Department and Chair
Mining Engineering III
- Surface Mining and Drilling -

# State of the art mining technologies in Europe – focus on high ash coal and high coal mine methane levels

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1st EU-Kazakhstan CCT/CCS Workshop,
Astana, 30.09.2010

# AGENDA

1. Introduction – who we are
2. Surface miner – selective mining in coal
3. Mobile equipment – continuous haulage in hard rock mines
4. Particulate matter – research on dust emissions
5. CBM – projects in Germany

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## Core competencies

- Deposit modelling
- Pit design (short-term / long-term planning)
- Equipment selections and optimization
- Environmental issues

## Main research (currently)

- Continuous surface mining in hard rock and unconsolidated formations
- Metaheuristic solutions for pit optimization (UPL)
- Mining and environment
  - Land management, particulate matter (dust), noise
  - Energy efficiency of mining processes
  - Soil, water, waste (controlled landfill)

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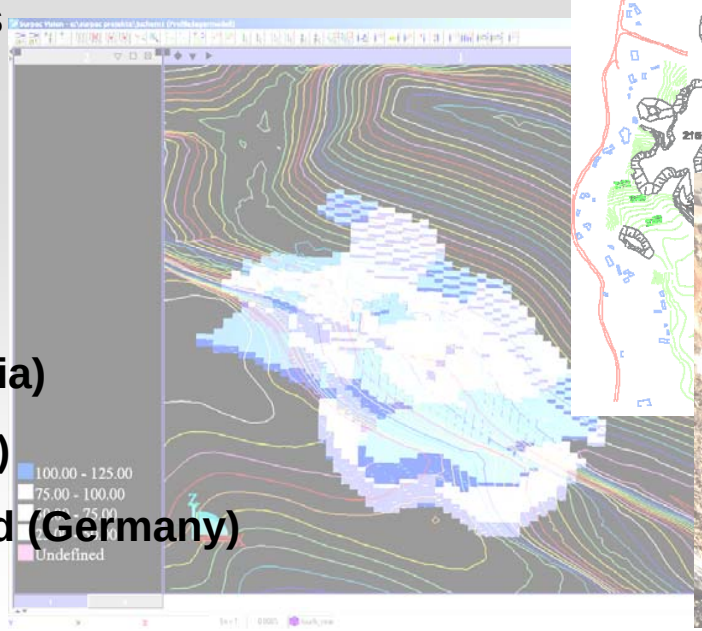
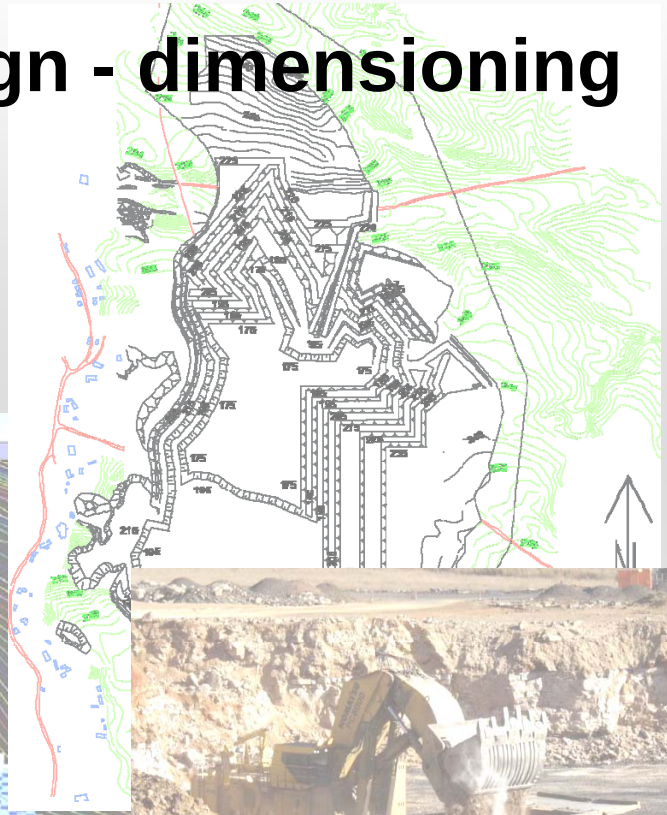
# Deposit modelling - pit design - dimensioning

