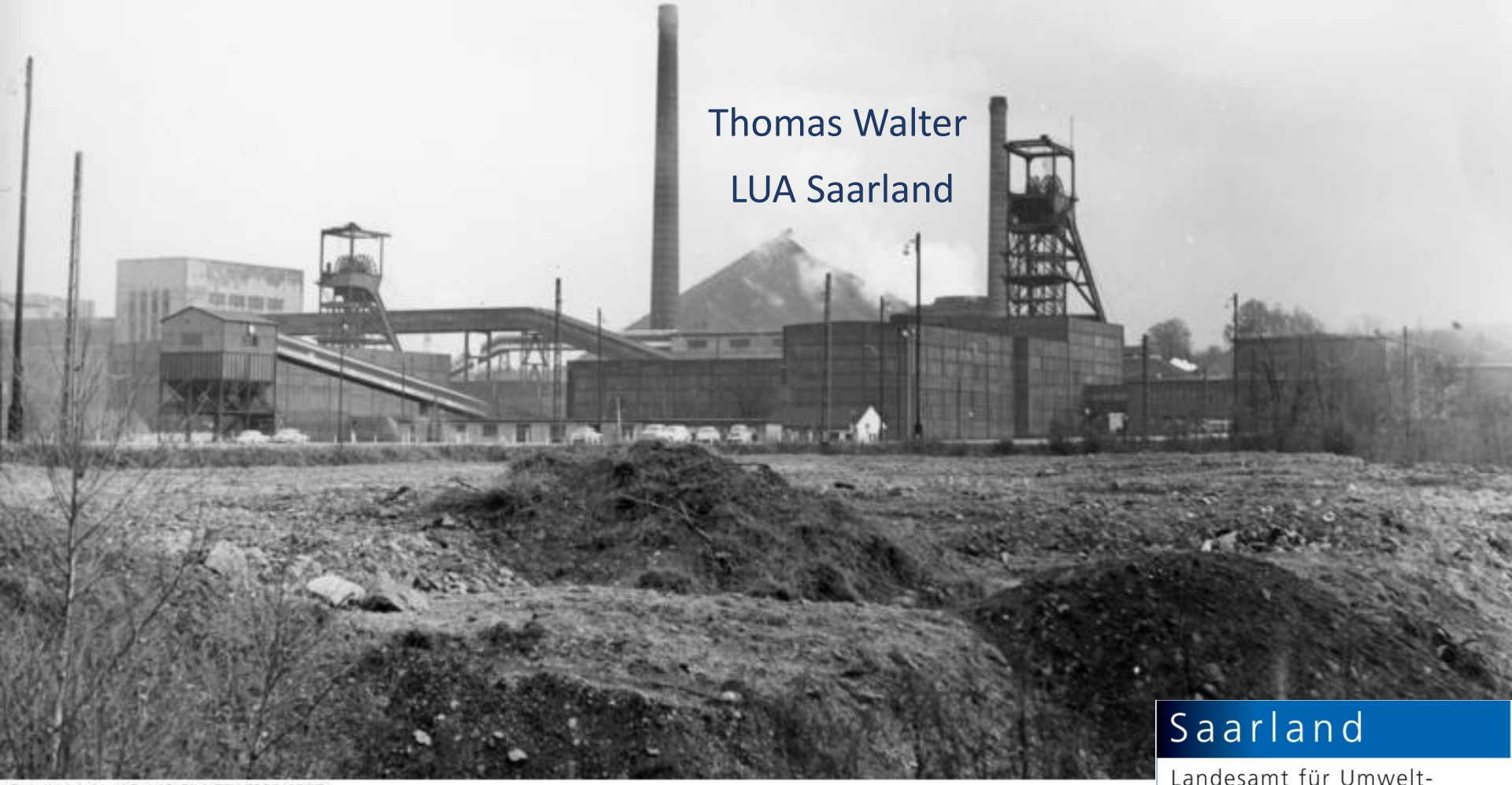
Closing down the mining in the Saar Region, Germany: Are we creating a transboundary "great man-made aquifer"?

Thomas Walter

LUA Saarland



Bundesarchiv, B 145 Bild-F015023-0007
Foto: Hoffel, v. | 1959 Anfang

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Landesamt für Umwelt- und Arbeitsschutz

A small German state in the middle of Europe…

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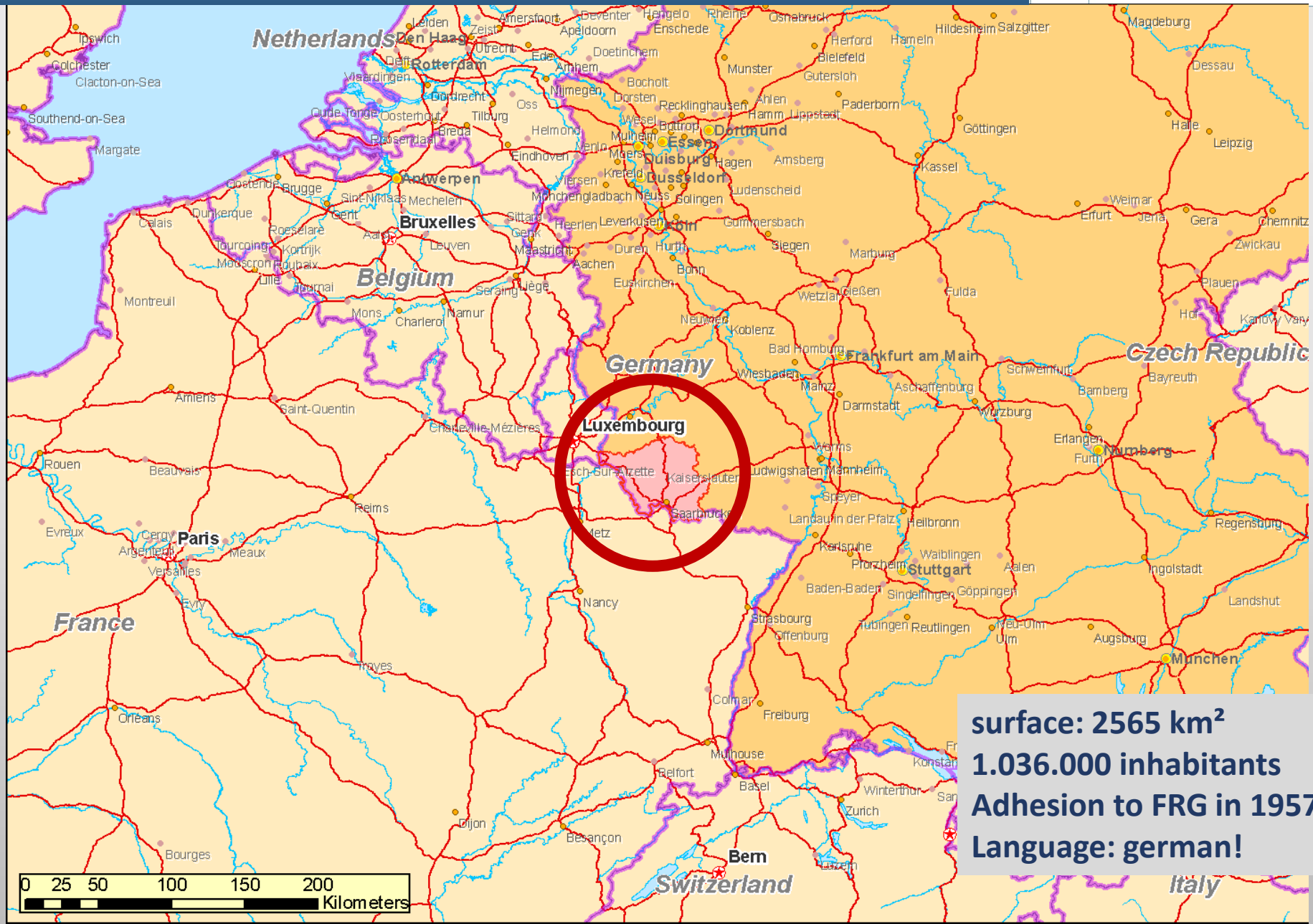
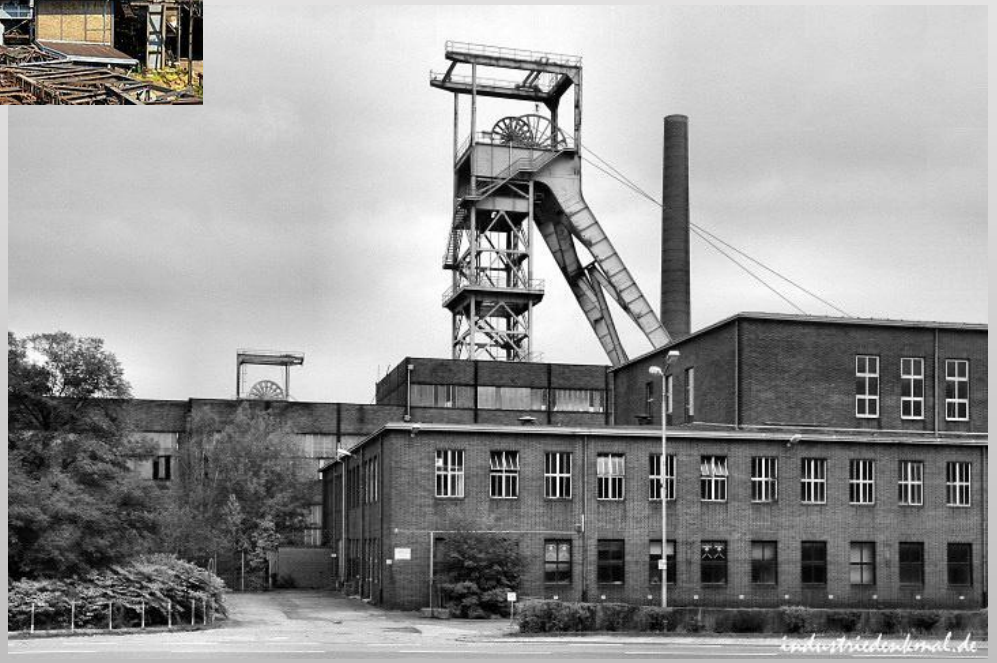


surface: 2565 km²
1.036.000 inhabitants
Adhesion to FRG in 1957
Language: german!

