


**ISE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr.techn. Robert Galler

**NATM – New Austrian Tunnelling Method**

**Keystones for successful tunnelling**

WKO  
 Sao Paulo, 16<sup>th</sup> May 2014




**Robert Galler** Head of ITA CET Communication Education Training Steering Committee  
 Representative of ITA Austria  
 Head of Chair of Geotechnics and Underground Constructions  
 Professor for Subsurface Engineering, MONTANUNIVERSITAET Leoben

**ISE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr.techn. Robert Galler

**Some examples of actual projects first**

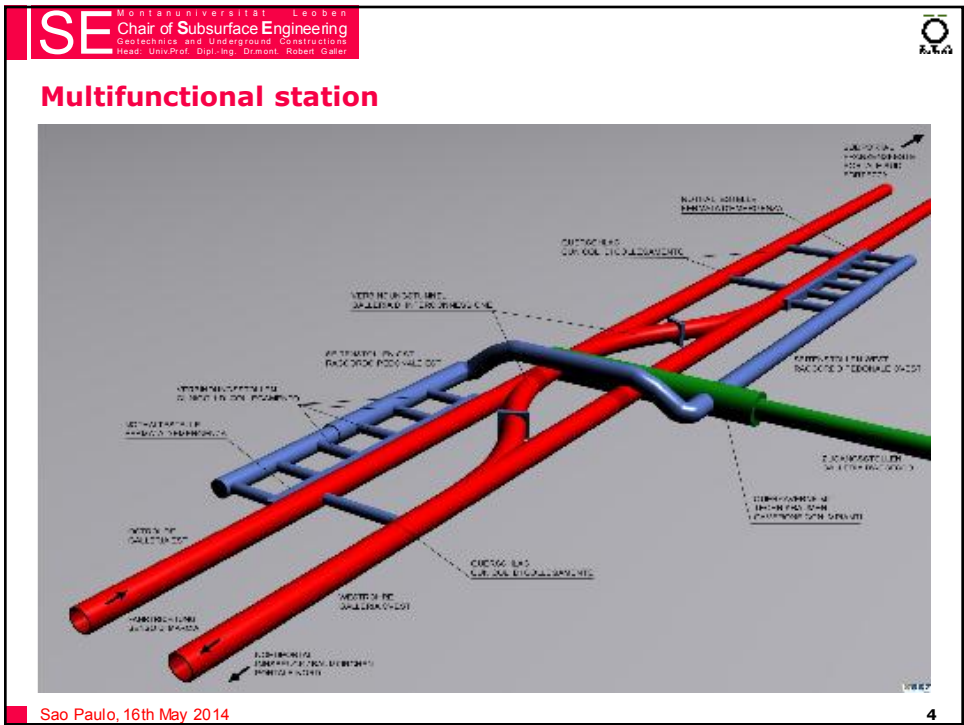
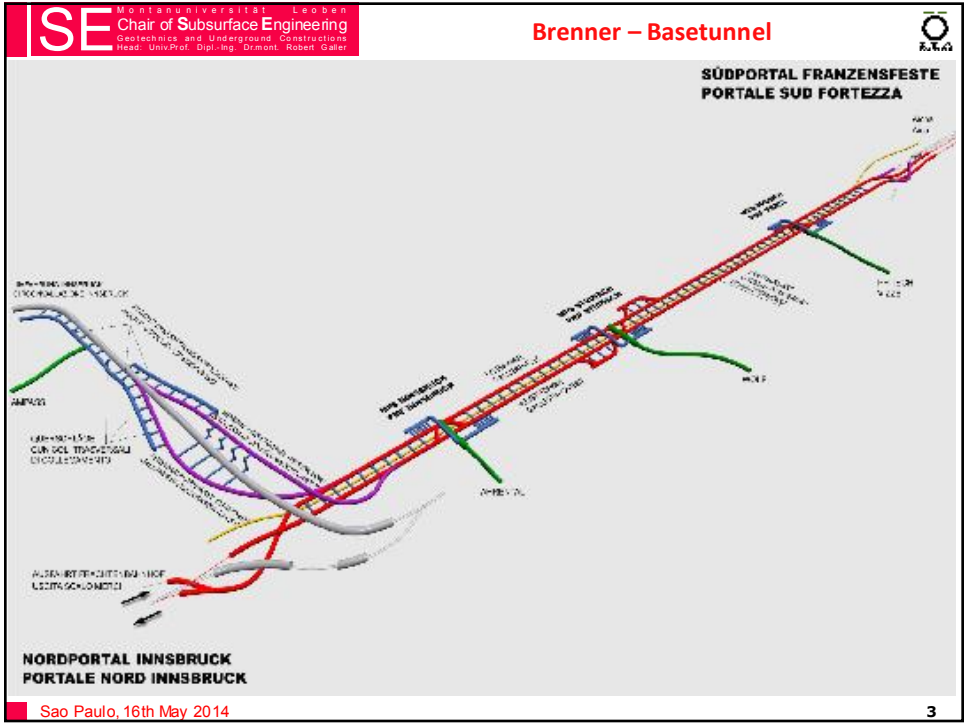
**TEN 1  
 Trans European  
 Network Nr. 1:**

