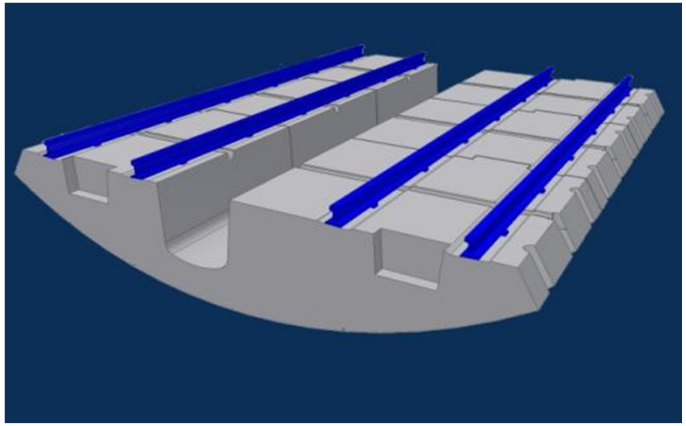
Material management KAT 2



Lining and segment production KAT 2

- Ring
  - Medium width 1,90 m
  - Sectioning 6+0 (+ invert element)
  - Outer diameter 9,5 m
  - Segment thickness 35 cm
- Production
  - No. of segments 103.500 pcs.
  - No. of invert elements 17.250 pcs.
  - Weight per ring 47,5 t
  - Weight invert element 13,4 t
  - Already produced 60.000 pcs.



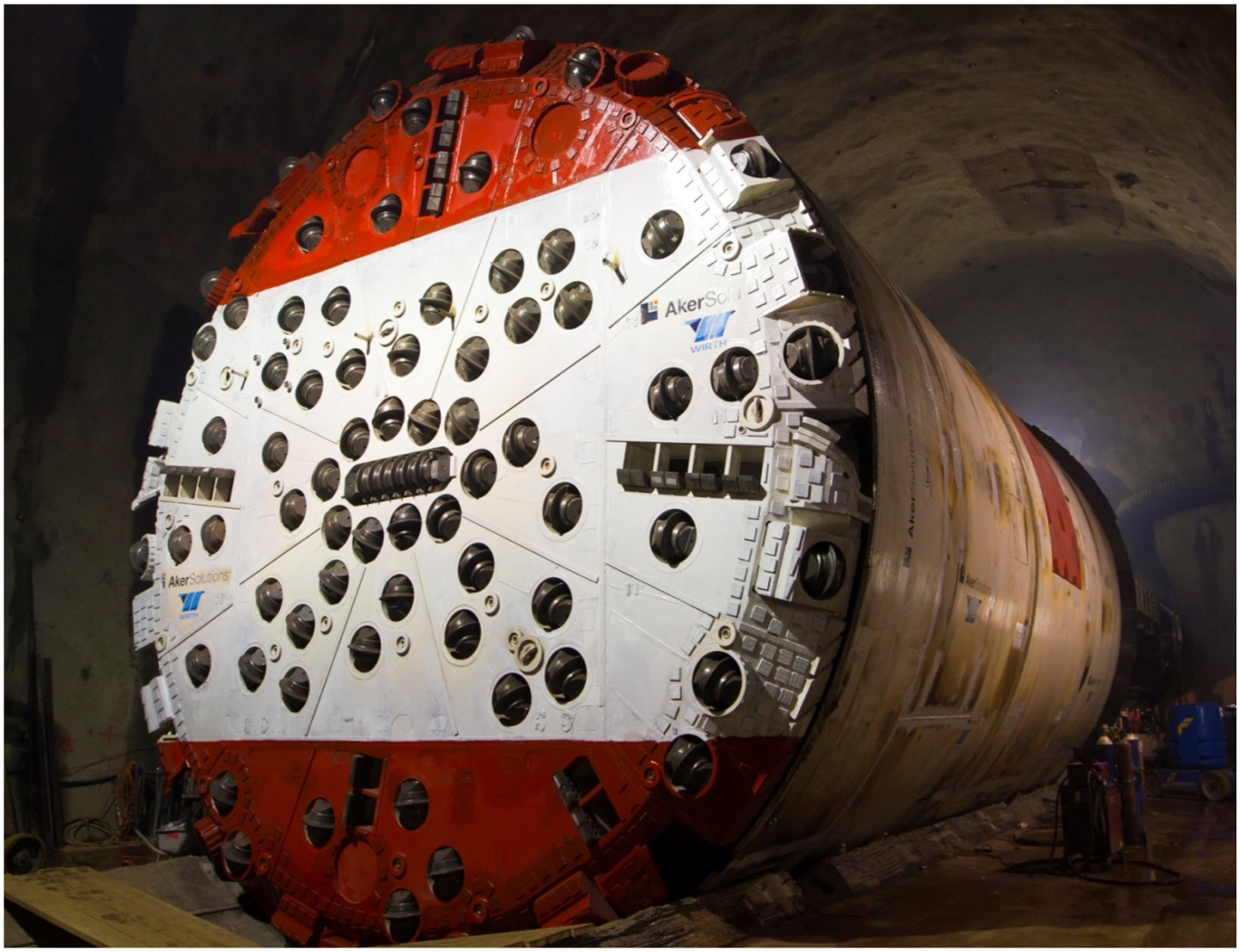


TBM excavation KAT 2

- 2 Double-shield TBM
- TBM ∅: 9,90 m
- Length of TBM excavation:

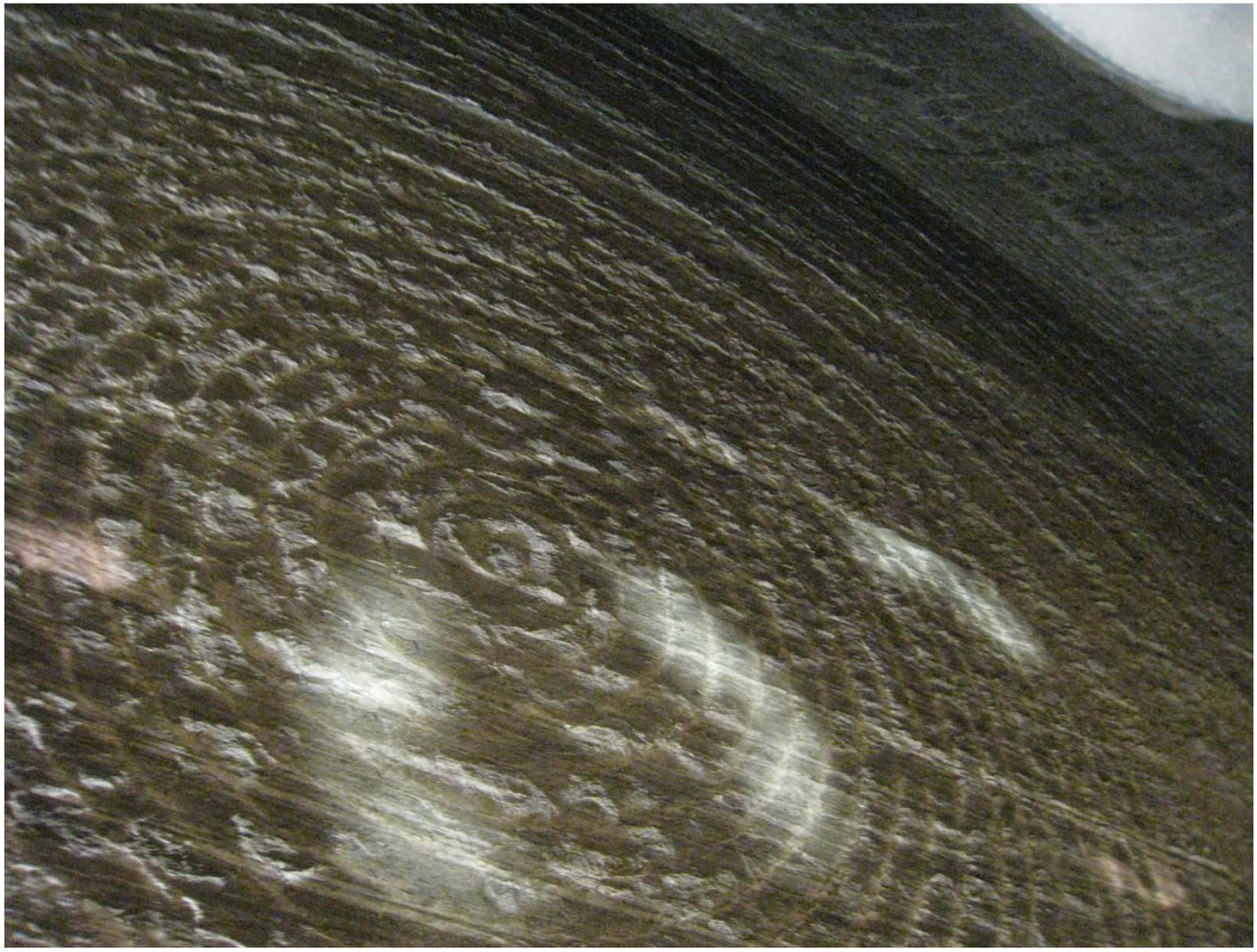
  32.800 m
- Excavated by March 2015:

  18.983 m (58%)