…with hundreds of years of industrial history

5 large Foundries and steel mills since 15th century, thereof 3 still working with a total of 15,000 employed

Mining since pre-roman times,
Systemstically since 18th century,
Number of know shafts > 900



Coal mining in the Saar Region

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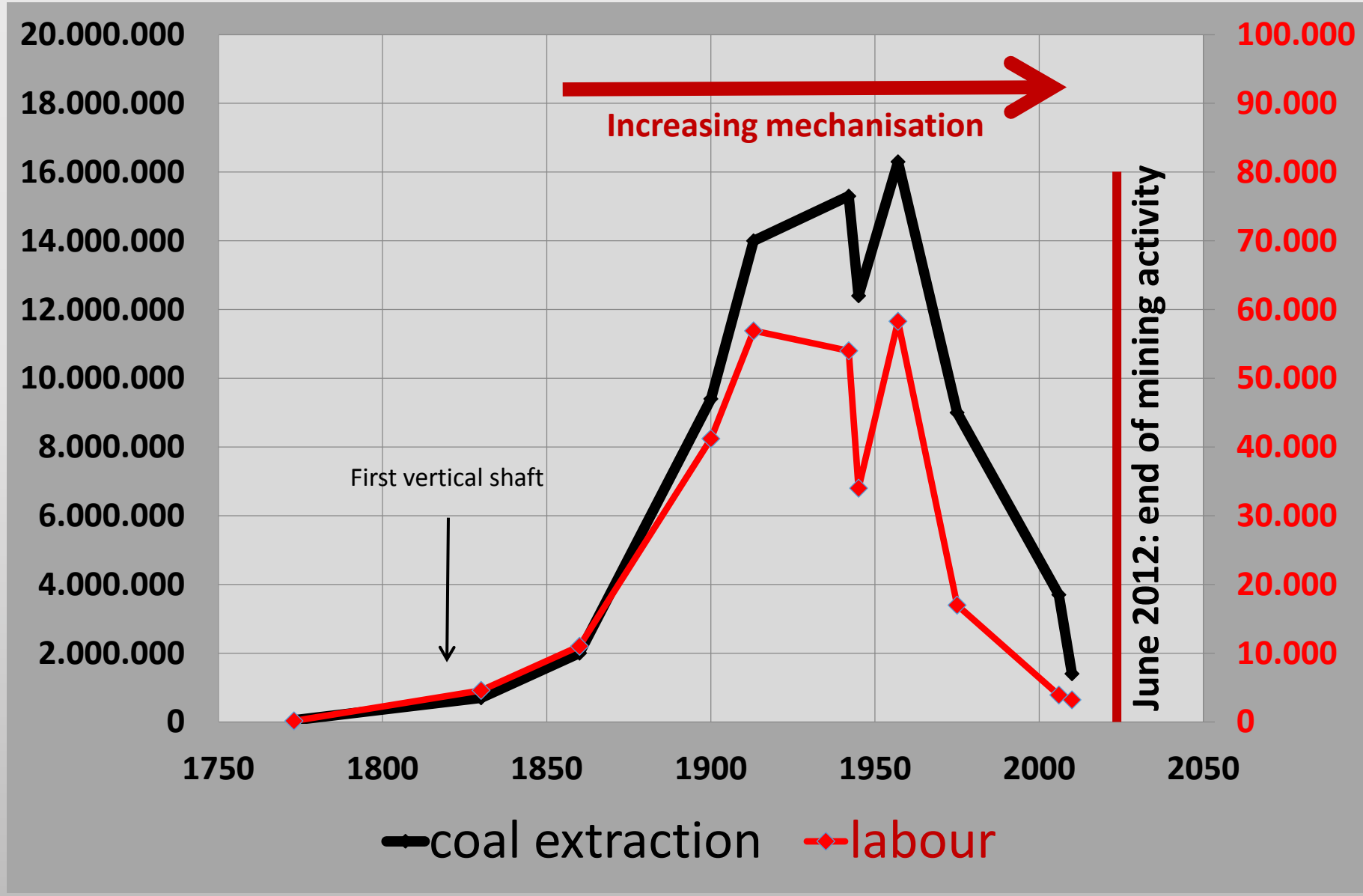

Overview over Mined Region

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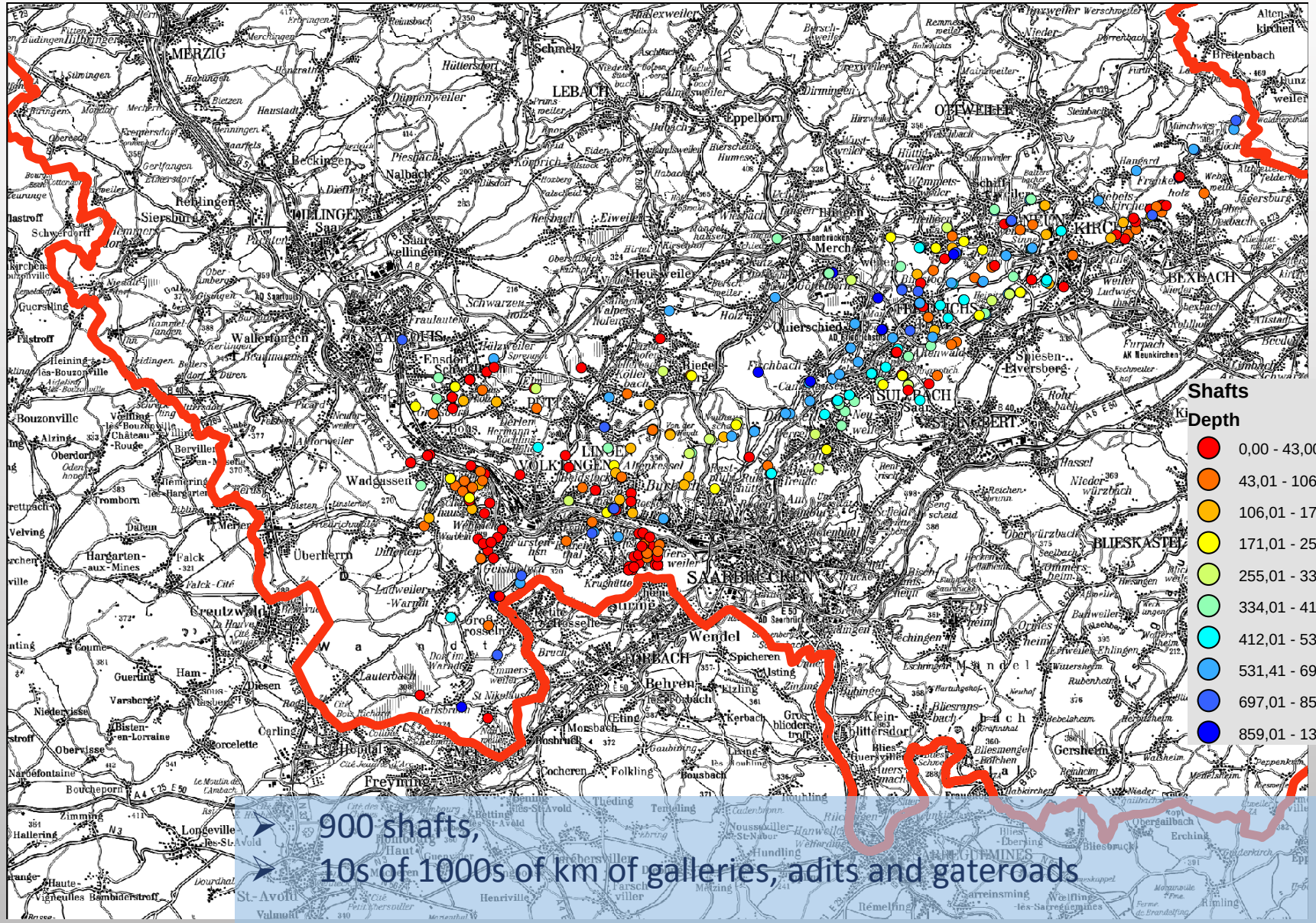
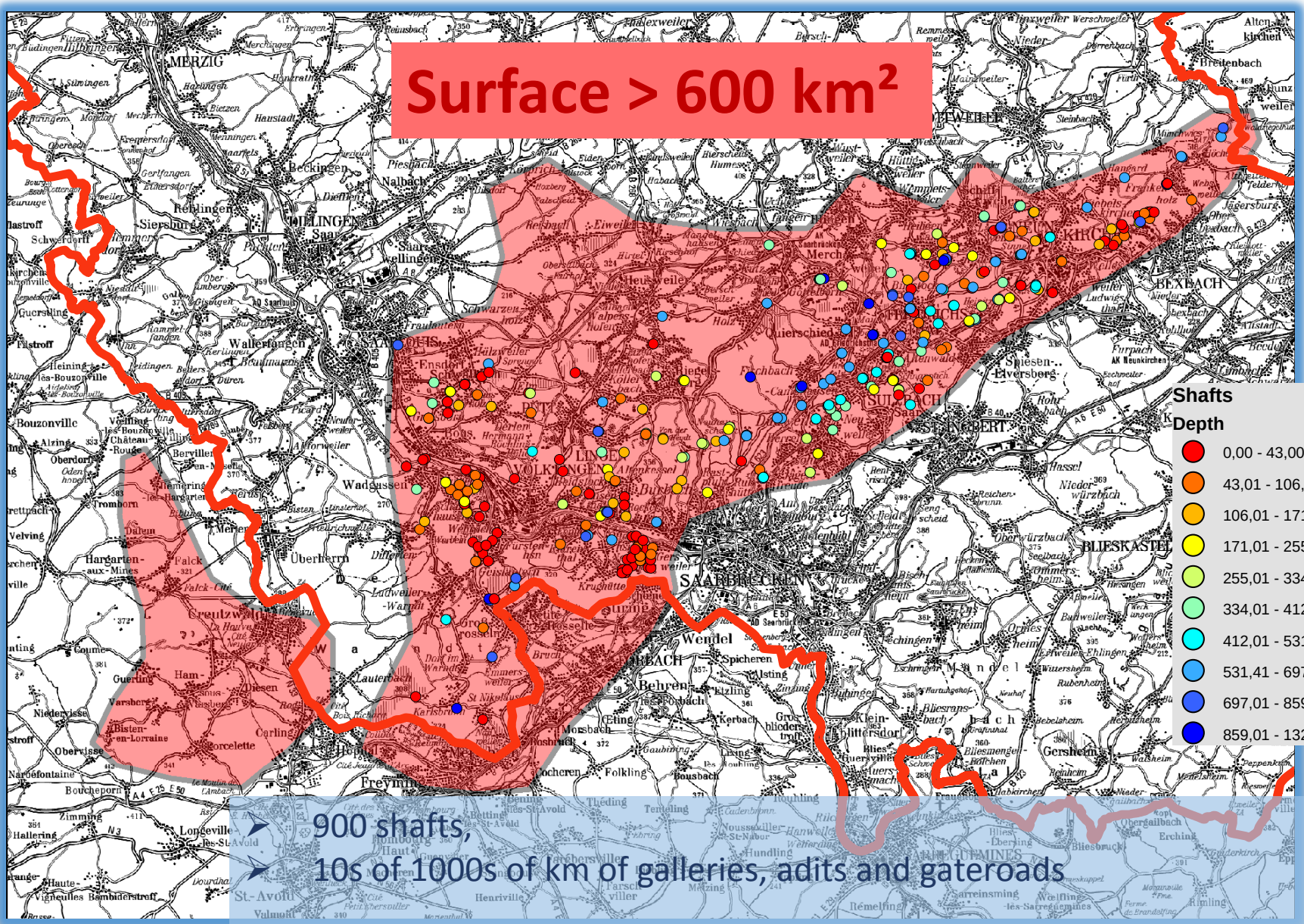