**including  
 Brenner –  
 Basetunnel**



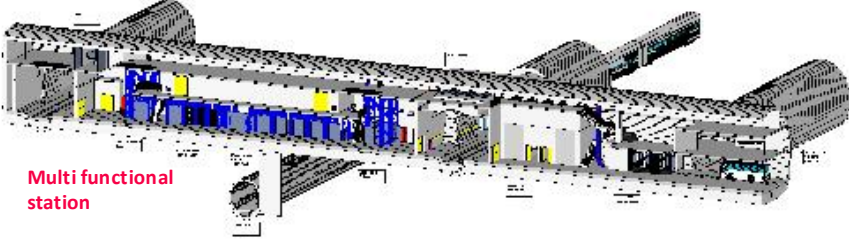
Sao Paulo, 16th May 2014

2

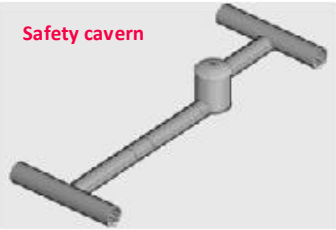


SE Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Galer

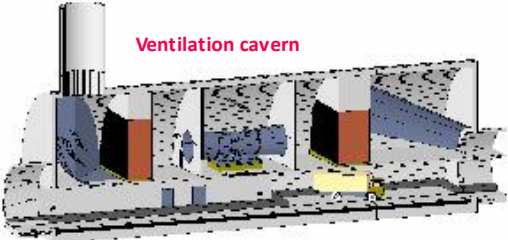
Complex structures



Multi functional station



Safety cavern



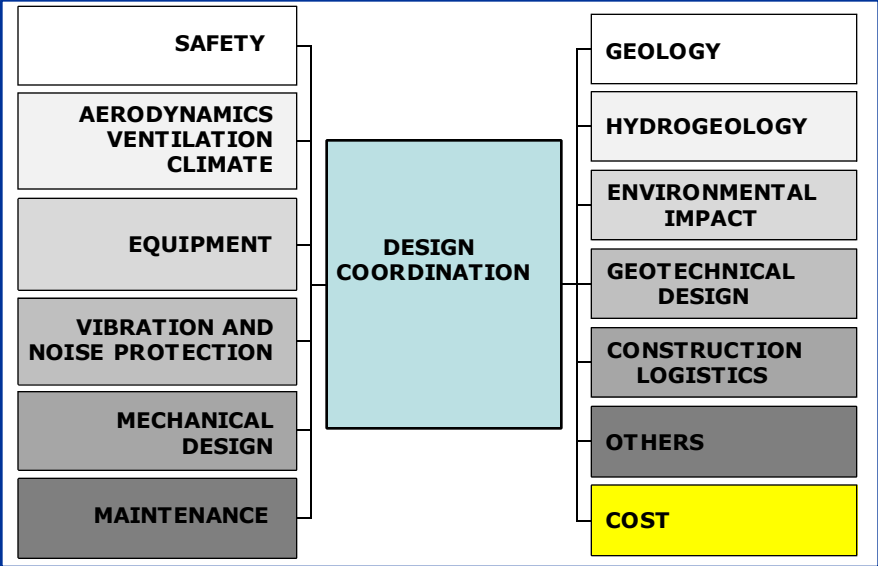
Ventilation cavern

Sao Paulo, 16th May 2014

5

SE Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Galer

Fields to be considered



SAFETY

AERODYNAMICS  
VENTILATION  
CLIMATE

EQUIPMENT

VIBRATION AND  
NOISE PROTECTION

MECHANICAL  
DESIGN

MAINTENANCE

DESIGN  
COORDINATION

GEOLOGY

HYDROGEOLOGY

ENVIRONMENTAL  
IMPACT

GEOTECHNICAL  
DESIGN

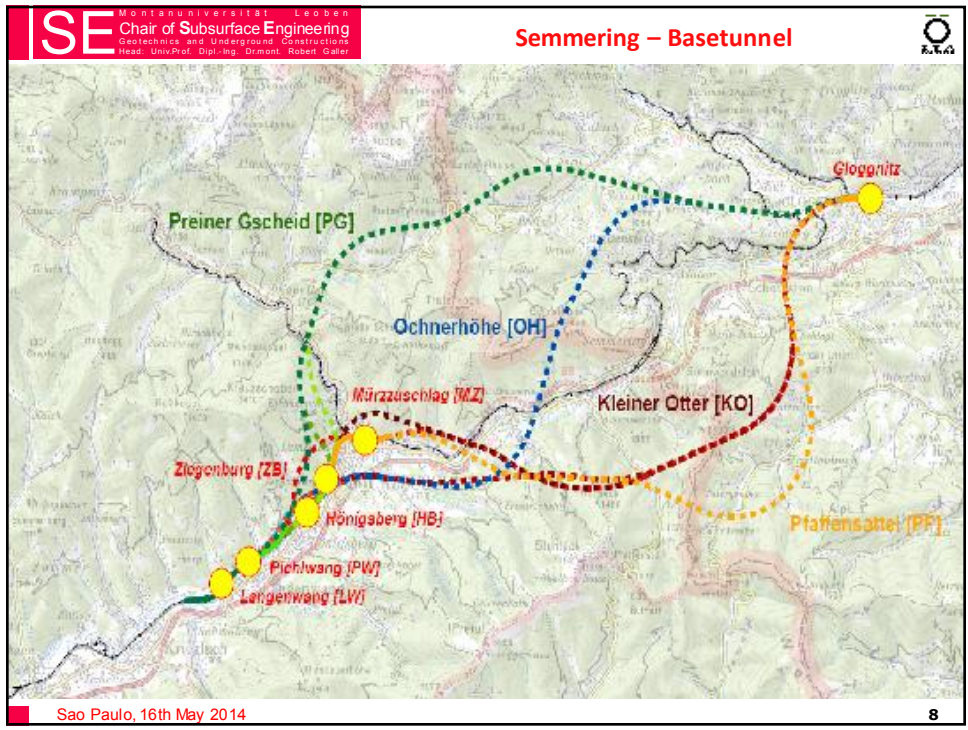
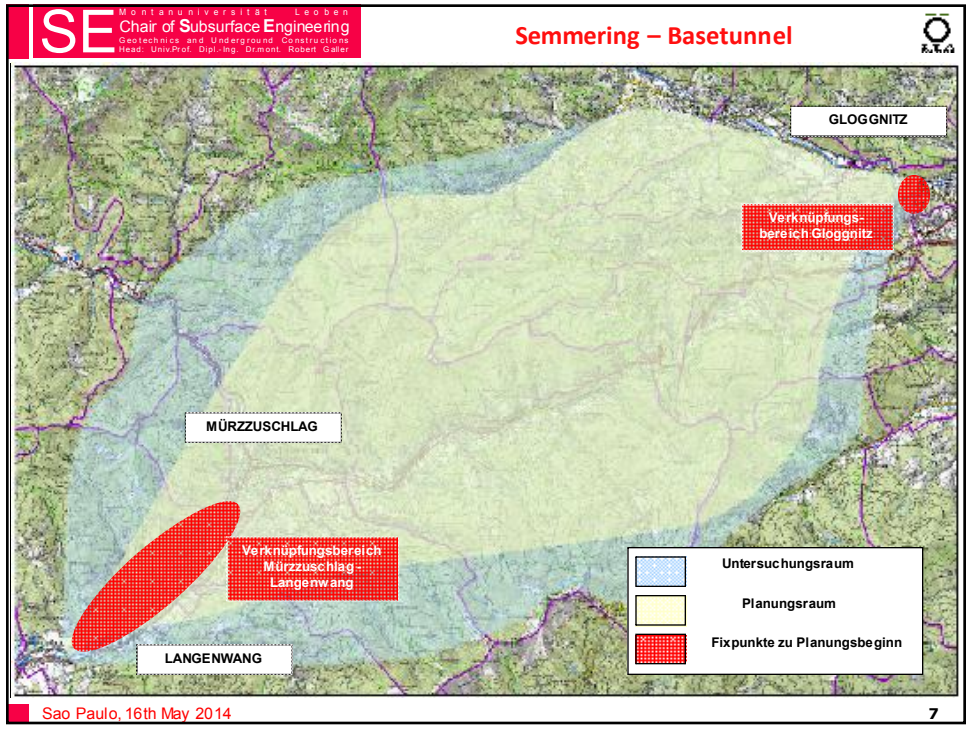
CONSTRUCTION  
LOGISTICS

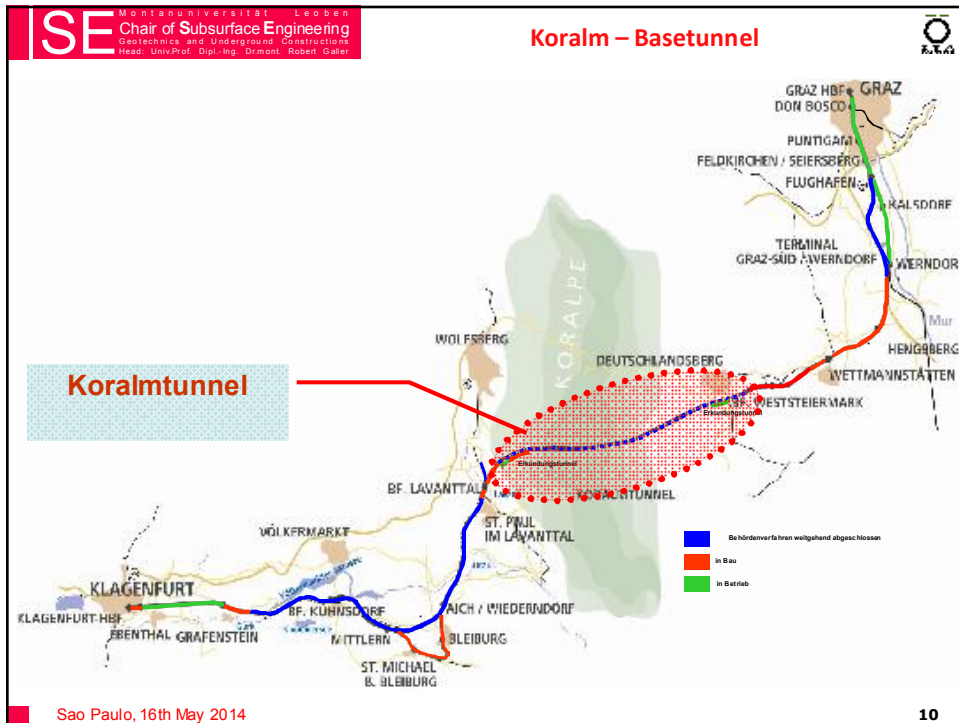
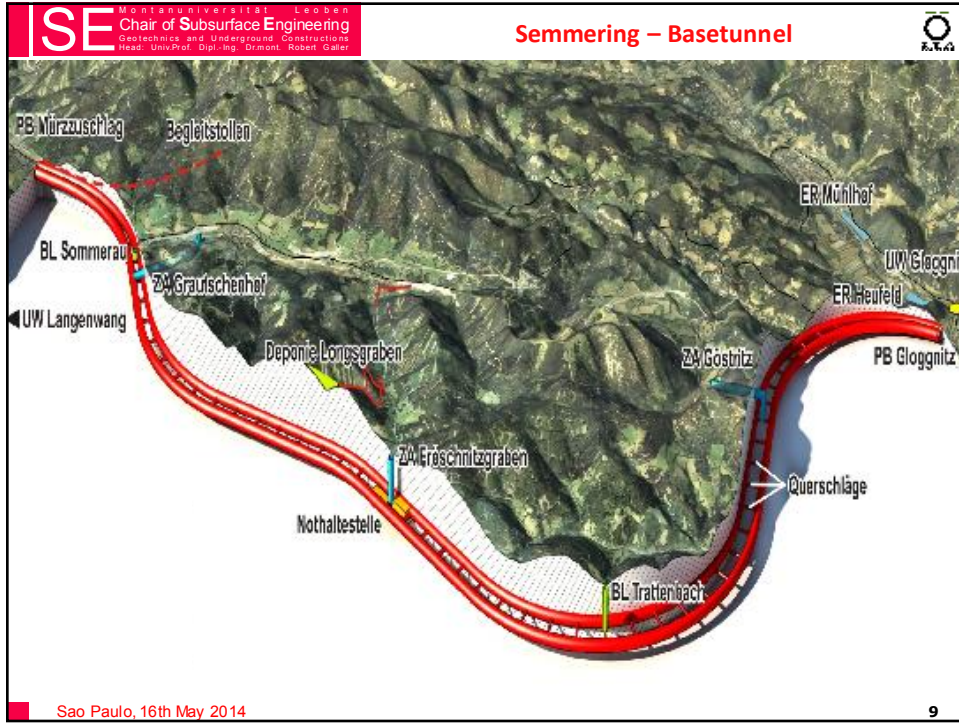
OTHERS

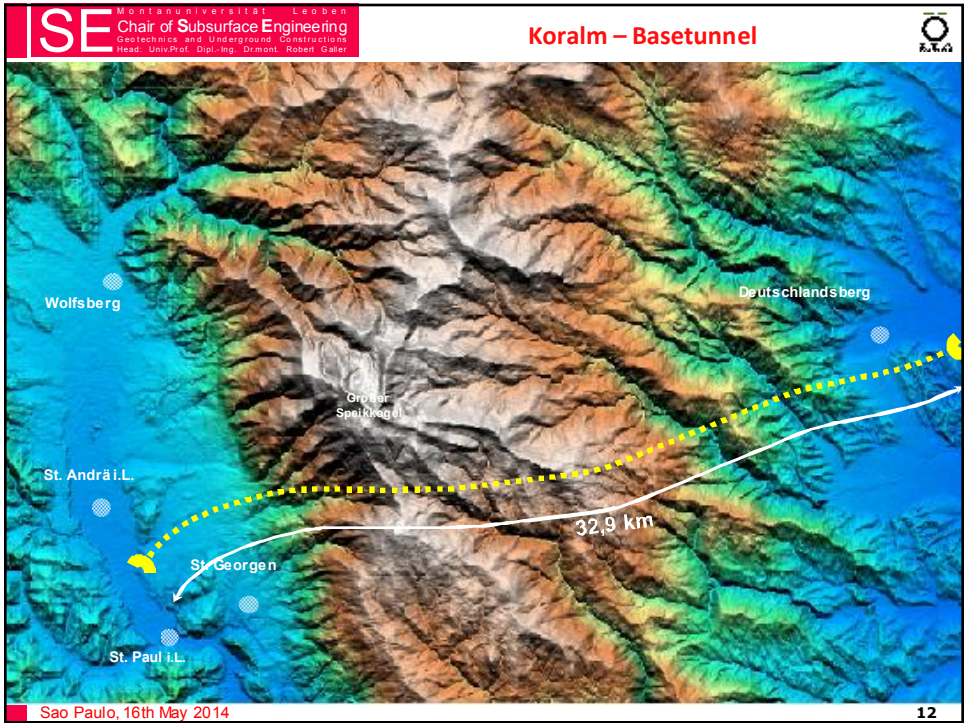
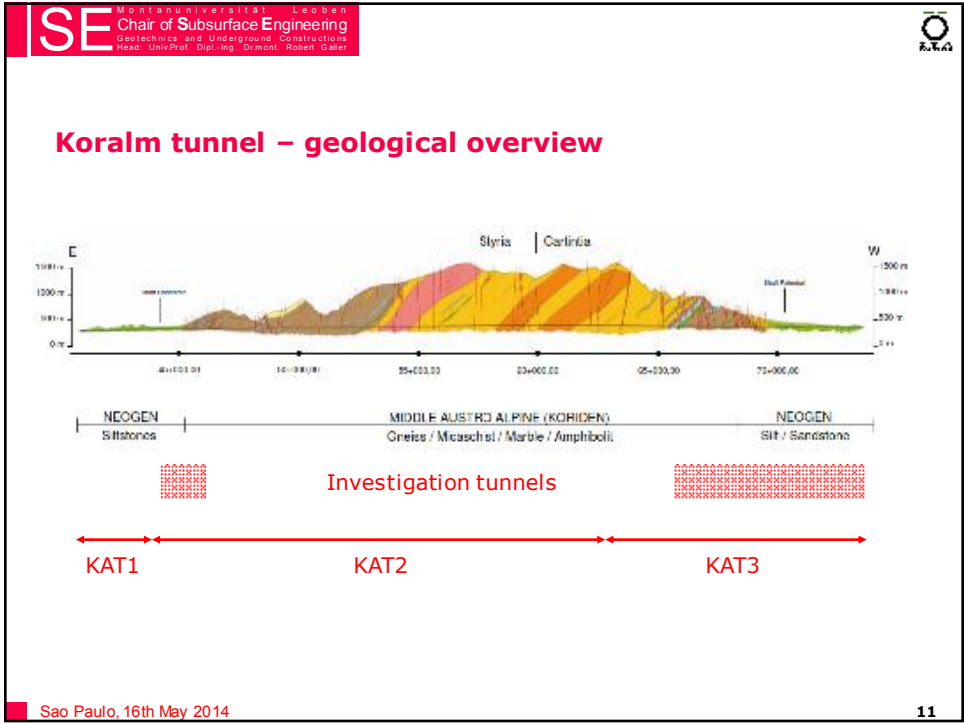
COST