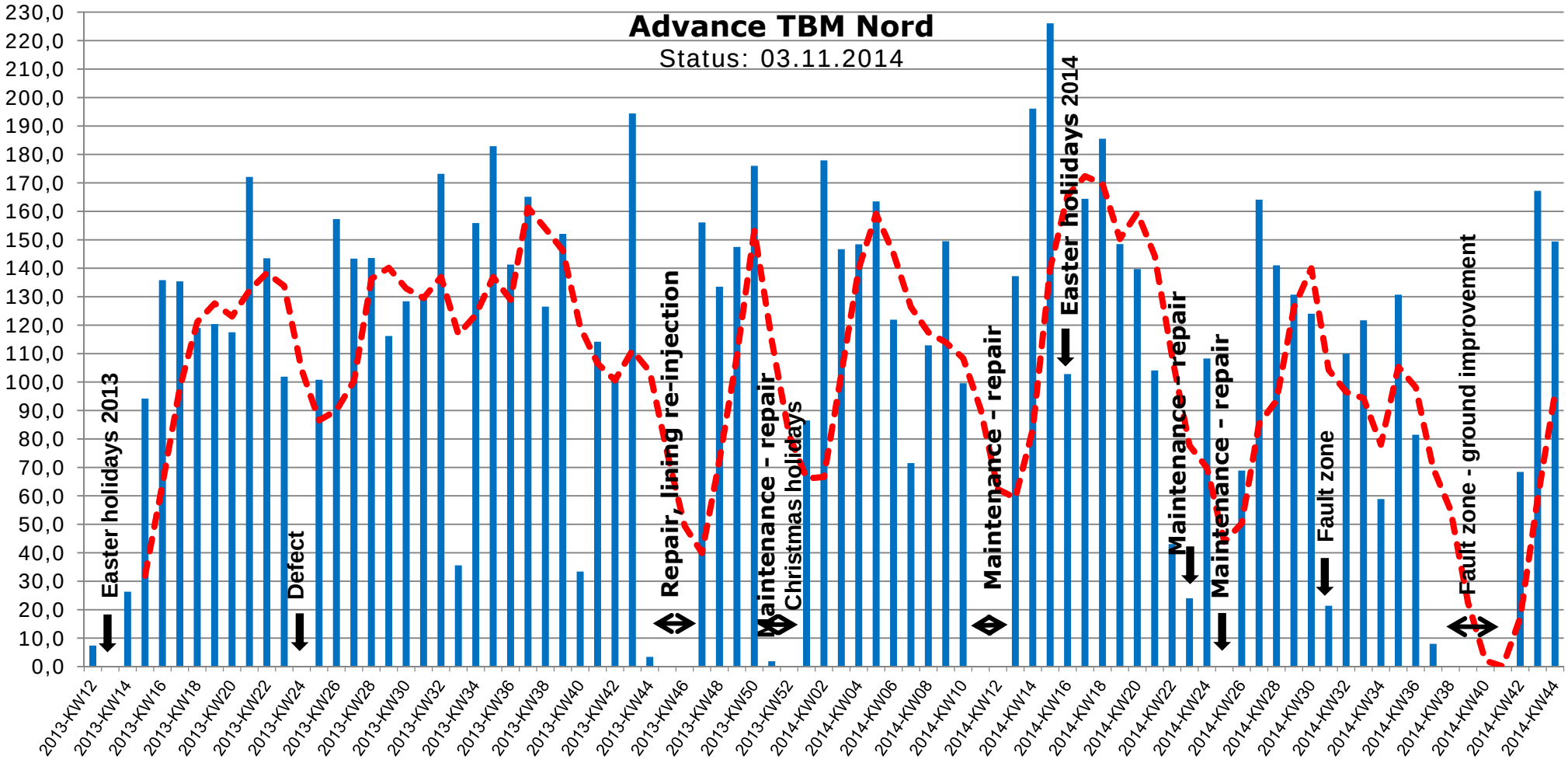


TBM excavation KAT 2

- Max. excavation speed
  ≈ 45,7 m/d
- ∅ excavation speed
  ≈ 110 m/week



TBM excavation KAT 2



TBM excavation – KAT 2

TBM excavation KAT 2

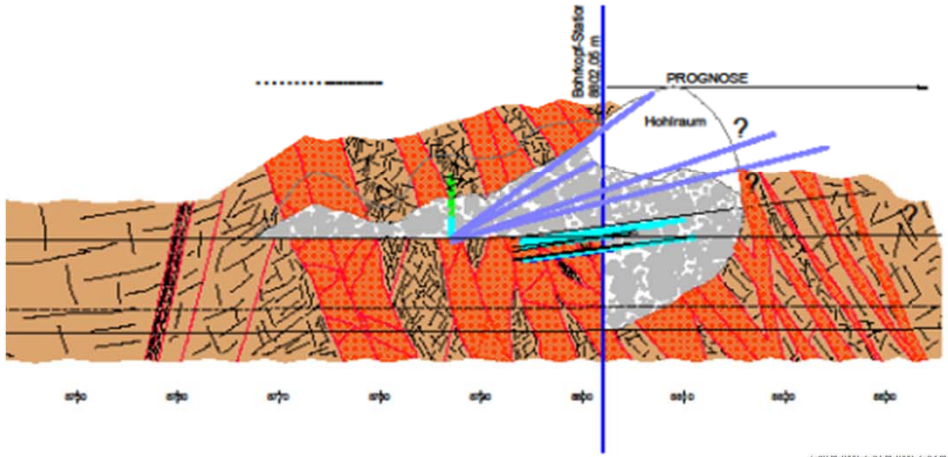
Max. water inflow (peak): ≈140 l/s, ≈ 20bar