Overview over Mined Region



Overview over Mined Region

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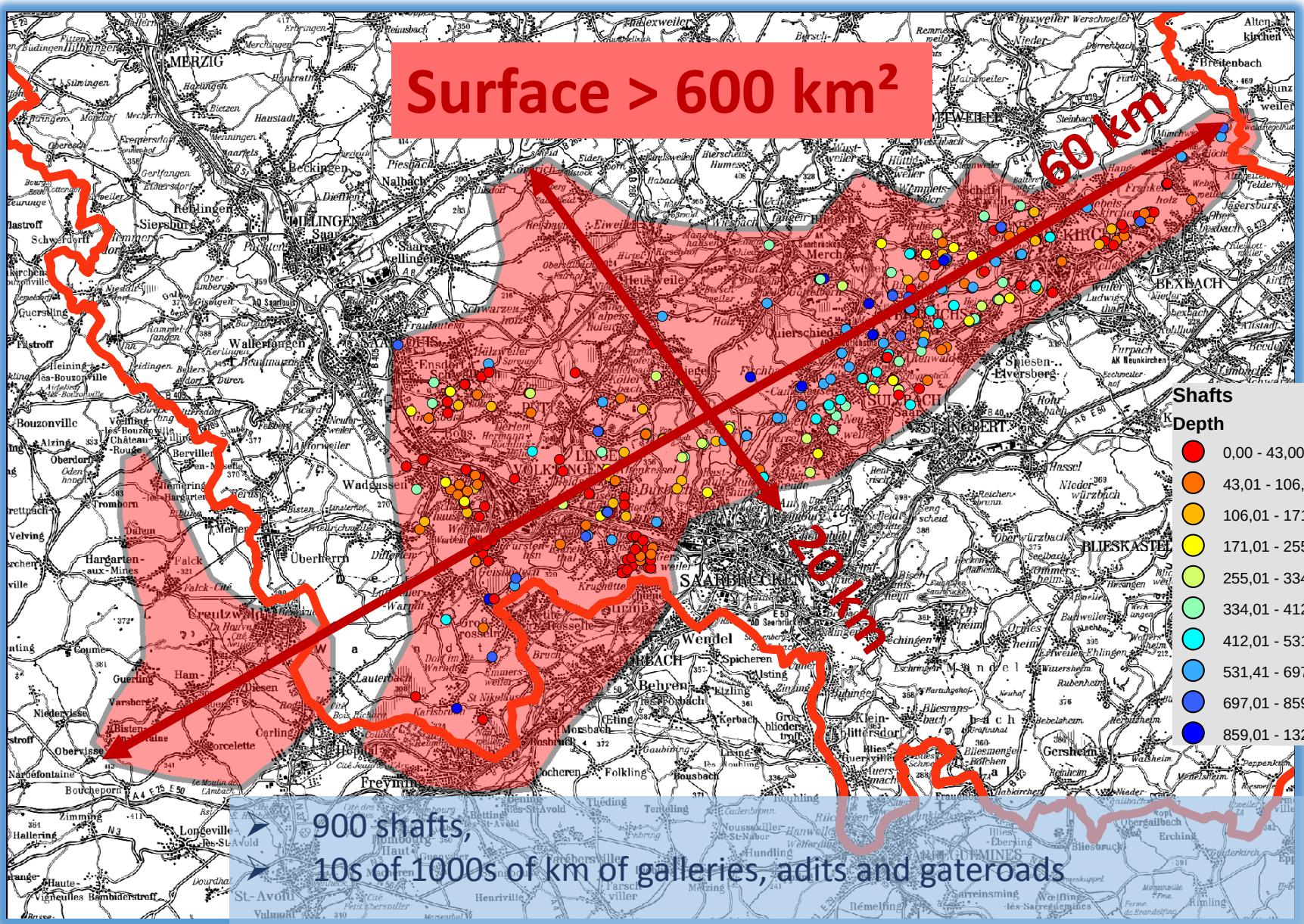

Overview over Mined Region

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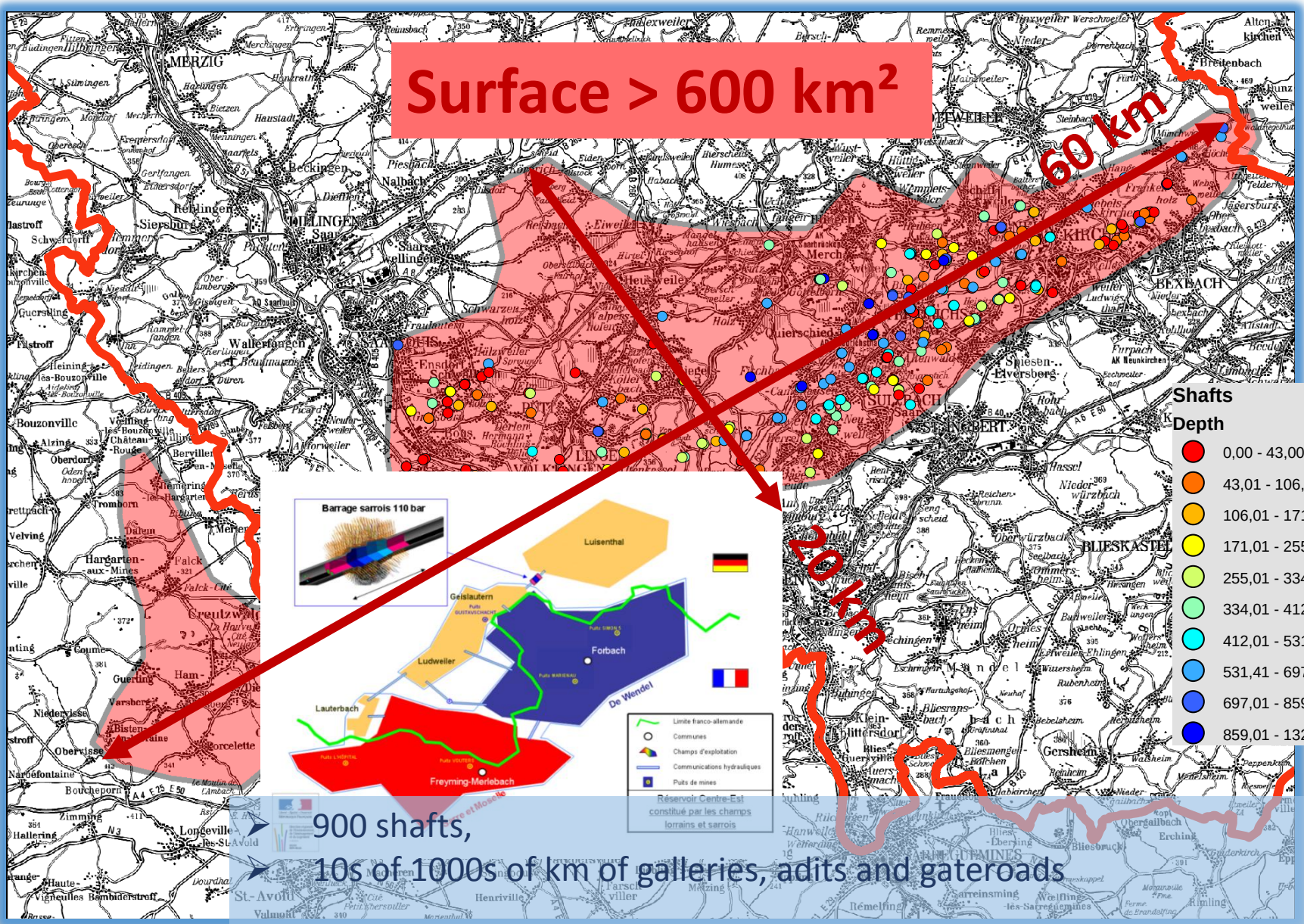
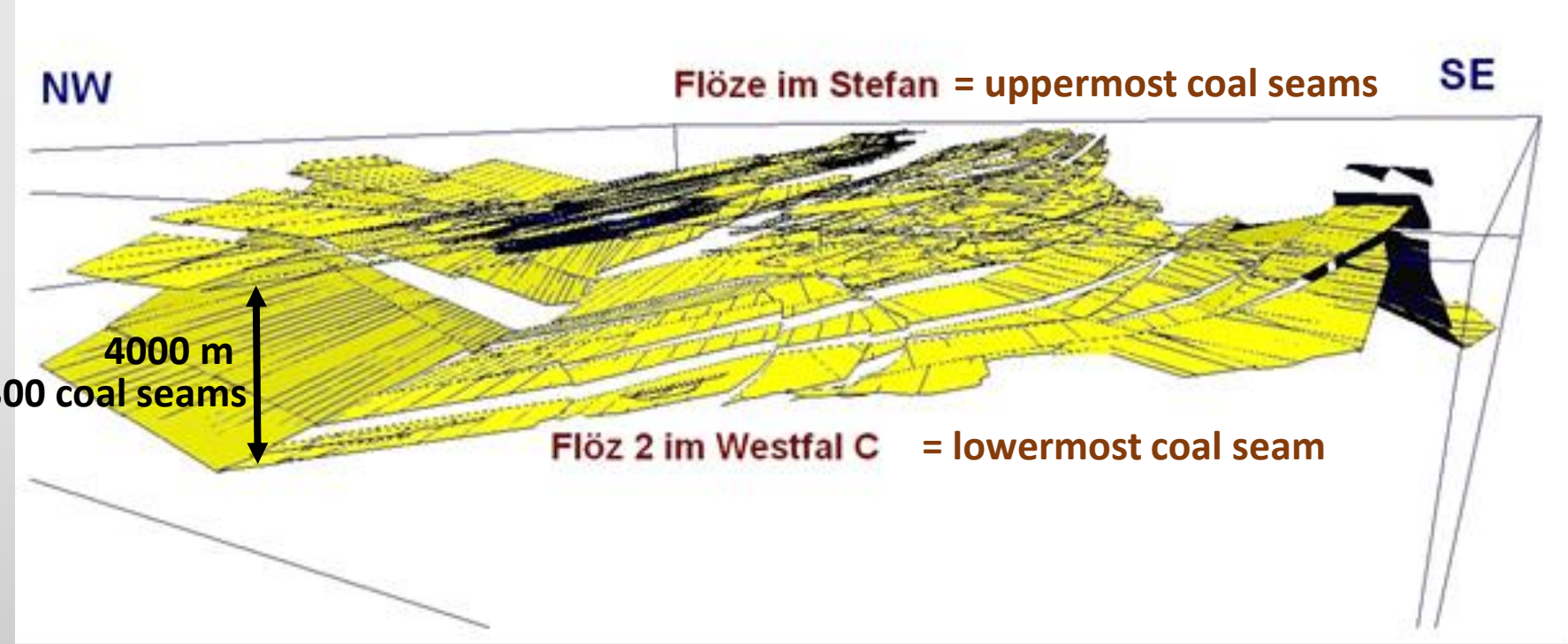