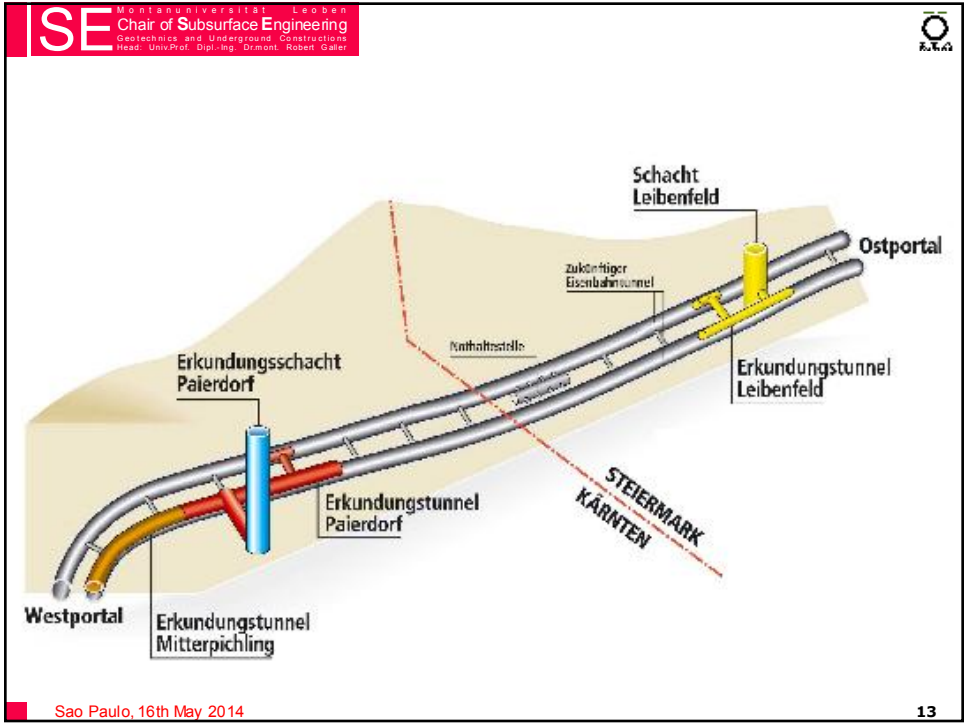
Sao Paulo, 16th May 2014

6





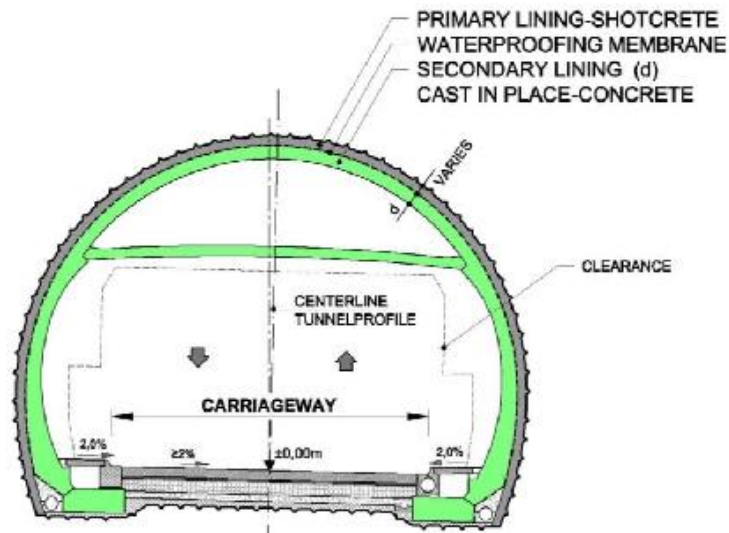




## Hard rock conditions – horse shoe shape

- The typical sequence for conventional excavation is subdivided into **top heading – bench – invert**.
- The top half of the tunnel cross section is excavated first, the **bench follows simultaneously a few hundred meters behind**. A ramp is maintained on one half side of the cross-section to enable access to the top heading.
- The **invert** is prepared at quite **some distance to the bench** excavation.
- An **invert arch is only** installed, where a **ring closure** is required by the prevailing rock conditions. The invert arch construction is also split into two halves to maintain access to the tunnel face at any time.

## Hard rock conditions – horse shoe shape



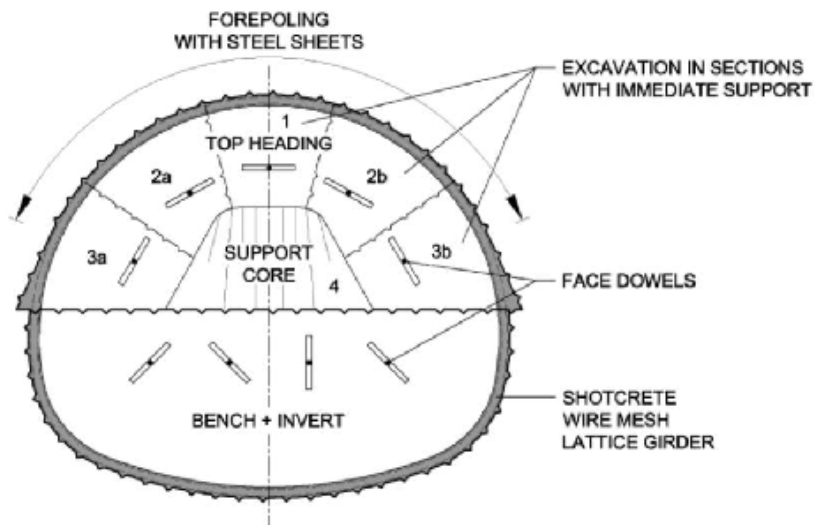


... and what about soft ground conditions?



Sao Paulo, 16th May 2014

Subway construction in soft ground



Sao Paulo, 16th May 2014

## Soft ground conditions

- Typically the length of **excavation rounds** in this example is **limited to 1.0 m** at a maximum and the **closure of the invert follows after 5.0 m**. The advance rate is restricted to 4.0 m in 24 hours to limit deformations of the young shotcrete primary lining.
- To allow excavation of a typically 60 m<sup>2</sup> double-track tunnel, the groundwater level is lowered by a system of external wells. The tunnel cross section is **excavated in small portions** when tunnelling in gravel which comprises flowing layers of soil.
- Massive **support of the excavation face** with shotcrete and face anchors or even ground treatment by grouting ahead of the face is occasionally required to provide safe tunnelling conditions.