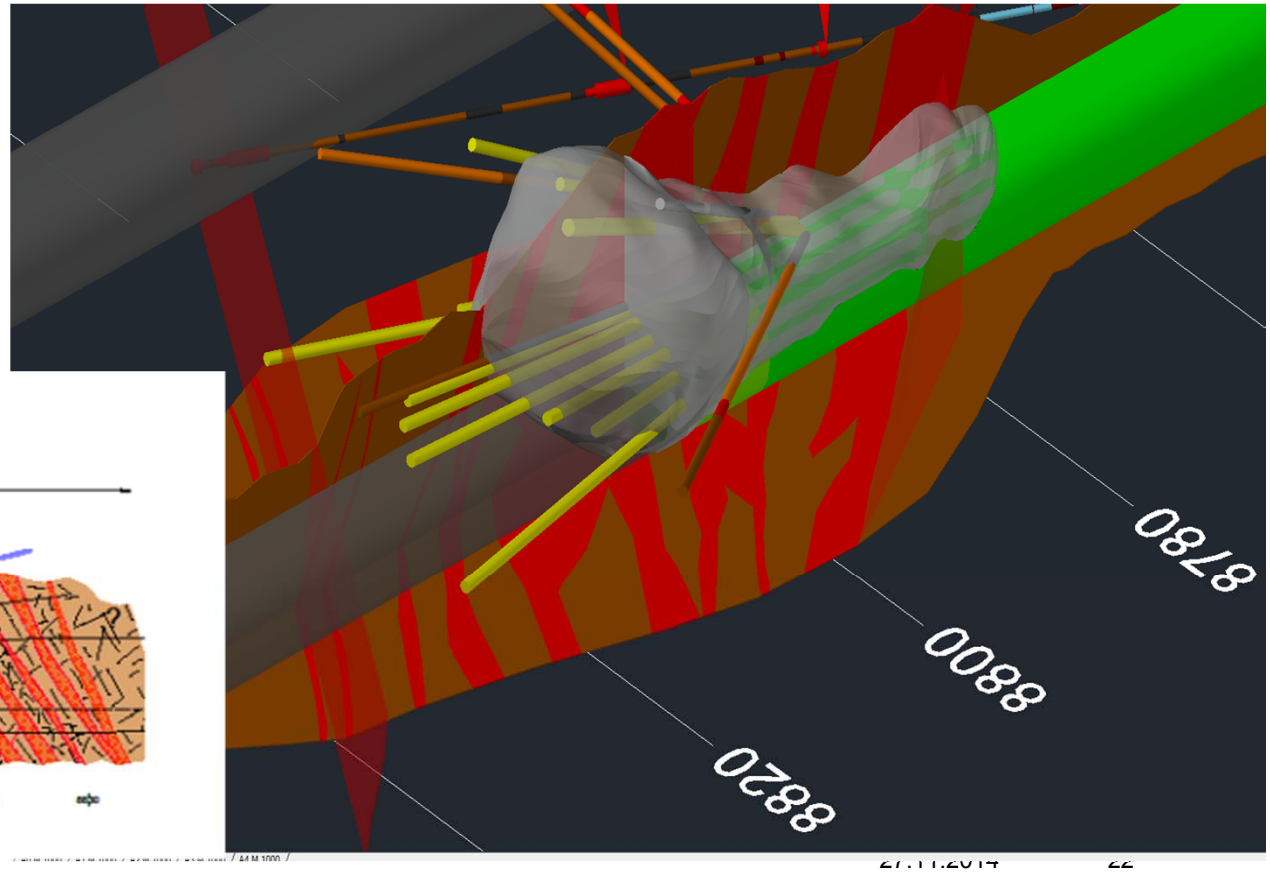
- Detected by means of pilot drilling
- Dewatering and depressurizing
- Orderly drainage
- No influence to second tube

TBM excavation KAT 2

Fault zones – ground improvement (example TBM South at 8.802 m)

- Overbreaking and face in advance
- Uncontrolled mucking
- Collapse ≈ 1.500 m³
- Blocked Cutterhead
- Detailed investigation by means of hammer and core drilling