- Surpac – Datamine
- In-house software development
- Holistic approach in case studies
- Evaluation of deposits



## Current projects

- Hard coal (USA)
- Molybdenum (Armenia)
- China clay (Germany)
- Hard rock, glass sand (Germany)

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# Continuous surface mining technology - development and implementation

## Objectives

- Reduction of costs
- Reduction of emission
- Selective mining

## Activities

- Feasibility studies
- Detailed planning
- Scientific monitoring during project realization

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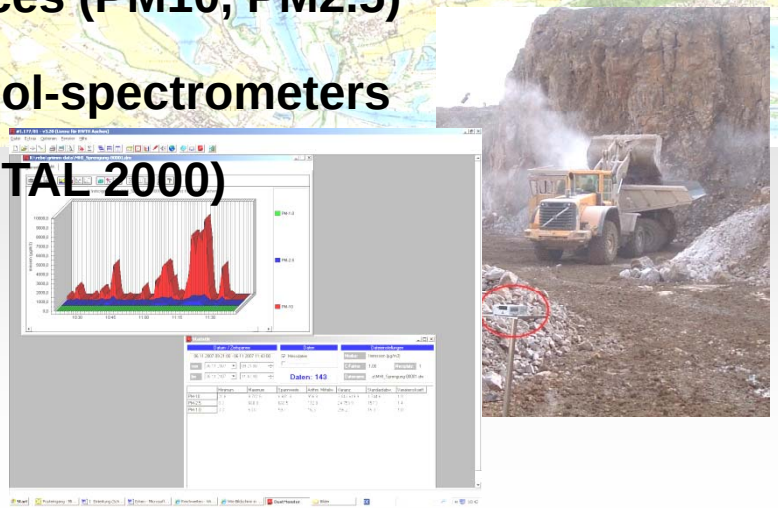
# Mining and environment - land management, particulate mater, soil, water

- Concept development for the re-filling of quarries
- Verification of efficiency in dust control measures
- Determination of particulate matter sources (PM10, PM2.5)
  - Field measurement with mobile aerosol-spectrometers
  - Simulated models of dispersion (AUSTAL 2000)



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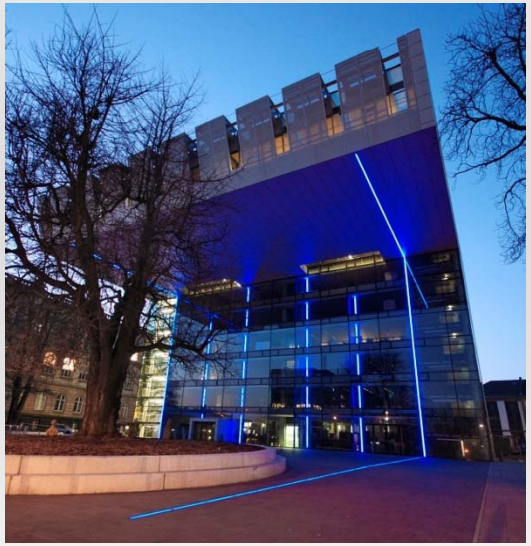
# Geothermal energy in urban areas

- Borehole depth 2544 m
- Completion Dec. 2004
- Tasks performed by BBK III
  - Technical planning
  - Technical tender
  - Mining permissions
  - Technical management