**ISE** Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Galer



# Self-drilling anchors and rock bolts in underground construction

**Wolfgang Dolsak**

DYWIDAG-SYSTEMS  
INTERNATIONAL 

Sao Paulo, 16th May 2014

**ISE** Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Galer





Sao Paulo, 16th May 2014

22

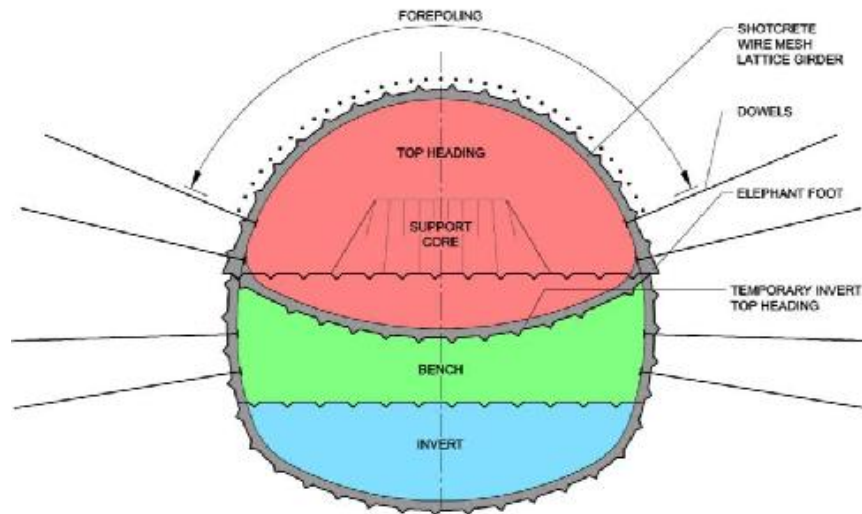
### Installation of a pipe roof



Sao Paulo, 16th May 2014

23

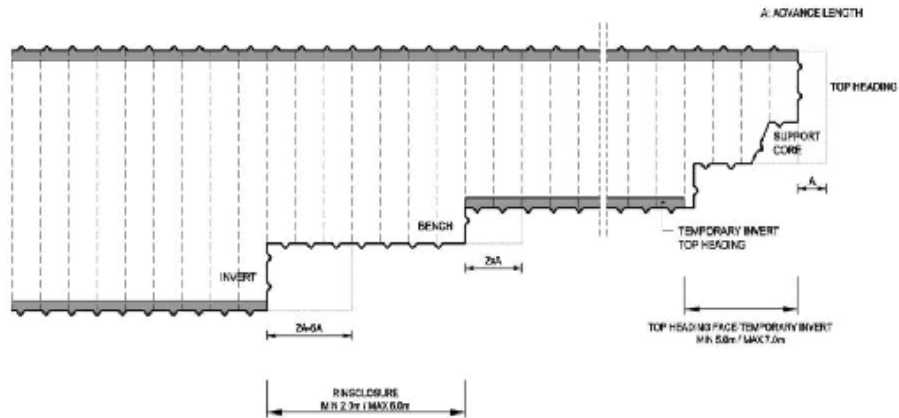
### Excavation sequence



Sao Paulo, 16th May 2014

24

## Excavation sequence



## Advanced Forepoling Systems

Karl Böhm

DYWIDAG-SYSTEMS  
INTERNATIONAL

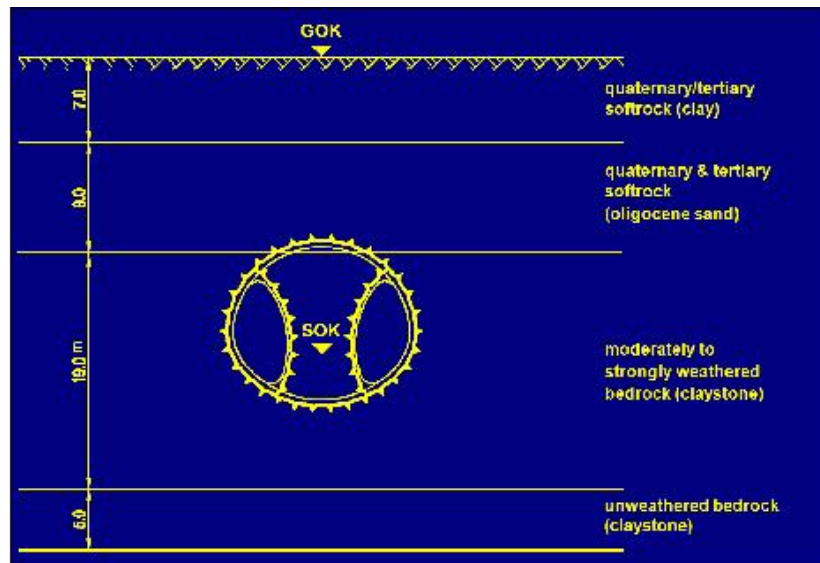


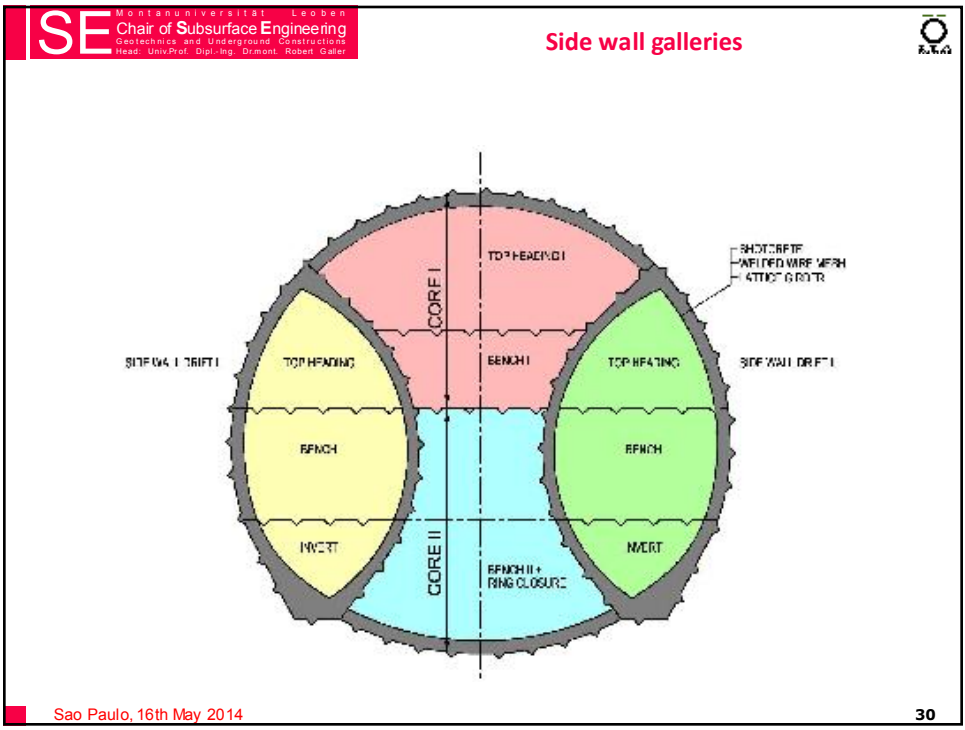
### Section south



- Undercrossing of BAB A3 Frankfurt – Köln
- Length: about 300 m
- Minimal overburden: 10 m

### Geological cross section





**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer

### Side drifts and core / excavation sequence

Sao Paulo, 16th May 2014

31

**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer

### Excavation sequence

SIDE WALL DRIFT I  
 SIDE WALL DRIFT II  
 CORE I  
 CORE II

cross section A-A  
 cross section B-B  
 cross section C-C  
 cross section D-D  
 cross section E-E

Sao Paulo, 16th May 2014

32





Sao Paulo, 16th May 2014

## How to handle Risk in NATM Tunnelling

Johann Golser



**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Gailer

**Monitoring**

**Extensometers**

**3D-displacement-targets**

**Measuring anchors**

**Strainmeters**  
**Pressure cells**

Sao Paulo, 16th May 2014

35

**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. mont. Robert Gailer

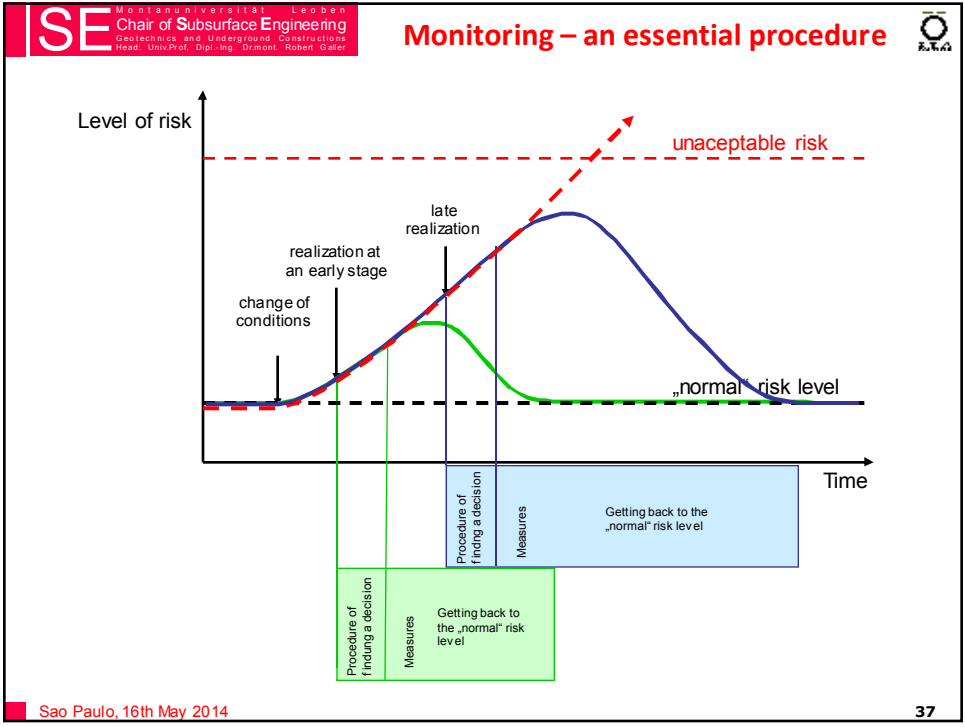
**Monitoring**

**Deformation monitoring  
of the tunnel face**

**ORTHOS Laser Tunnel Scanner**  
**Mobile platforms - Tripod solution**

Sao Paulo, 16th May 2014

36



**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer

**High-precision NATM tunnelling through advanced surveying and monitoring technology**

**Klaus Rabensteiner**

**GEODATA**  
We turn data into information.

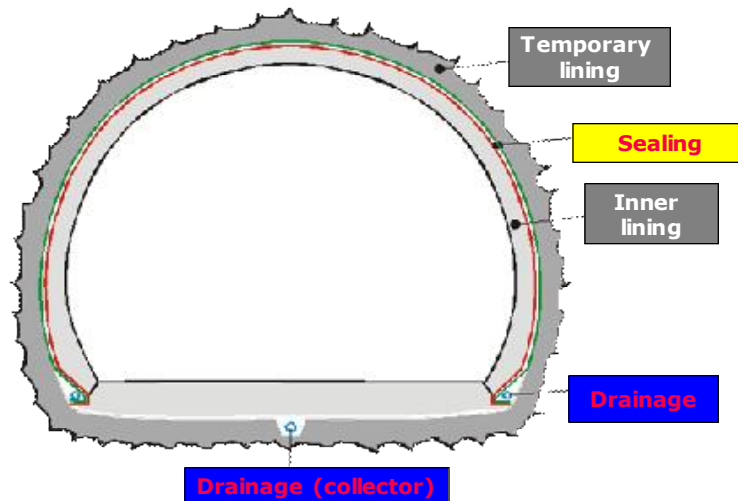
Sao Paulo, 16th May 2014



[Exploration Tunnel Fiecht]