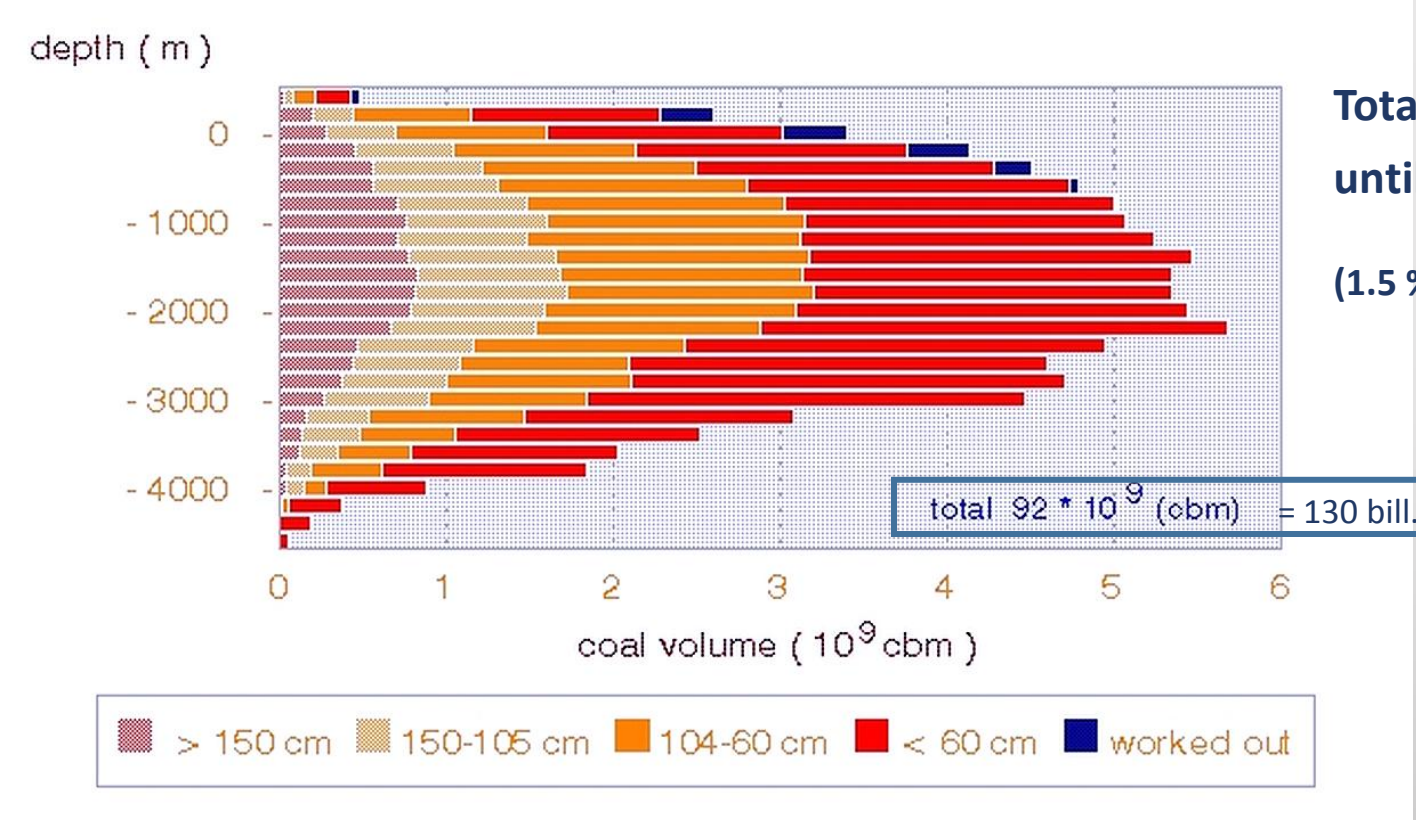
- 900 shafts,
- 10s of 1000s of km of galleries, adits and gateroads

3D-Model of the Deposit



KVB-Model: calculation of coal resources in Germany as a cooperation project of the Geological Surveys of Northrine-Westphalia and Saarland and the German coal industry

Coal Volume and Mined Volume



Total amount mined until 2012: 2 bill. t,

(1.5 % of total volume)

Estimated remaining void volume: 1.5 billion m³

JUCH et. al, 1994; JUCH, 1997

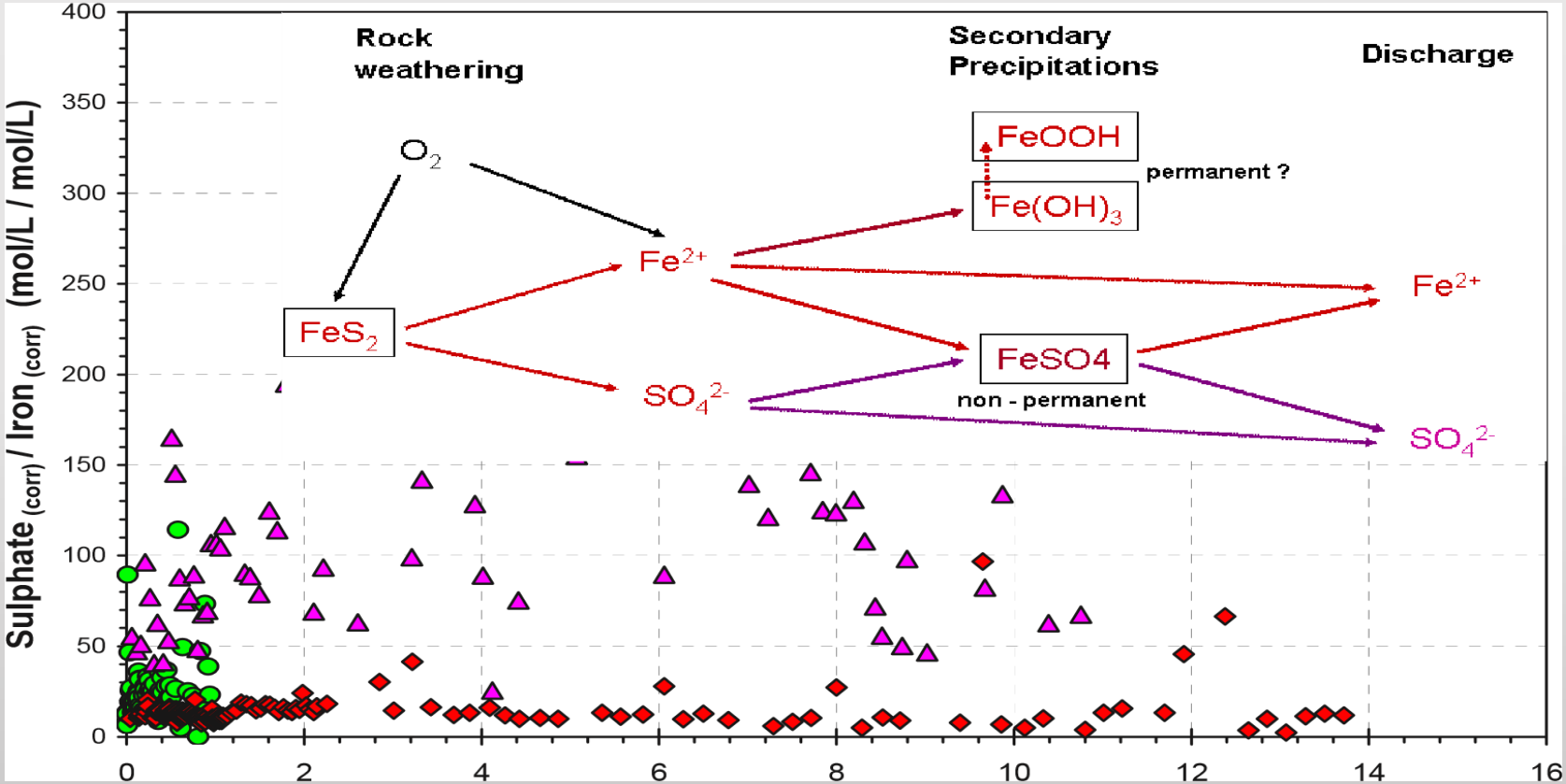
Problems:

- Continuing pumping causes long term costs: ~ 20 Mio. €/a

→ **Mine flooding seems to be unavoidable and therefore a flooding strategy is essential**

first phase: flooding process	• Rising groundwater levels in densely populated regions • Complex hydraulic structure makes mine rebound difficult to predict • Additional damages to expect at the surface, due to buoyancy of the rock pile
second phase: long term problems	• Flooding will change the hydrogeochemical environment • Long term behaviour of void system? • Long time stability of conduits?