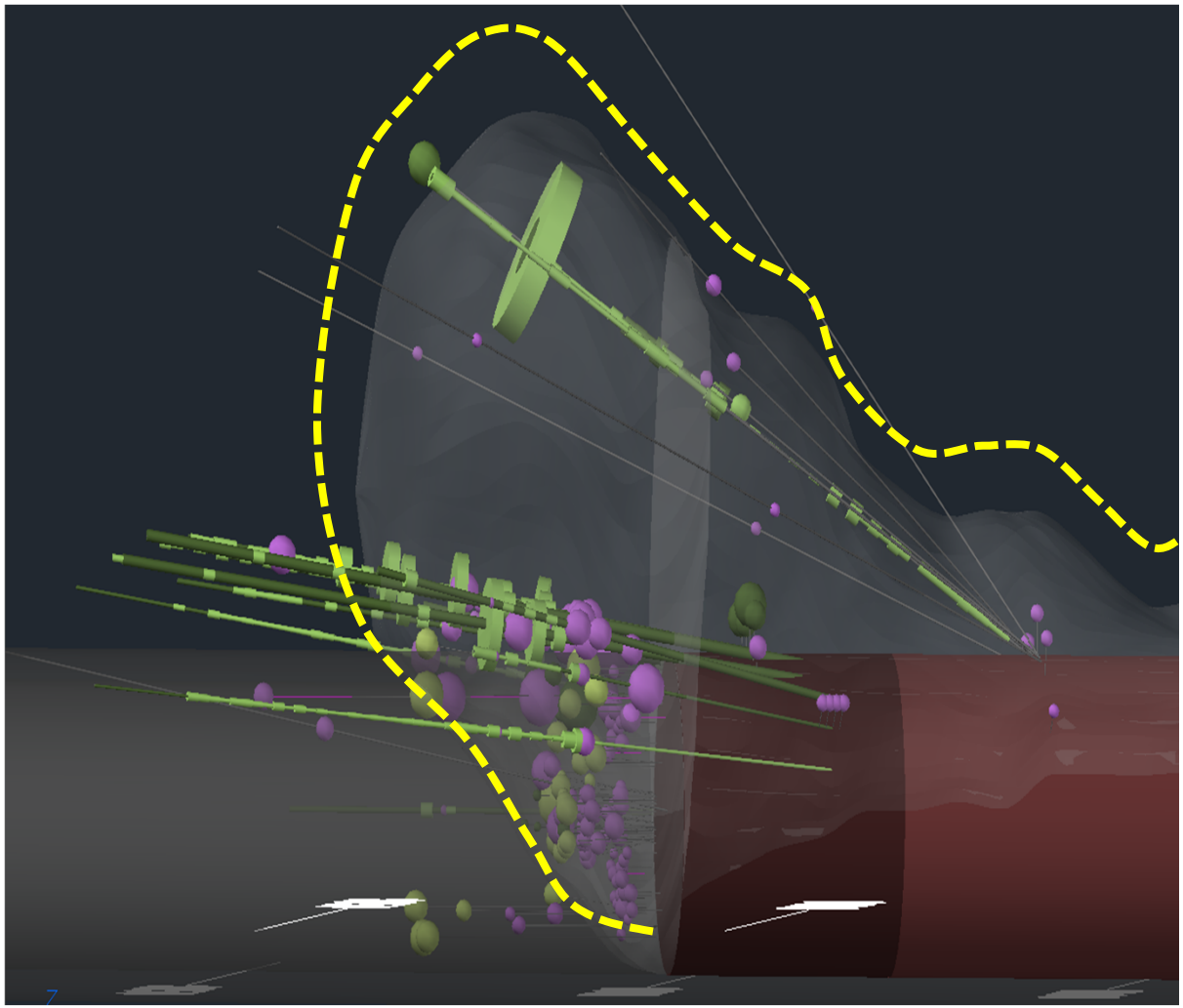




TBM excavation KAT 2

Fault zones – ground improvement (example TBM South at 8.802 m)

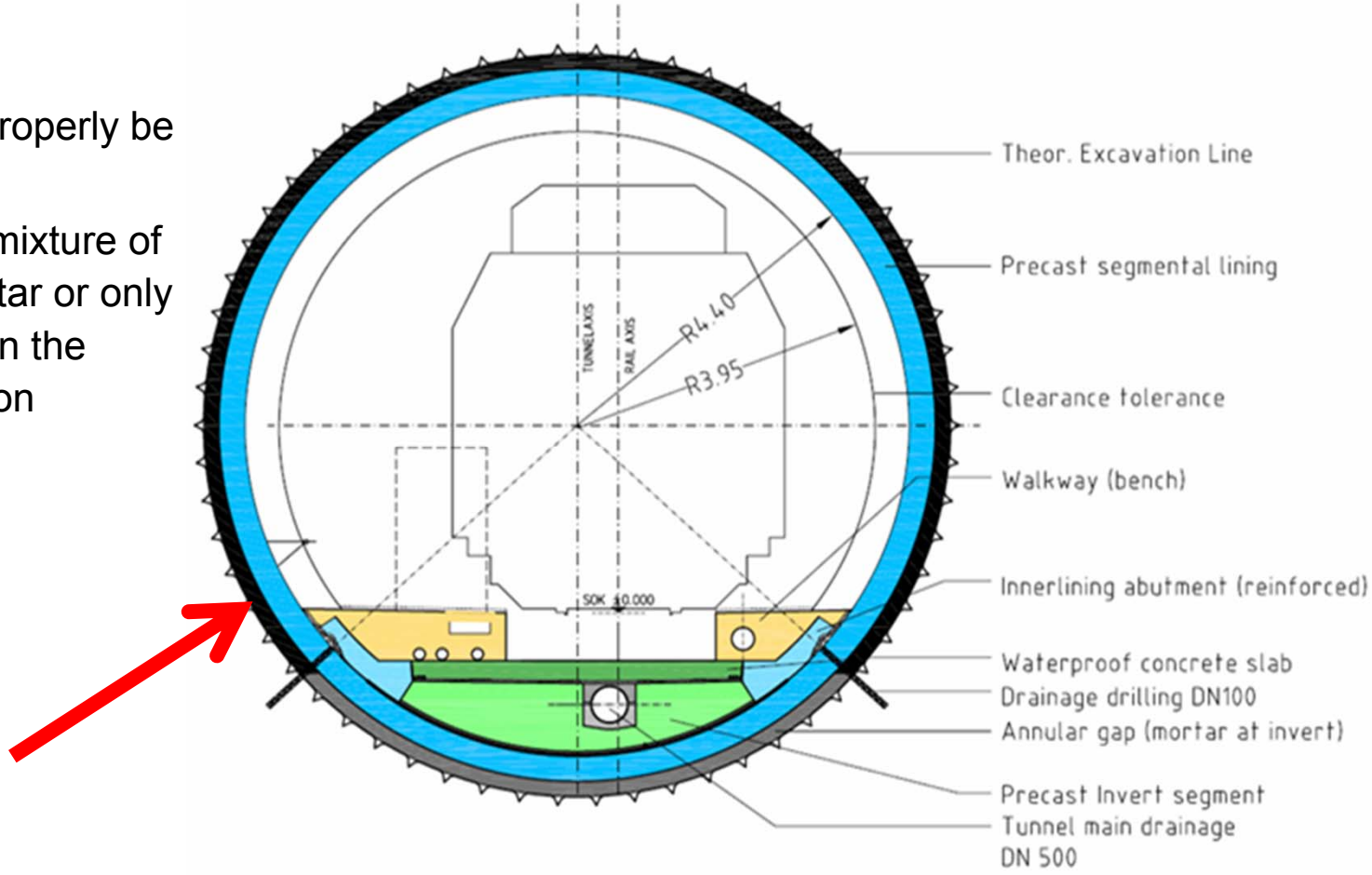
- Several grouting campaigns (silica foam and cement grouting)
- glas fibre self drilling anchors through the cutterhead
- extra boreholes drilled through the segmental lining
- Stand-still over several weeks
- Single-shield modus