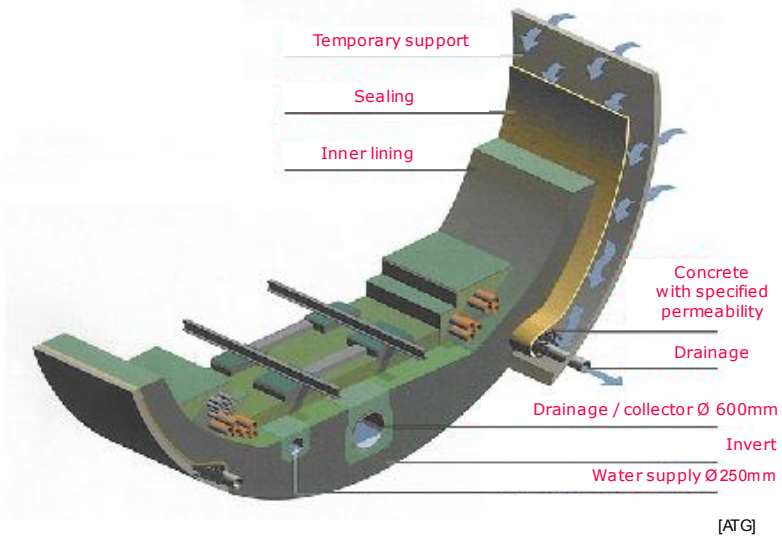
Sao Paulo, 16th May 2014

### Drained tunnels

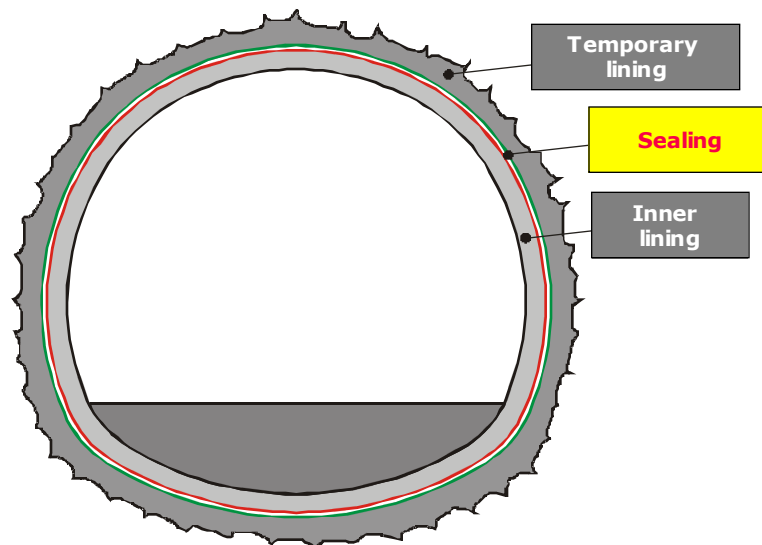


Sao Paulo, 16th May 2014

## Drained tunnels



## Fully tanked (watertight) construction



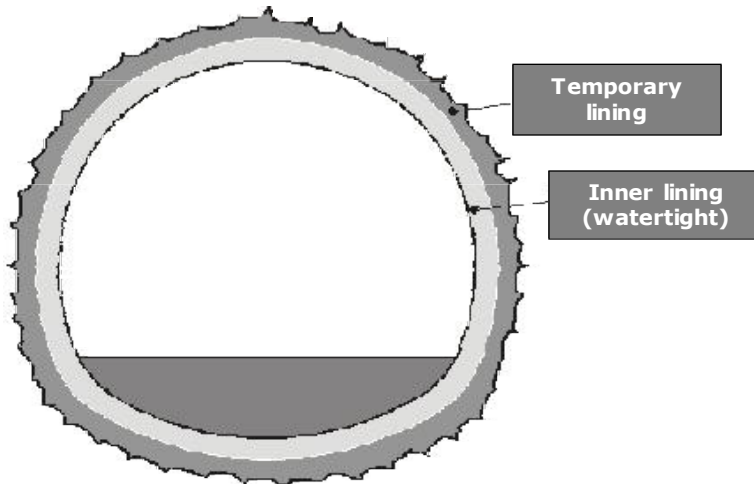
### Fully tanked (watertight) construction



Sao Paulo, 16th May 2014

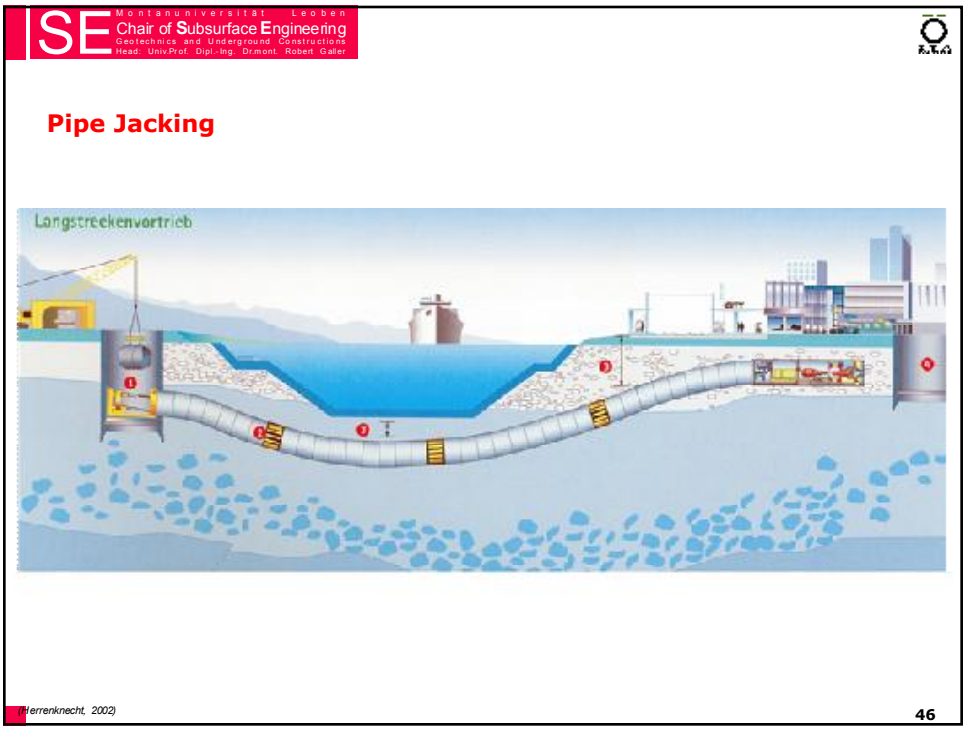
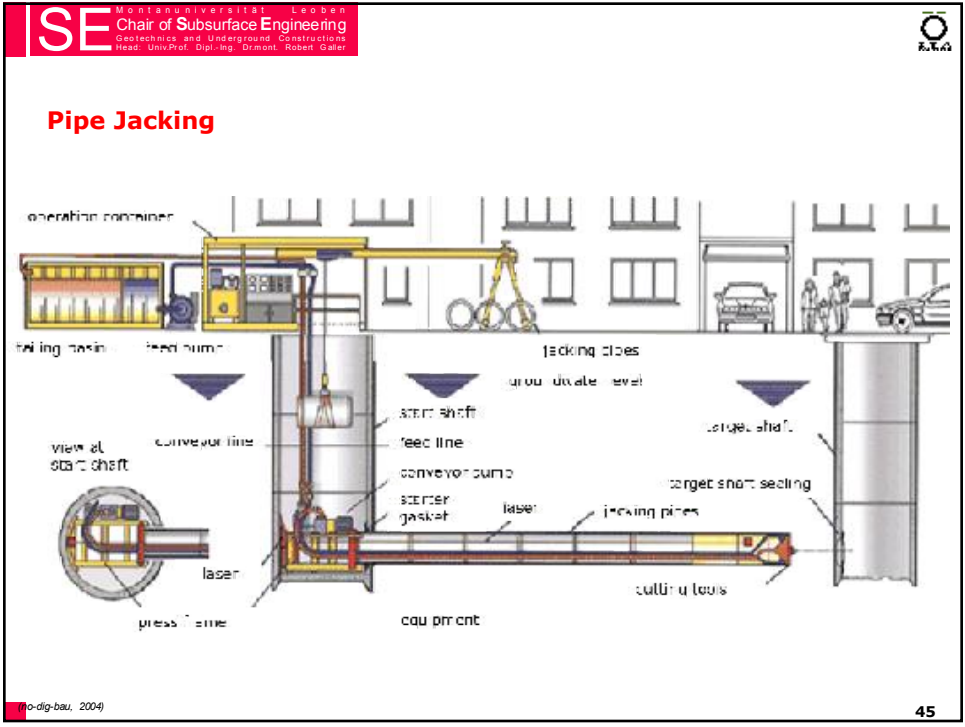
43

### Fully tanked (watertight) construction



Sao Paulo, 16th May 2014

44



## **HOBAS Big Diameter Pipe Jacking Projects Czajka and Burakowski**

**Barbara Prommegger,**

Sao Paulo, 16th May 2014

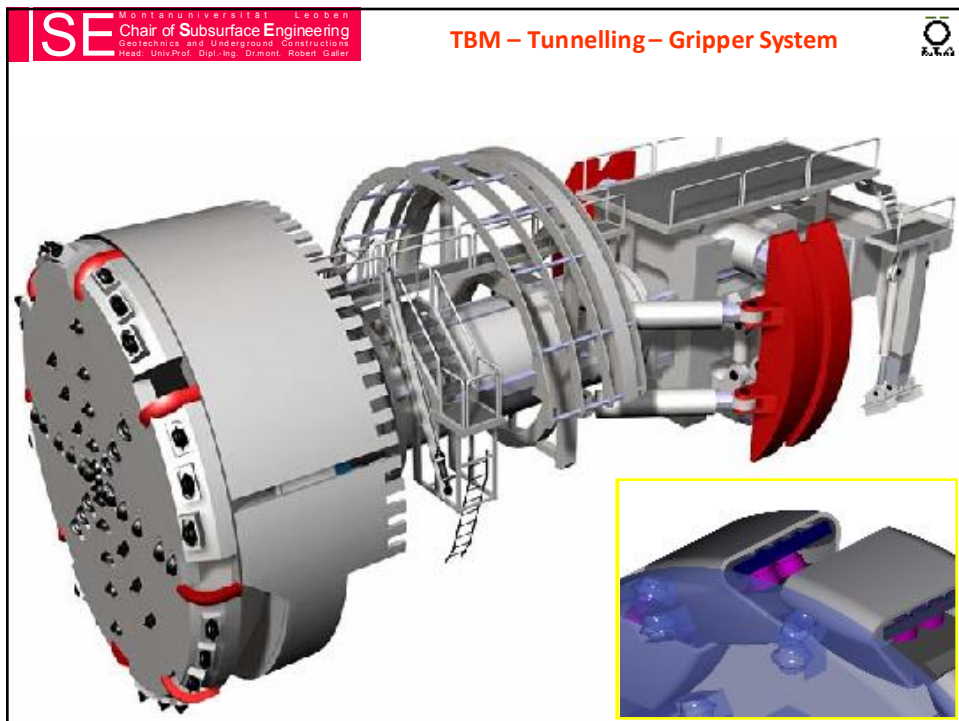
**... at the end some words to actual  
research projects**