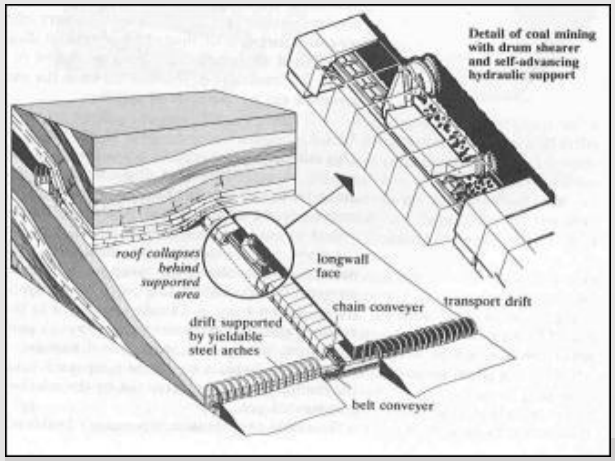
Development of Water Quality

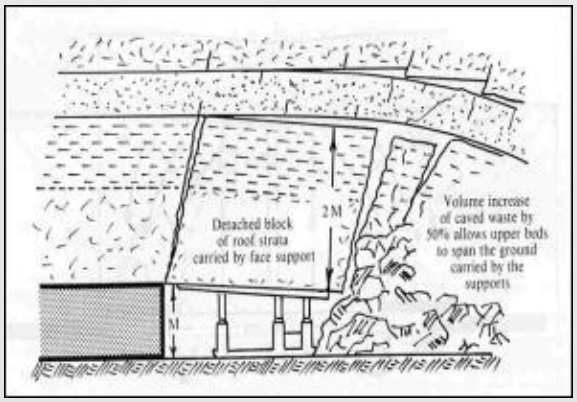


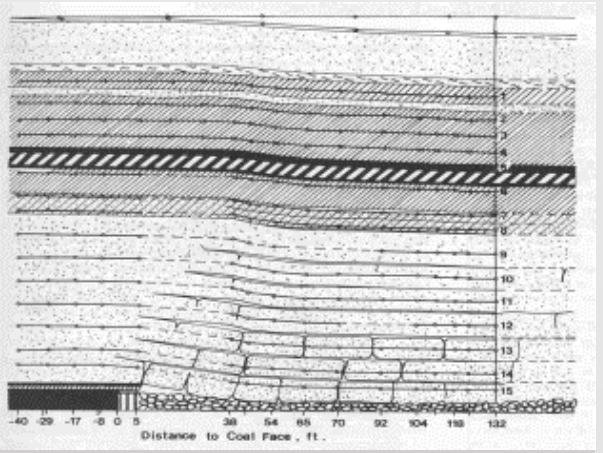
Pastor & al. (2007): Optimisation of mine water discharge by monitoring and modelling of geochemical processes and development of measures to protect aquifers and active mining areas from mine water contamination