Source: stahl-info.de

# **Surface Miner technology** – we consider it an

**Economical,**

**safe and**

**environment friendly mining method**

**for**

**selective mining of**

**coal and lignite**

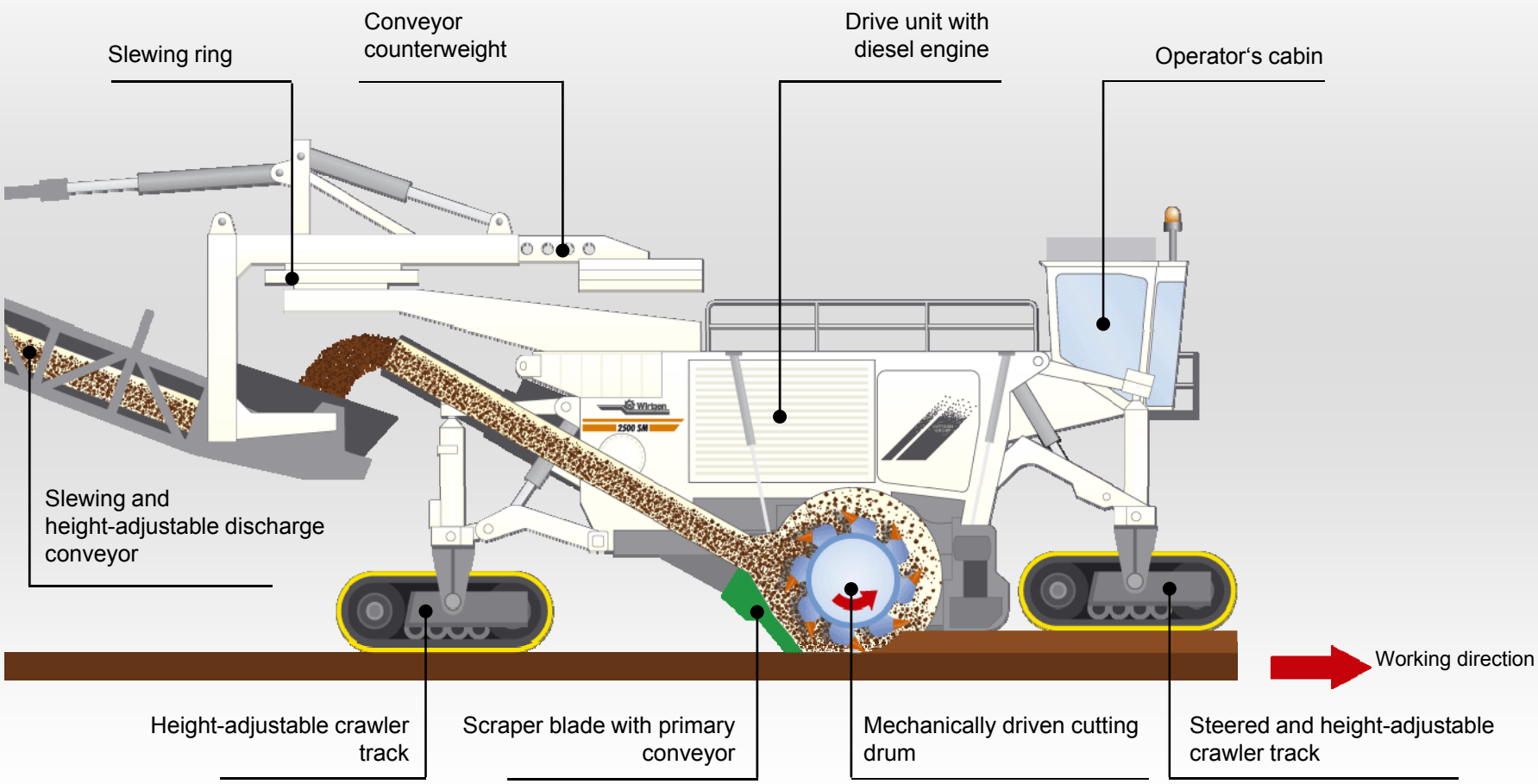
# Suppliers of Surface Miners – different working modes