Sao Paulo, 16th May 2014





TBM Tunnelling  
Tunnel Boring Machines




SE Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer

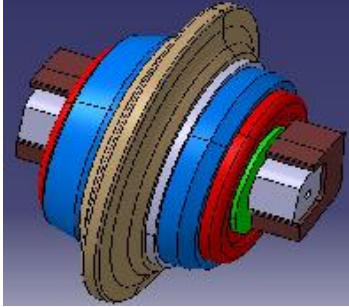
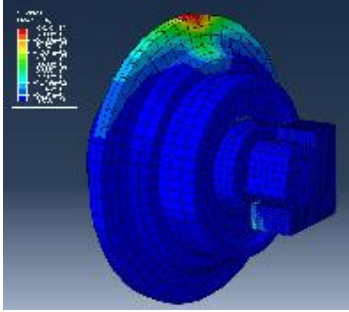
### TBM – Tunnelling – Gripper System

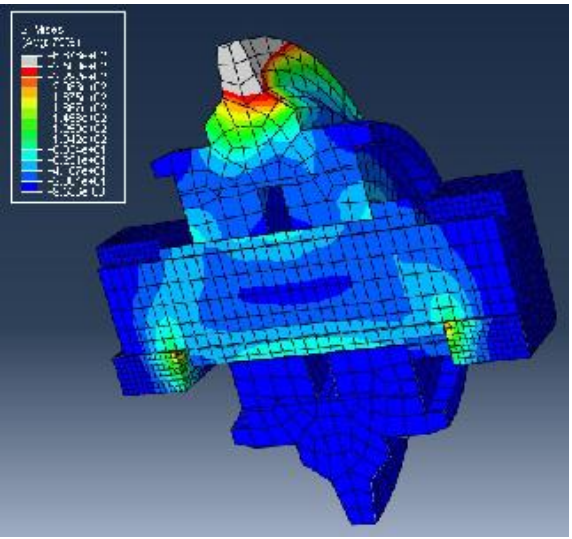


**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer




### Numerical Calculations and measurements regarding the cutting process

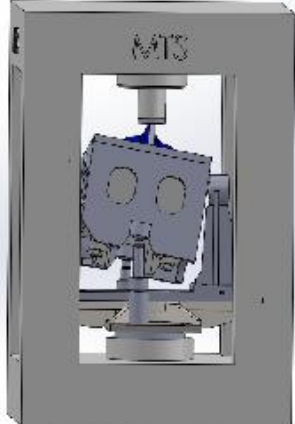






Sao Paulo, 16th May 2014
51

**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Galer

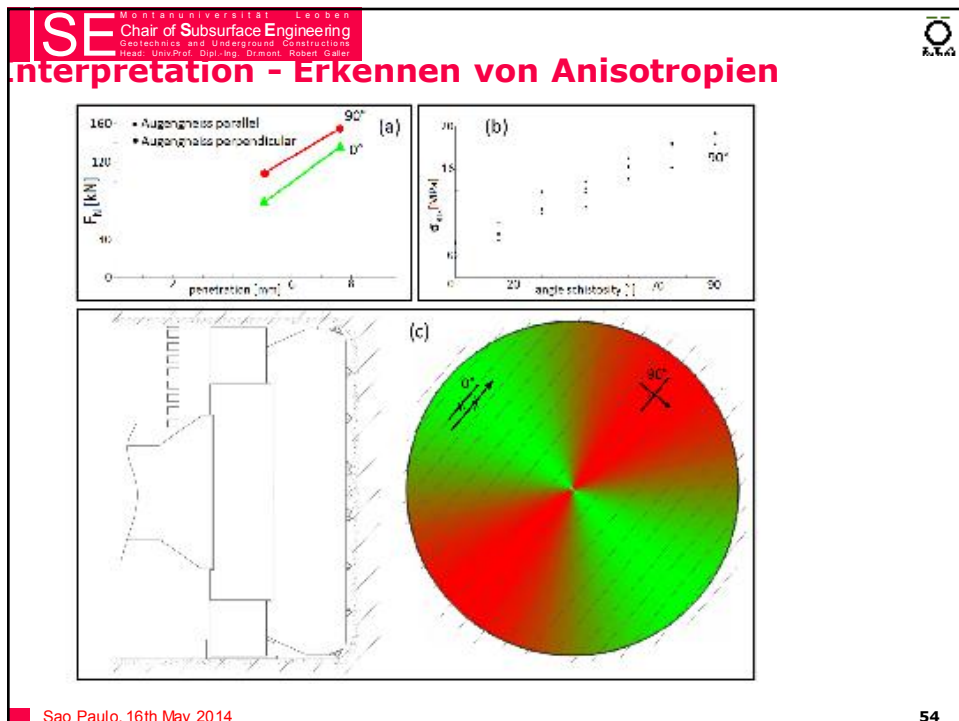


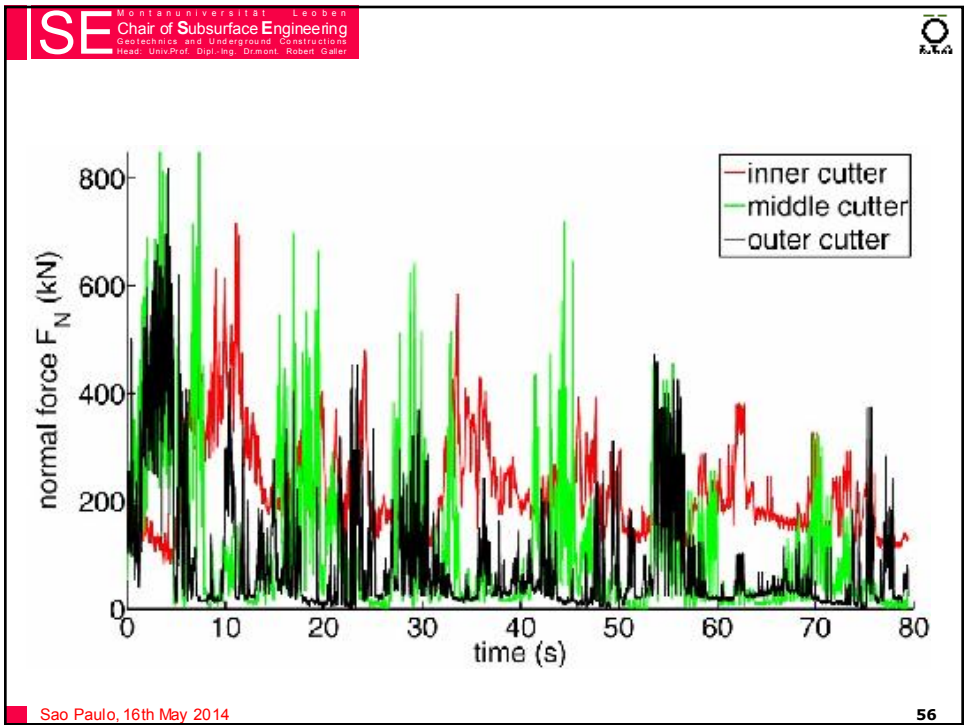
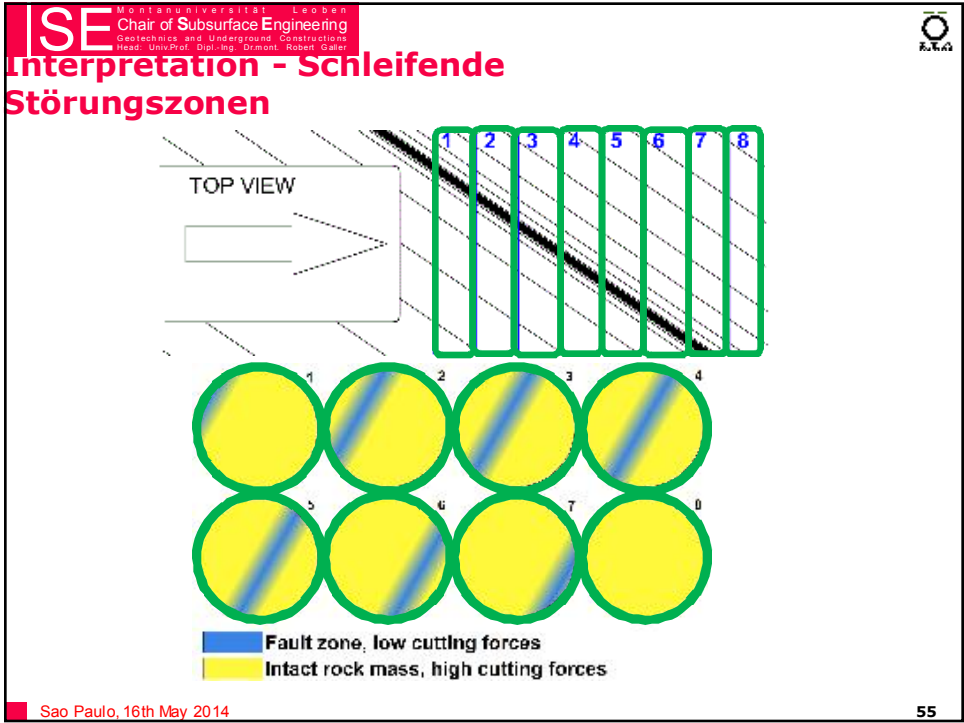