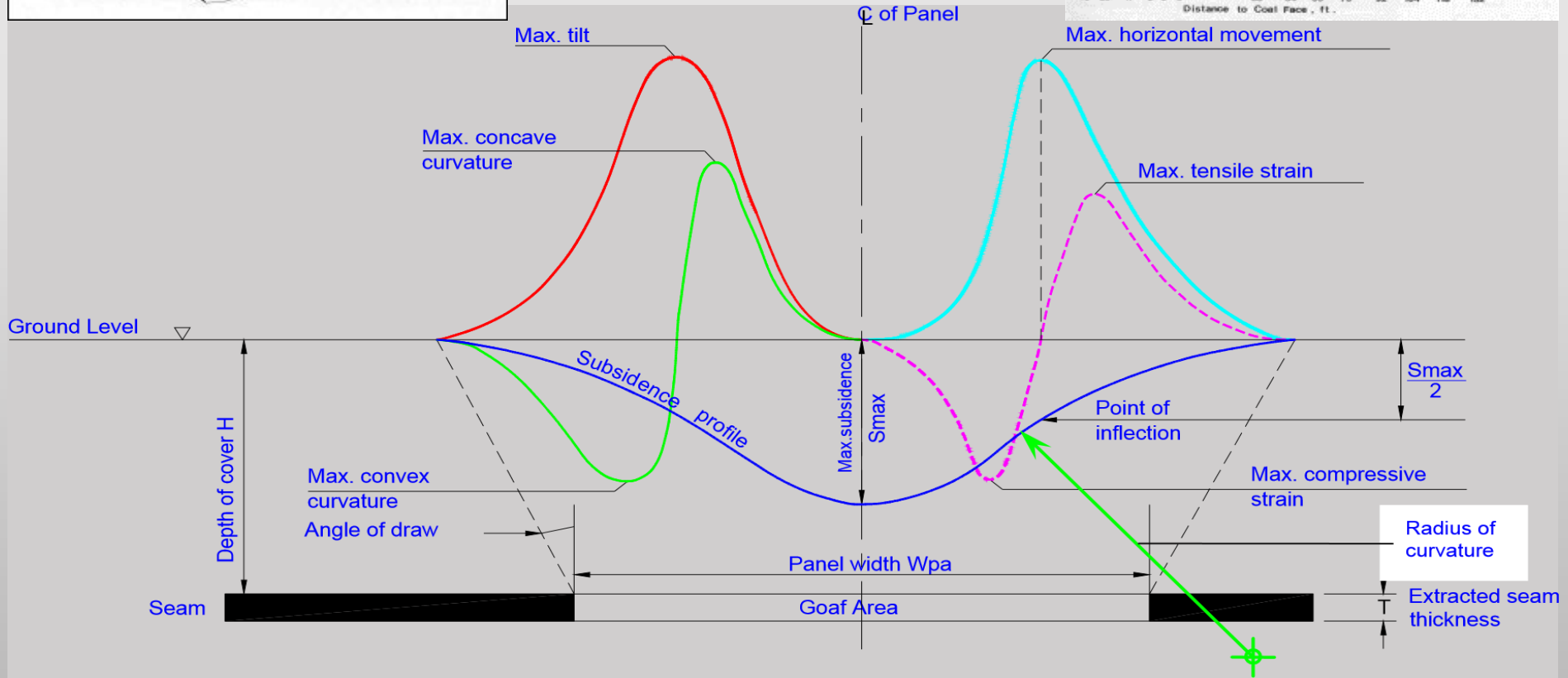
Hydraulic System

Longwall Mining

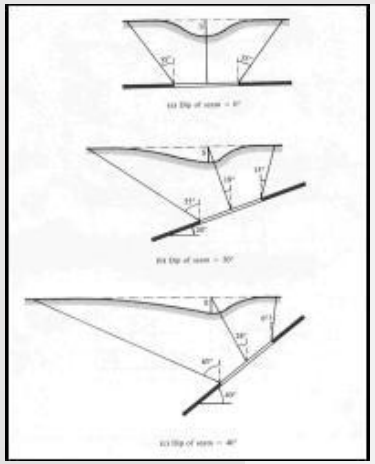


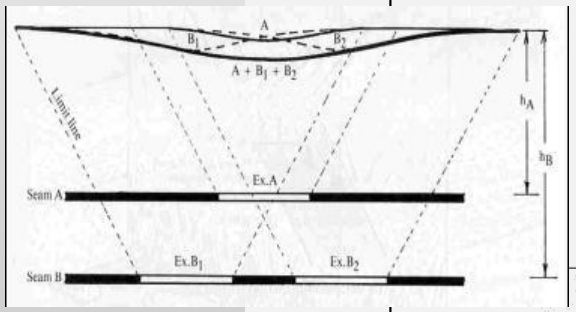






Mining Subsidence





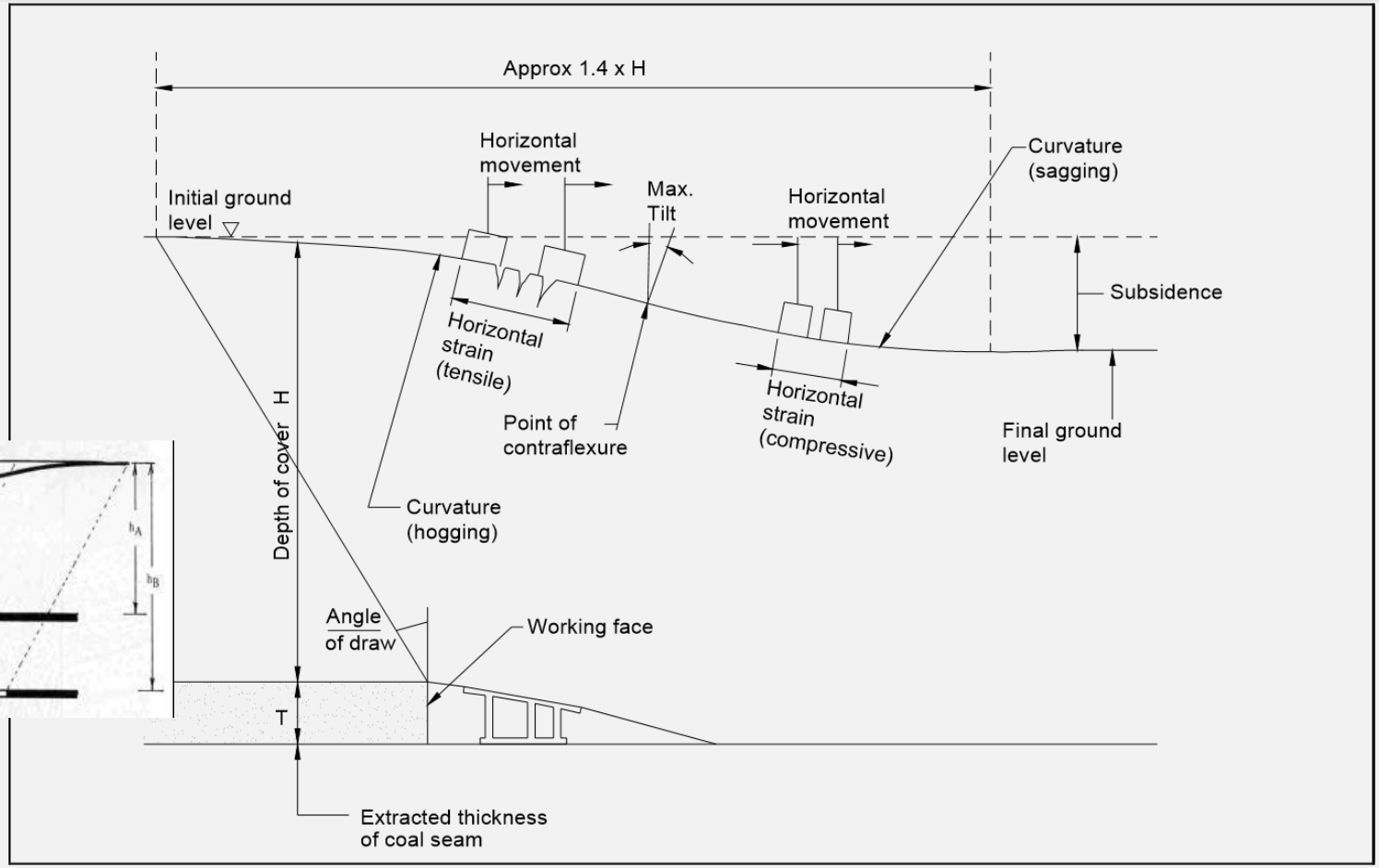


Fig. 1.7 Development of a Subsidence Trough (to an exaggerated vertical

Hydraulic Concept

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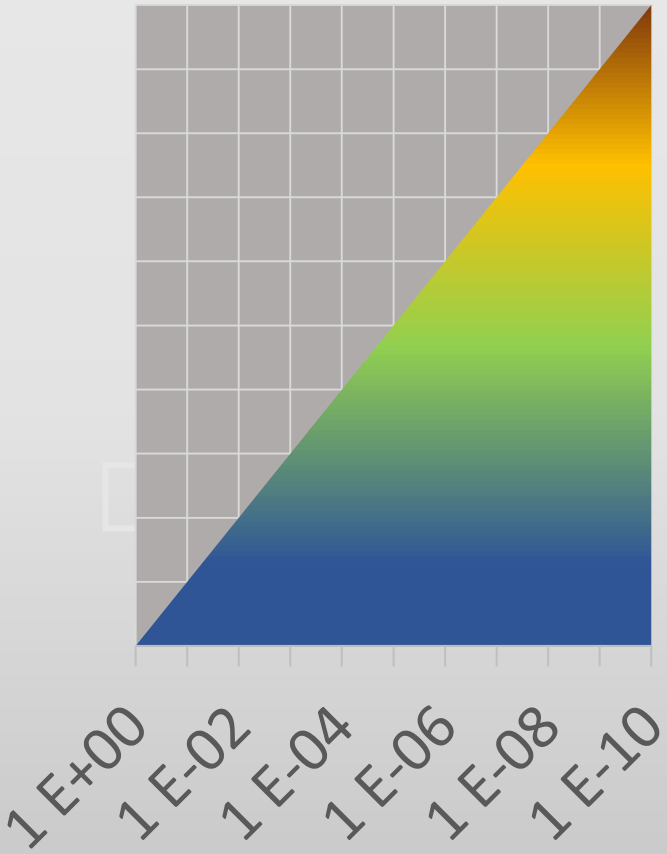

Unmined rock

strata above mined coal seams:
increased permeabilty through mechanical stress

Mined coal seams:
large flat draining areas with high porosity ~20%)

Shafts and adits:
system of regionally communicating conduits

Natural porosity

Technically induced Porosity

- tertiary technical porosity
- secondary technical porosity
- primary technical porosity

Hydrogeological Model

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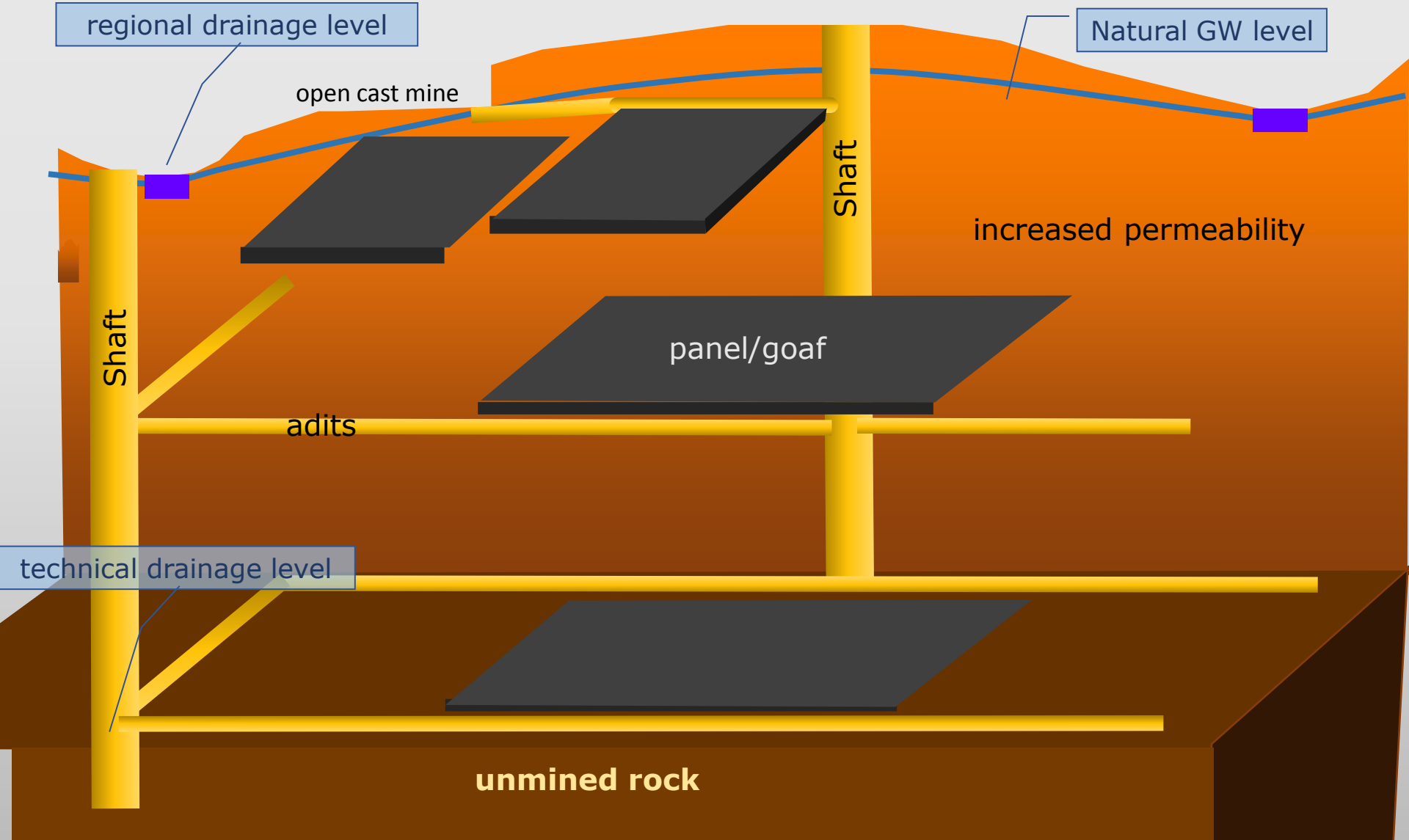
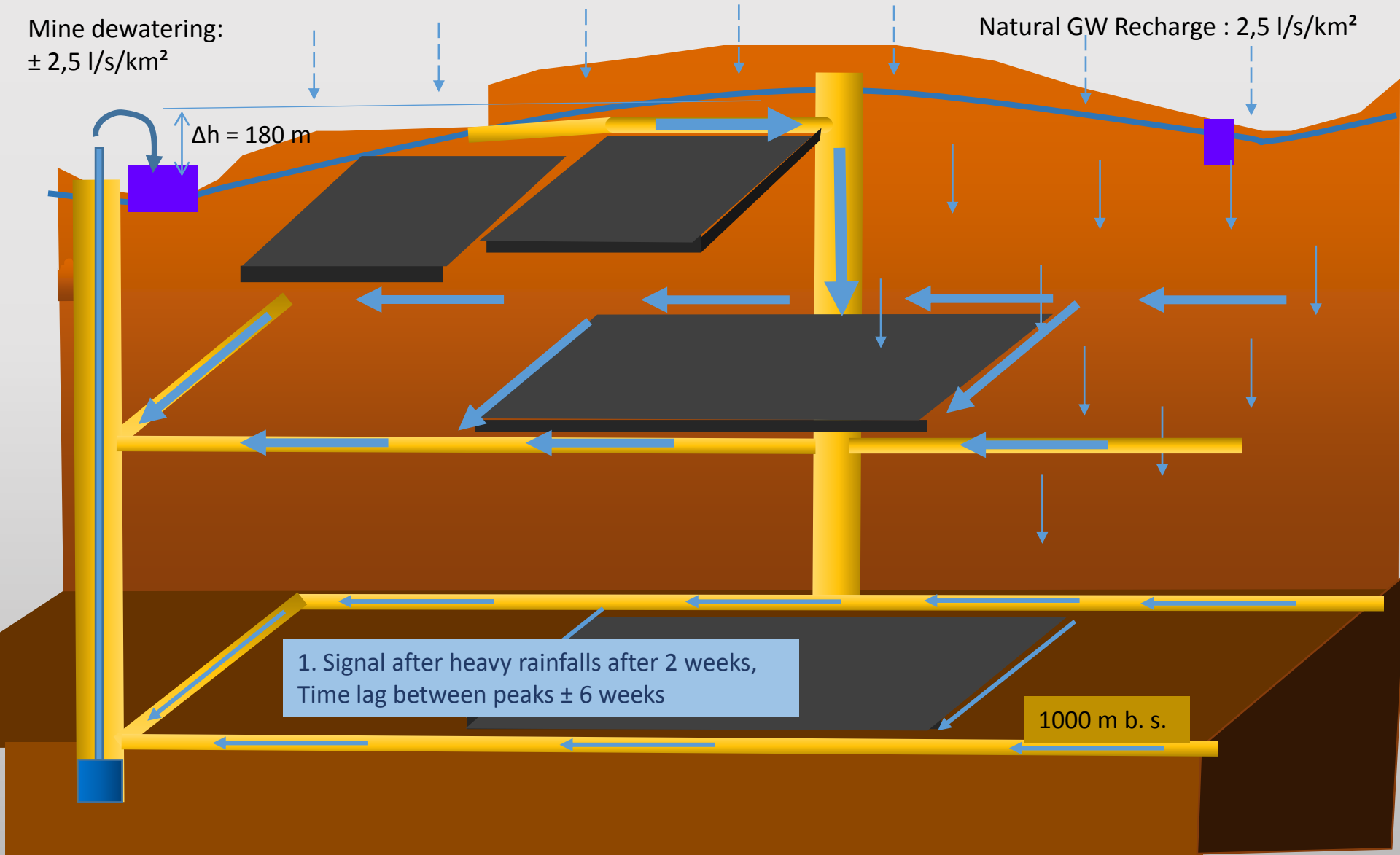