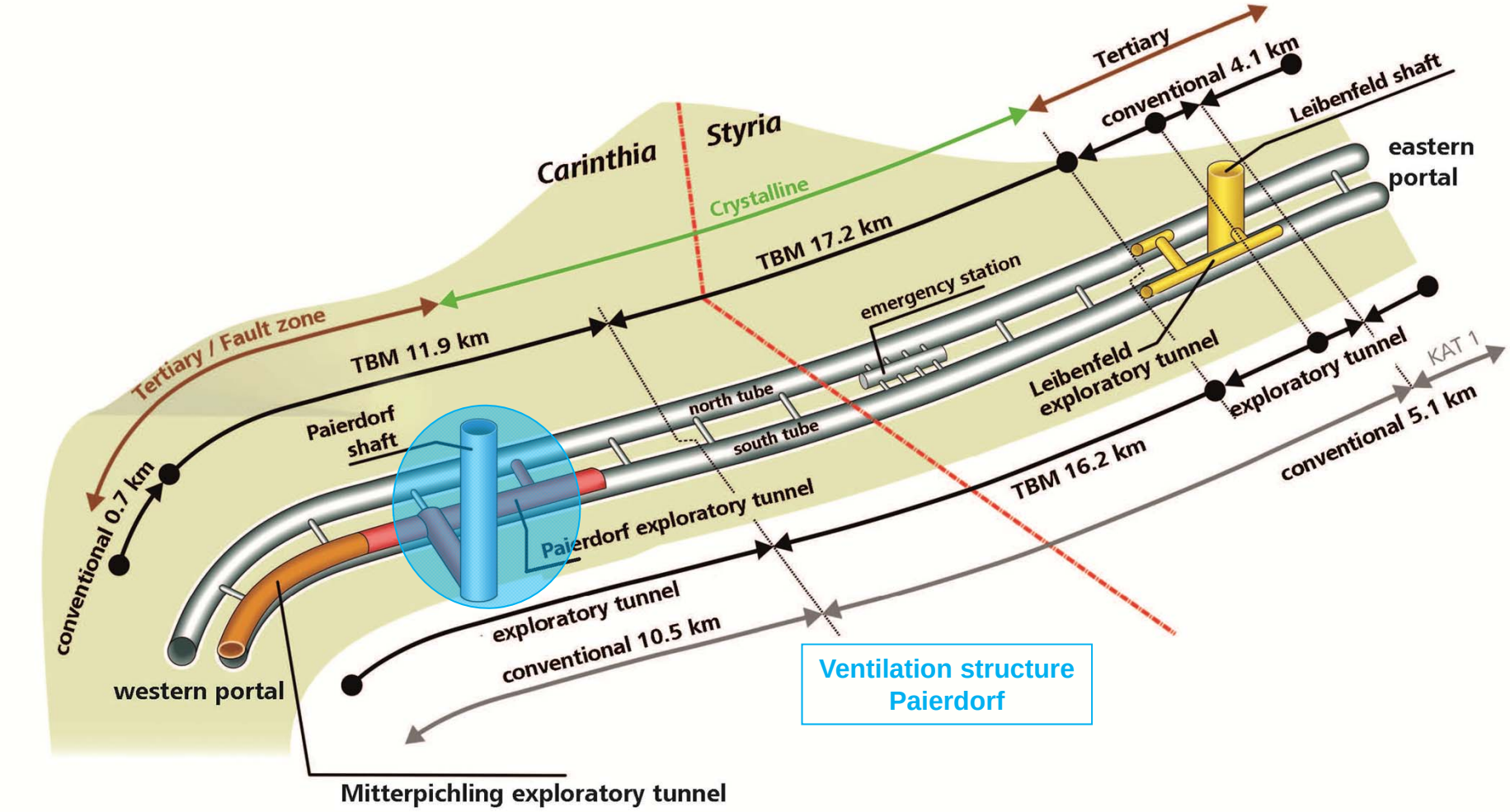
TBM excavation KAT 2

Friable rock mass – annular gap backfilling

- Annular gap must properly be backfilled
- Use of pea gravel, mixture