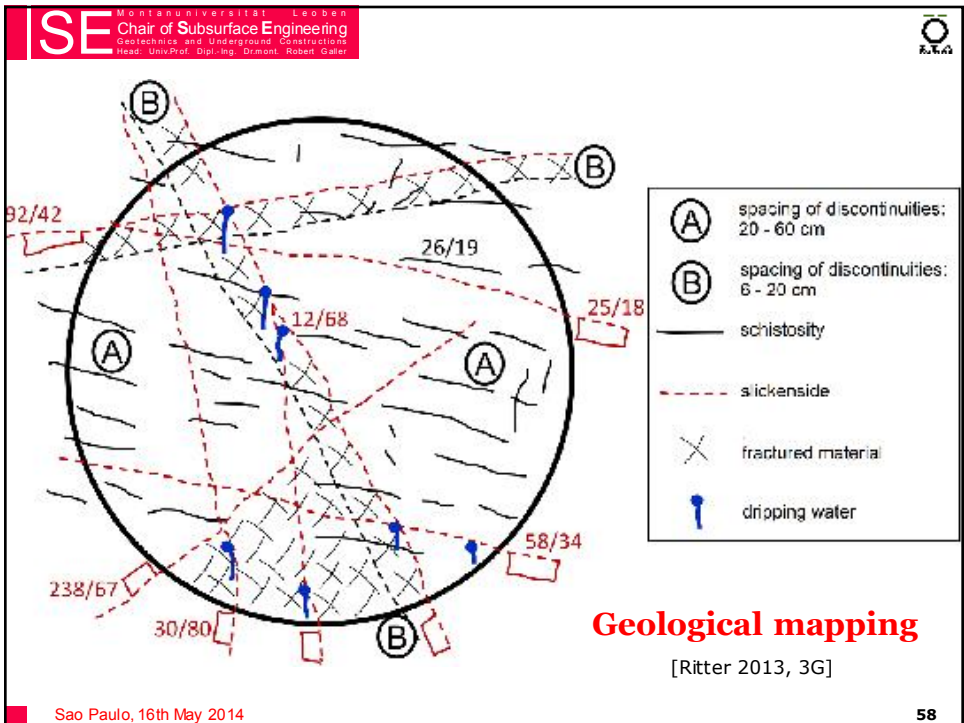
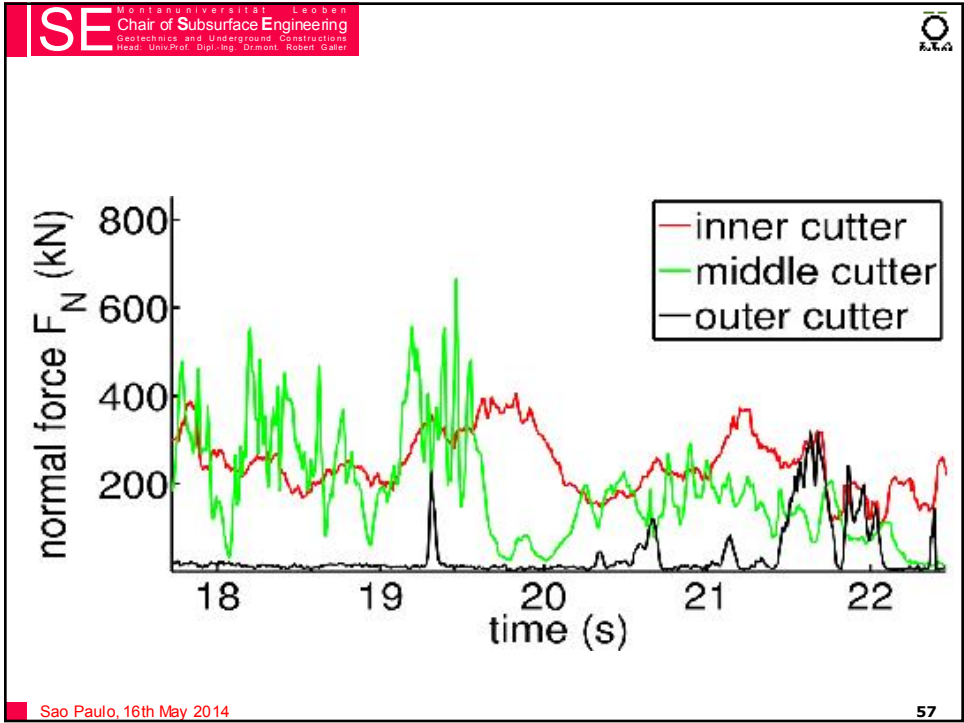
Konstruktion und Aufbau des neuen DCLM Prüfstand

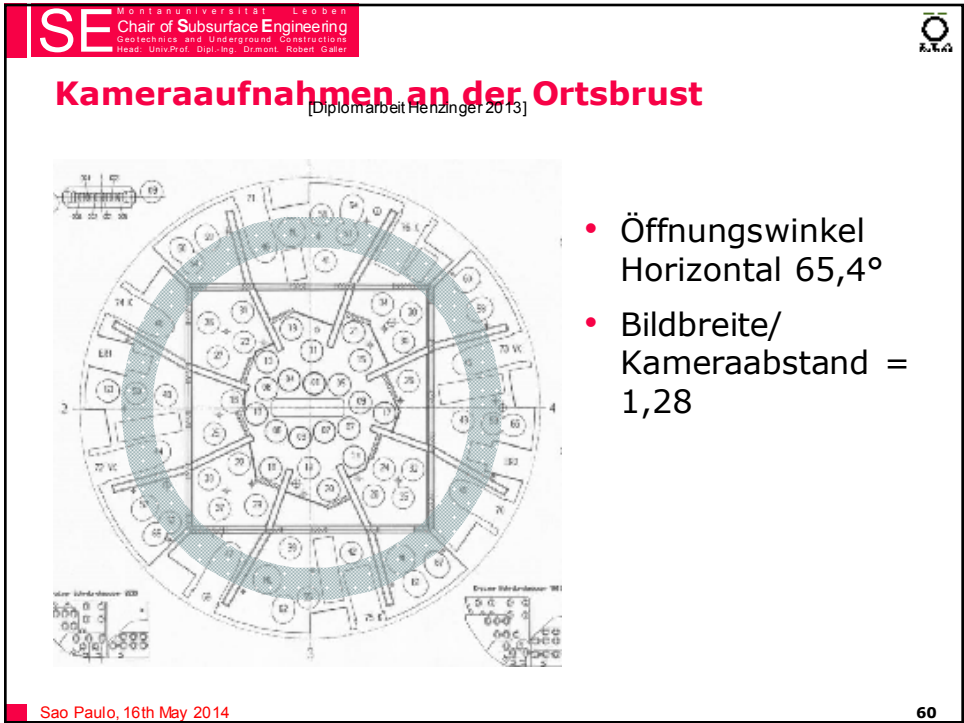
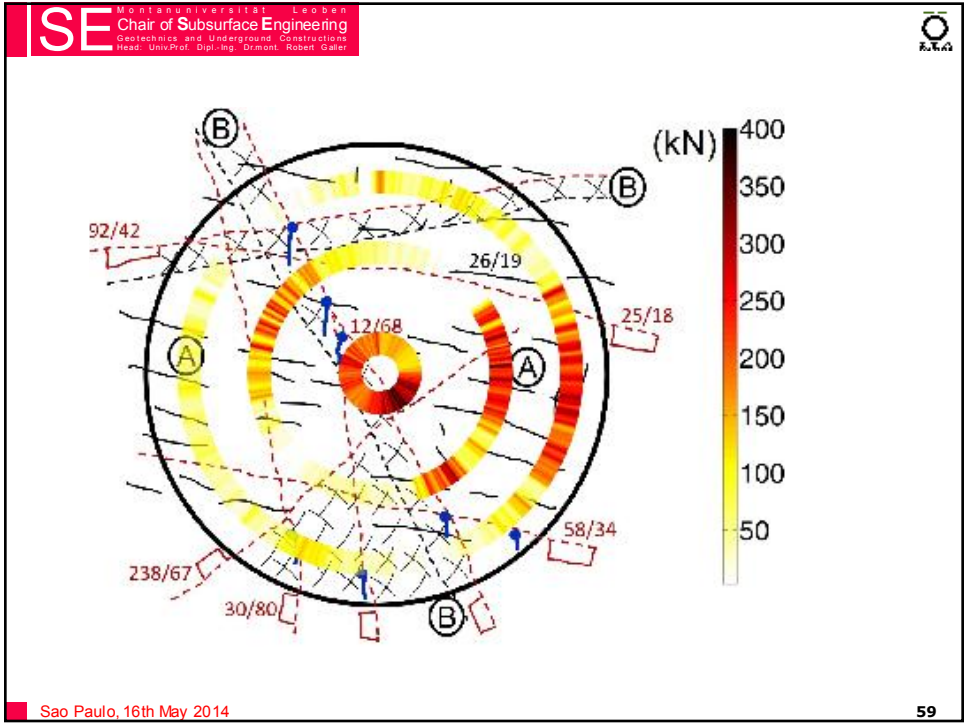