Groundwater Recharge



Natural Analogon:

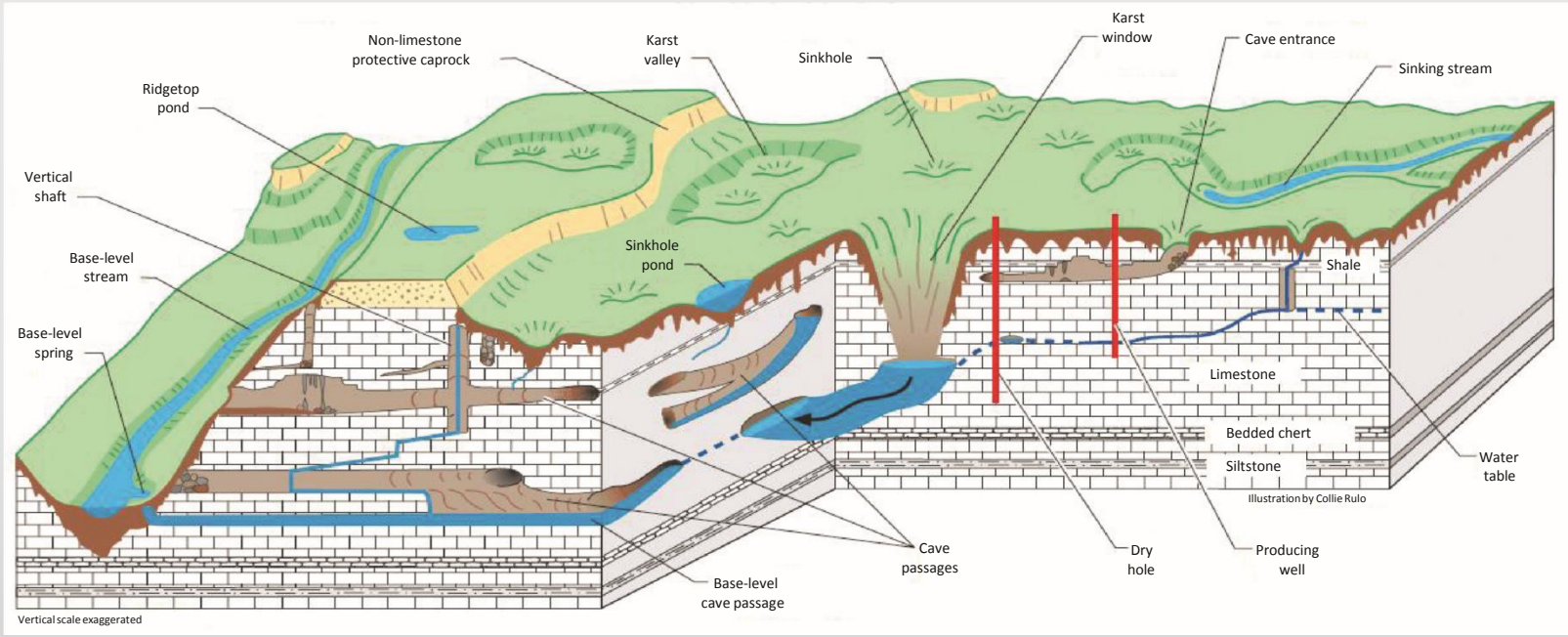


Figure 1. Physiographic and hydrologic features typical of a well-developed karst terrane (modified from Currens, 2001, Kentucky Geological Survey, used with permission).

Taylor & Greene: Hydrogeologic Characterization and Methods Used in the Investigation of Karst Hydrology

Mining systems could be considered and modeled as a „Technical Karst System“ , Forming an Artificial Groundwater System

Overview:

- Large hydraulic system with relevant pore volume
- Densely interconnected conduits with large diameters
- Goaf zones act as internal drainage zones with a very high internal surface
- Rock up to 1000 m depth unsaturated since more than 100 years

→Long and at least partially very fast flow paths

→Enormous mineralisation potential

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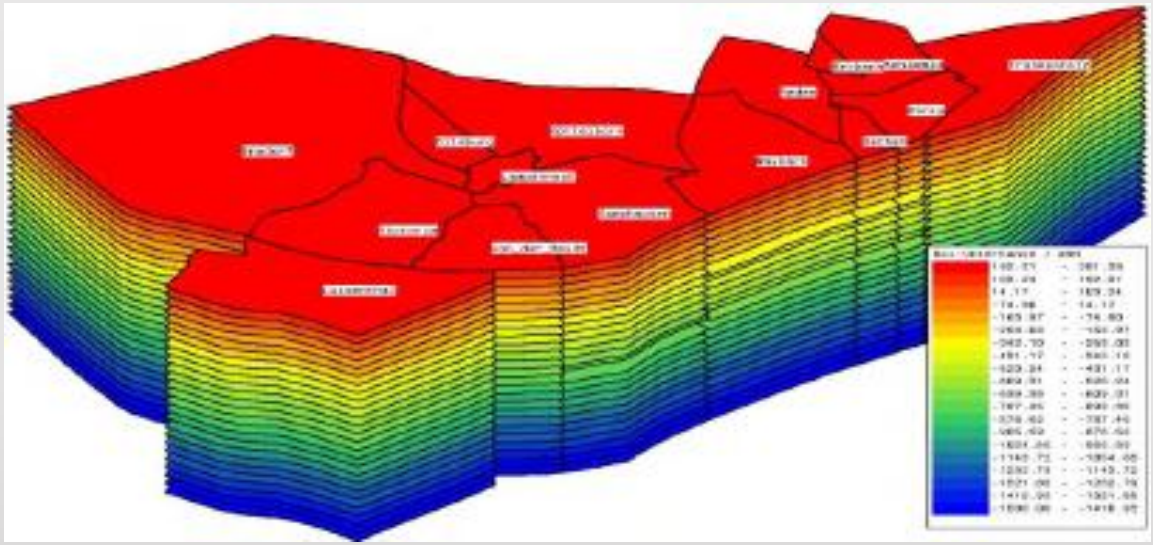
Prediction of Flooding Process

Box Model of the Saar Region (DMT)



single homogeneous boxes representing available void volume
hydraulic connections by geometrically correct representations of mine workings