of pea gravel and mortar or only mortar depending on the geotechnical situation



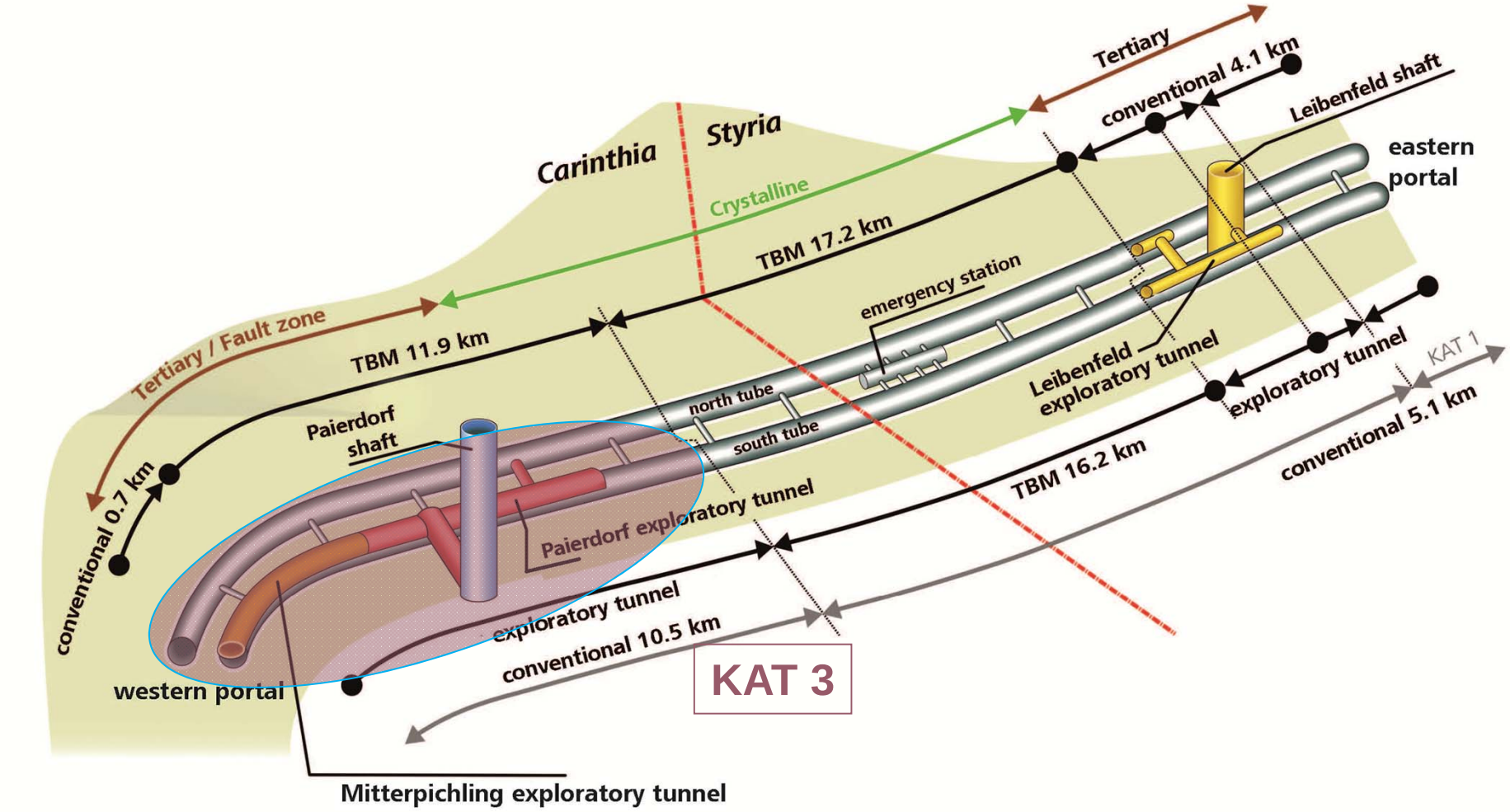
Koralm Tunnel – Ventilation structure Paierdorf