Sao Paulo, 16th May 2014
52









**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Gader

**Fotografische Aufnahme**

- Automatisch zusammenfügen
- Überlagerung ähnlicher Punkte

Sao Paulo, 16th May 2014 61

**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dipl.-Ing. Dr. rer. oec. Robert Gader

**Typische Ergebnisse**

Sao Paulo, 16th May 2014 62

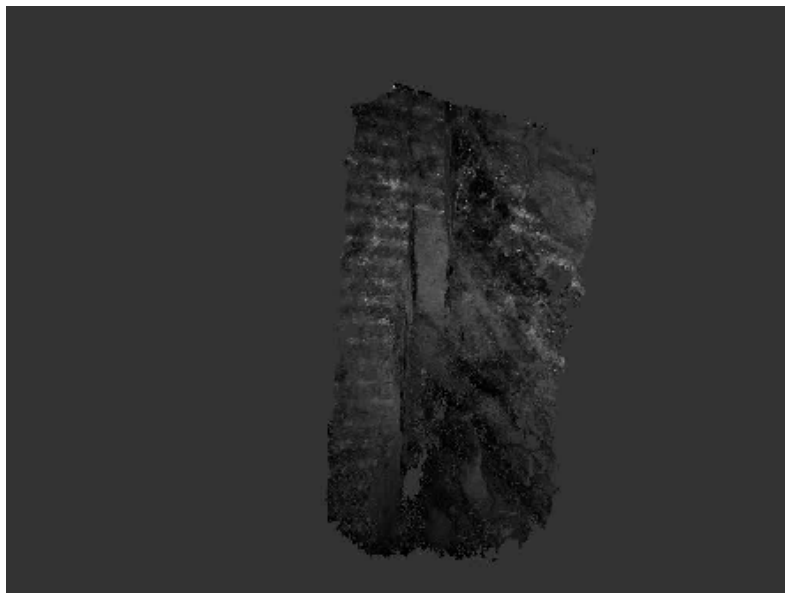
## Videoaufnahme



Sao Paulo, 16th May 2014

63

## Automated Face Mapping




Sao Paulo, 16th May 2014



64



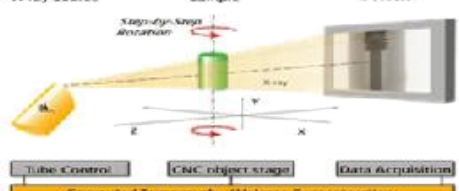
**SE** Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. Ingrid Zeman, Robert Gahr

### Geotechnical tests on highest standard



X ray Source
Sample
Detector



Sao Paulo, 16th May 2014
65

**SE** Montanuniversität Leoben  
Chair of Subsurface Engineering  
Geotechnics and Underground Constructions  
Head: Univ.-Prof. Dipl.-Ing. Dr. Ingrid Zeman, Robert Gahr

### Long term tests





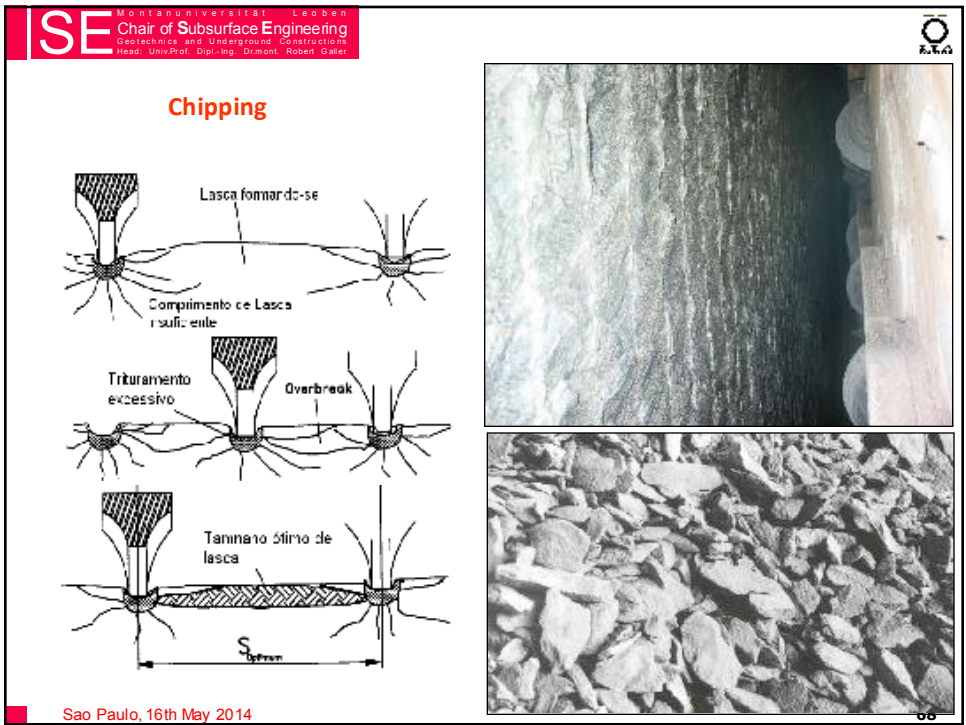
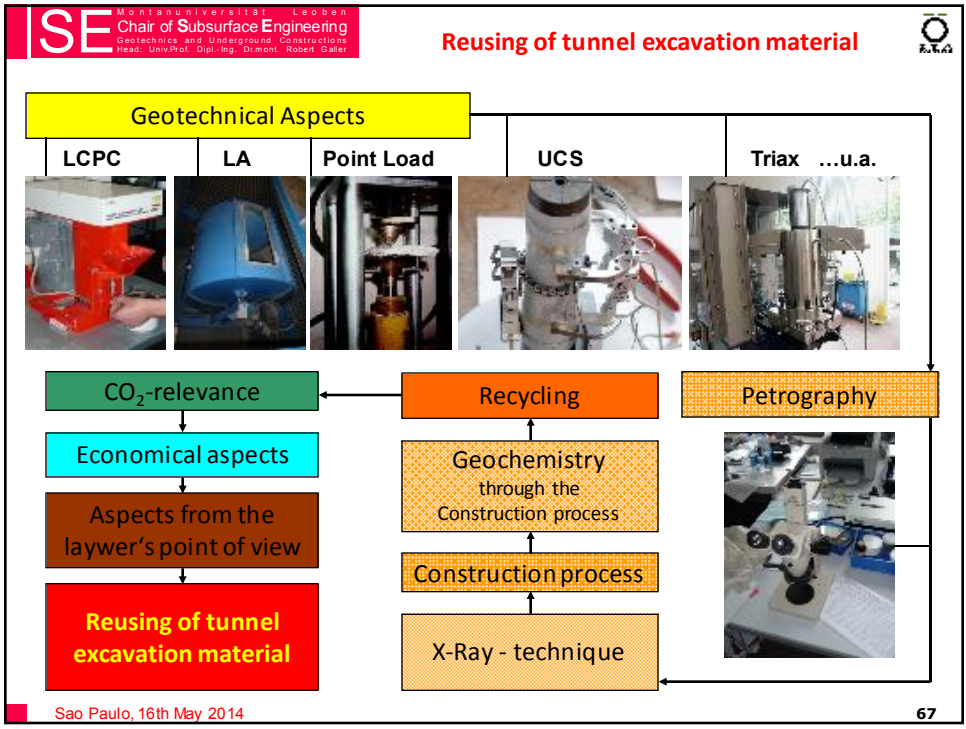

**Climatic cell**  
6m x 3m x 3m  
from -15°C to 80°C  
From 10% to 90% humidity

**Hydraulic aggregates**  
Up to 70 MPa  
→ 1000 kN force




**Long term testing equipment**

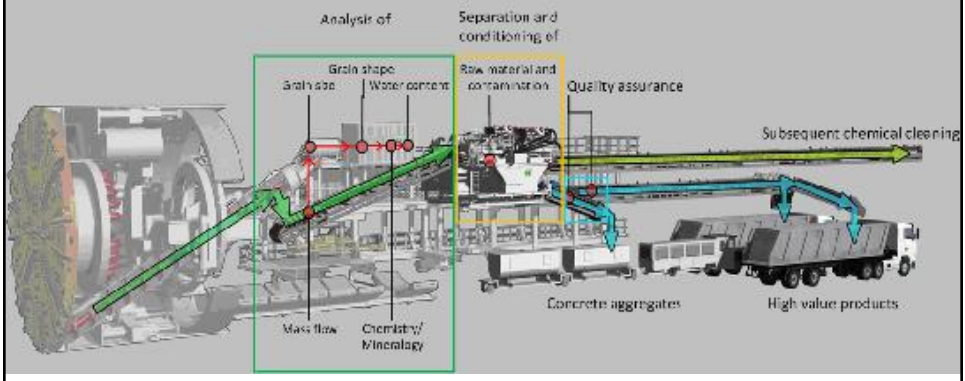
Sao Paulo, 16th May 2014
66



**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dr.-Ing. Dr.techn. Robert Gailer




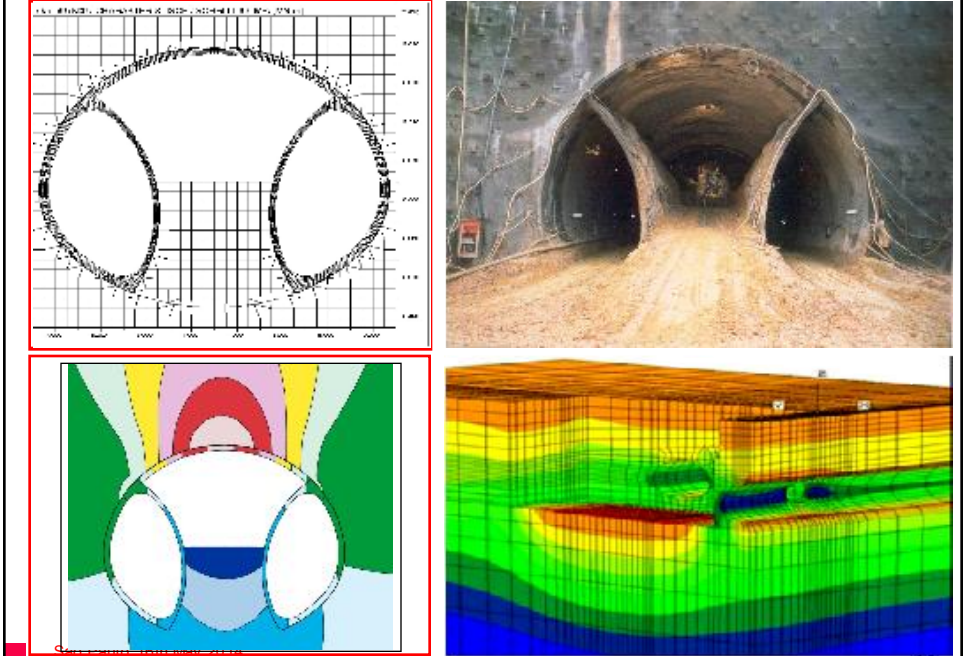
## DRAGON Concept



Sao Paulo, 16th May 2014 69

**SE** Montanuniversität Leoben  
 Chair of Subsurface Engineering  
 Geotechnics and Underground Constructions  
 Head: Univ.-Prof. Dr.-Ing. Dr.techn. Robert Gailer





Sao Paulo, 16th May 2014



**Thanks for your attention!**