Transboundary Sytem of Boxes

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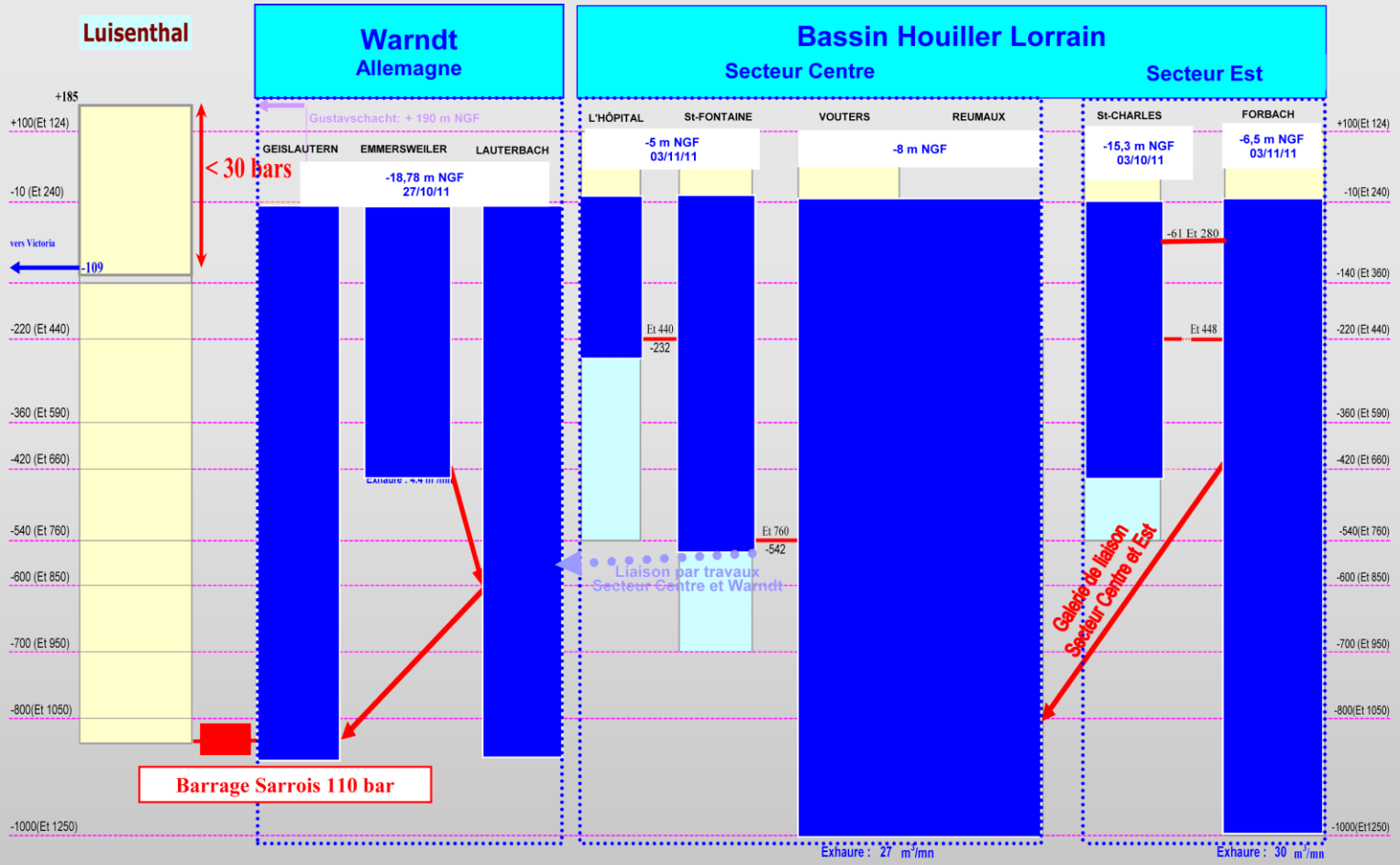
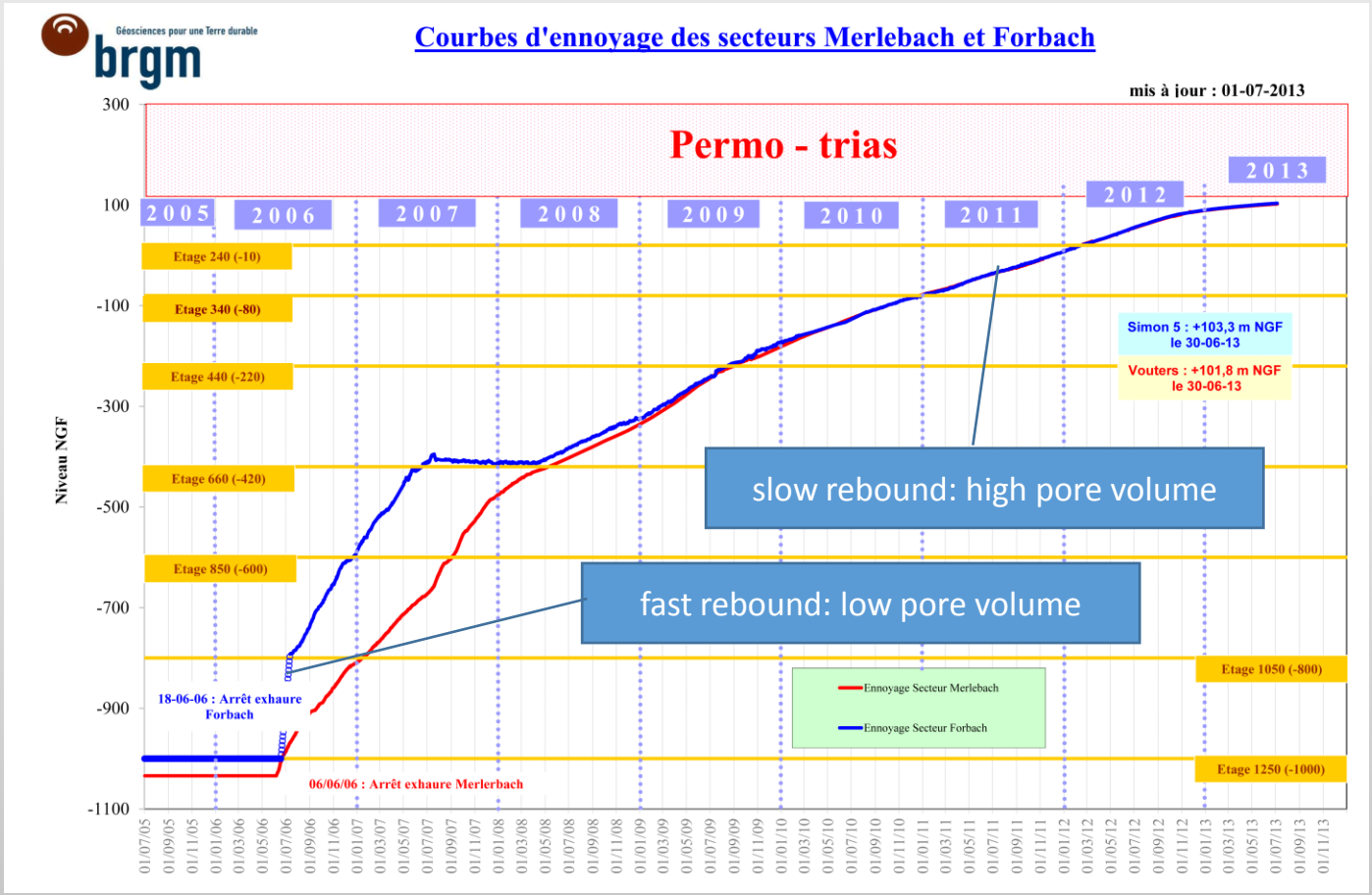


Géosciences pour une Terre durable
brgm

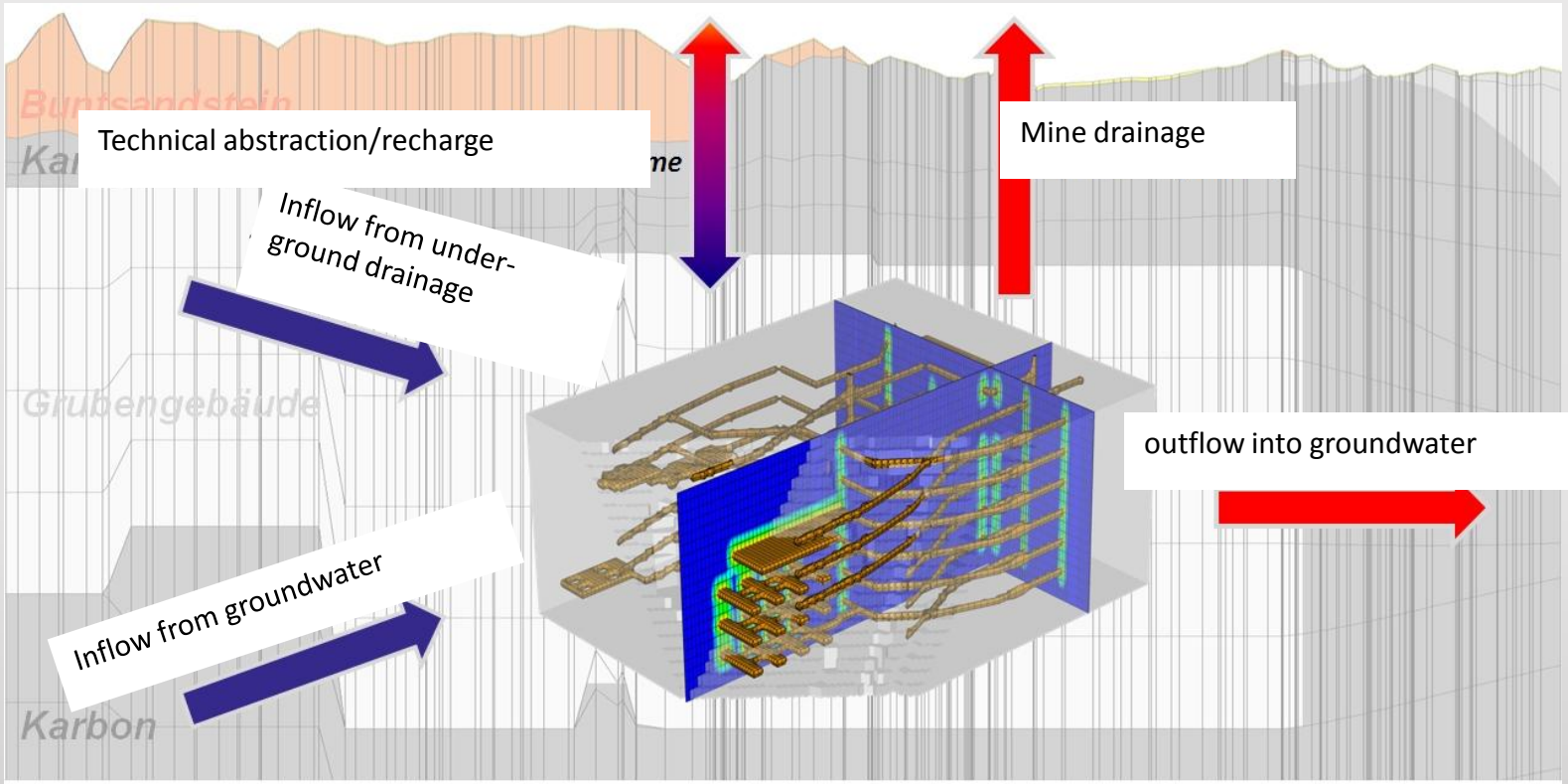
Total des venues d'eau 63,3 m³/min

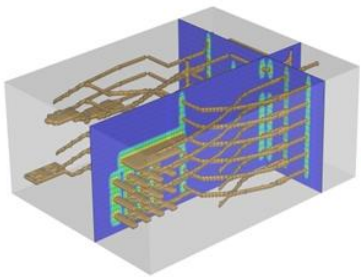
mis à jour : 03/11/11

Flooding Process of the Lorrainian Mines

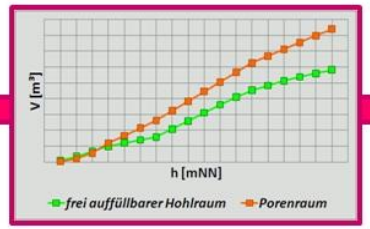


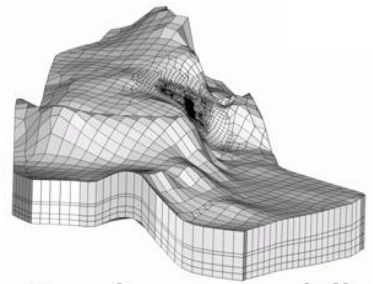
Linking Box and Groundwater Model





Boxmodell





Grundwassermodell

But what about long term behaviour?

The Karst analogon seems to be a reasonable approach,

but

even if a 3D-model of the deposit already exists and geometrical information is available with a very high degree of reliability,

it most probably will turn out as not practible due to information overflow,

Solution:

Finding the right balance between detailed view and overly simplification!

Conclusion

- It is fairly large
- It is obviously man-made
- It crosses an international boundary
- And it is capable to transport water over large distances

-> so it is a large transboundary man-made aquifer!

…. especially having in mind future mine closures (Germany, Poland, Ukraine etc.)