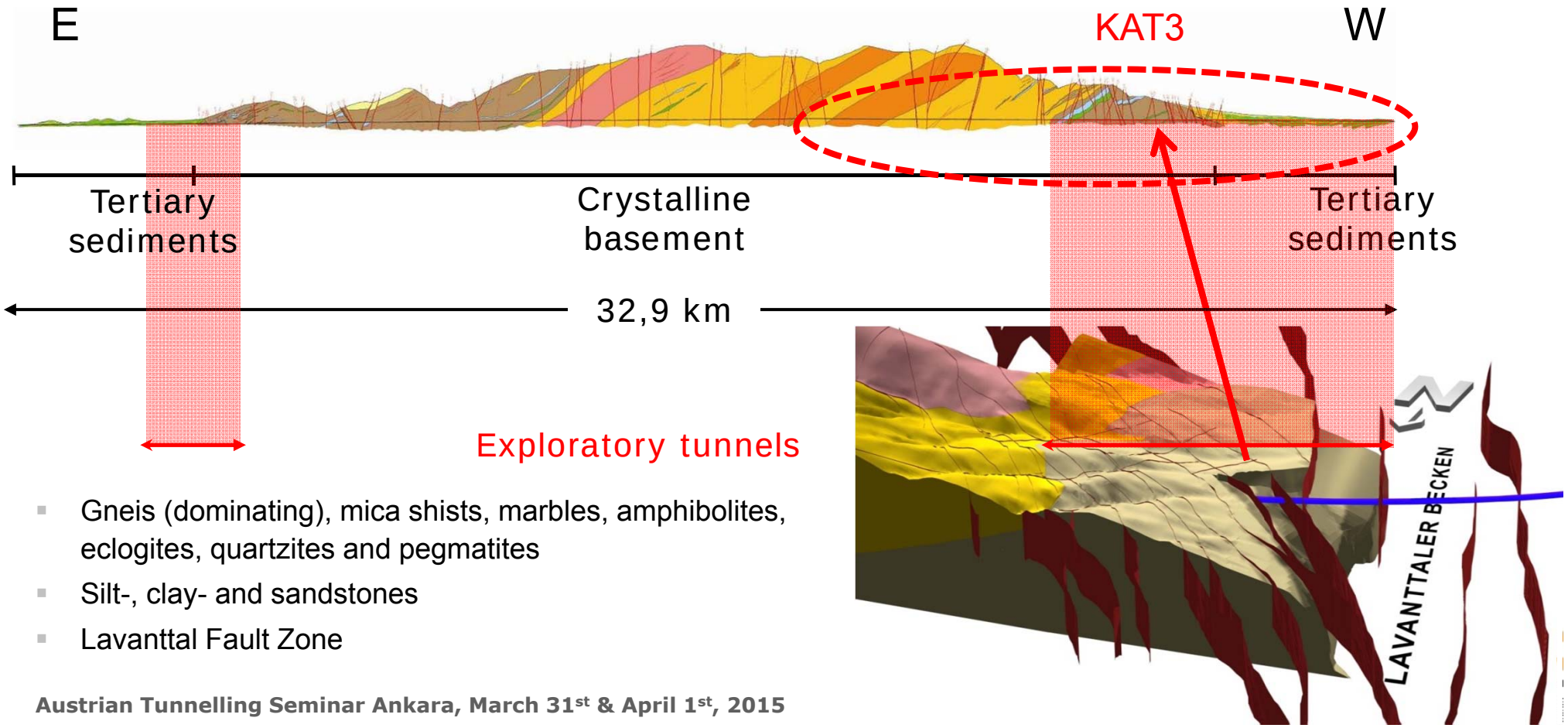
Koralm Tunnel - Ventilation structure Paierdorf

- Additional lot situated within Lot KAT 3
- Inner lining in the 120 m deep ventilation shaft Paierdorf
- Ventilation tunnel (100 m)
- Entry cavern and expanded cross section for the shield maschine of Lot KAT 3
- Contractor Wayss & Freytag
- Contract worth < 10 Mio Euro
- Works are finished

Koralm Tunnel – contract section KAT 3



Geological framework KAT 3



- Gneis (dominating), mica shists, marbles, amphibolites, eclogites, quartzites and pegmatites
- Silt-, clay- and sandstones
- Lavanttal Fault Zone

Koralm Tunnel – Lot KAT 3

- Construction started January 2014
- Southern tube: Enlargement to full profile (7.8 km) of top heading from the exploratory tunnel plus 2.7 km of full profile excavation
- Northern tube: shield machine with earth pressure components with conversion into a single shield TBM (11.9 km)

Koralm Tunnel – Lot KAT 3

- Sequential (NATM) and continuous (TBM-DS) tunnel drives
- Contractor Porr
- Contract worth 297 Mio. €

Conclusion

- A stepwise investigation and design process is required, especially for TBM tunnelling
- Investigation and design, which considers specific ground parameter and behavior is essential for TBM-, excavation and support design
- Consequent investigation ahead of excavation is indispensable for TBM tunnelling
- Competent staff on site and good workmanship is needed

Conclusion

- Logistics influences directly the advance rates of TBM tunnelling - weak links in the chain must be detected and eliminated
- Flexibility is one major advantage of NATM, in particular in case of special situations with high deformation rates, low overburden
- Treatment and improvement of ground conditions from TBM is difficult and time comsuming


Thanks for your attention!