Tenova TAKRAF TSM300 – front-end drum

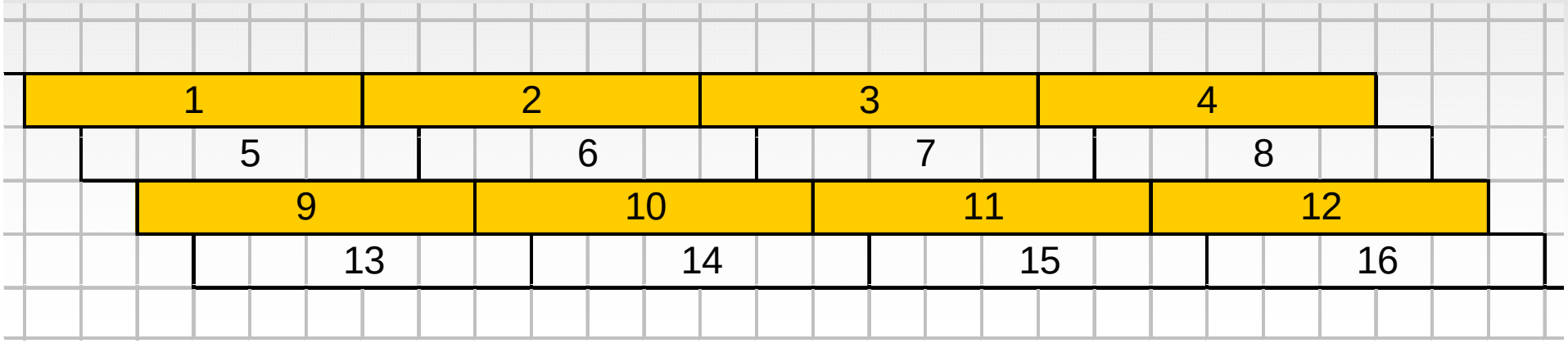
Wirtgen 4200SM – middle drum

Vermeer T1255 – tail-end drum

# A Surface Miner – here's how it works



# Cutting sequence in a block



# Highly-selective mining

Parting

Coal

Parting

Coal

Parting

# Highly-selective mining

# Highly-selective mining

Parting

Coal

Parting

# Highly-selective mining

Coal

Parting

# Highly-selective mining

Benefits:

- High quality ROM-products
- Reduced processing cost (less washing, less crushing)
- Reduced waste material handling
- Better exploitation of deposit
- Better stripping ratio

# Mining without blasting

- Environmentally friendly:
  - No dust generation
  - No ground vibrations
- Improved safety:
  - No explosives used
  - No fly rocks
- Better exploitation:
  - Mining down to the deposit boundary

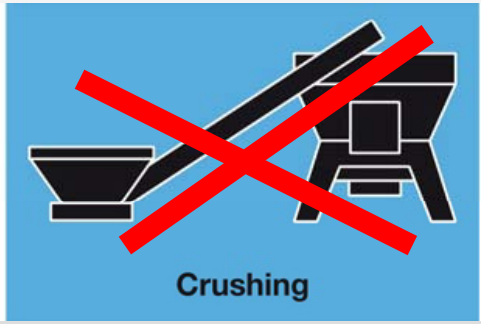
# Other advantages:

- Levelled surface
- Steep and stable slope cutting

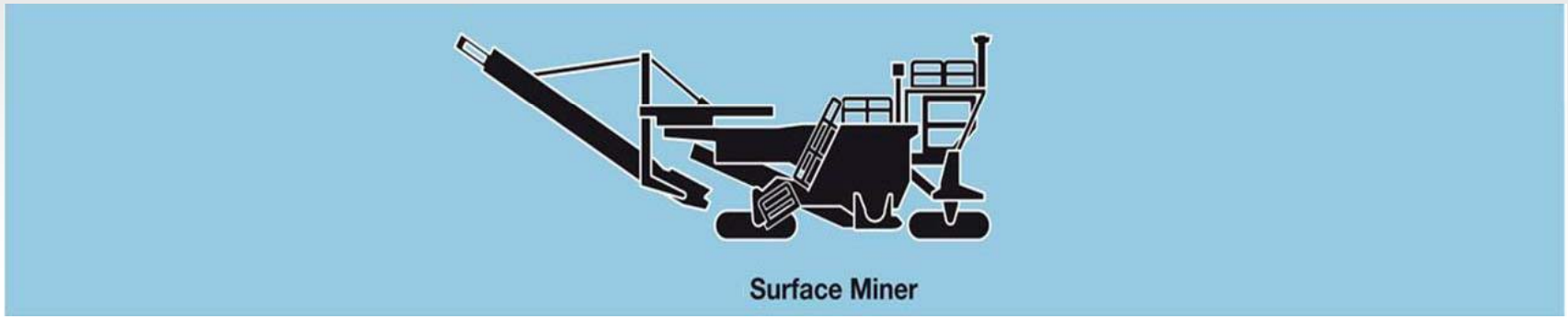
Mahanadi Coal Field, India

# Capabilities of Surface Miners

The following jobs are not longer required:




Cut, crush, load in one operation with one machine



# 3500SM in Lignite, Gacko, Bosnia

| | |
|---|---|
| Bucket wheel excavator | Surface Miner 3500 SM |
| Heating val. 7300 KJ/kg | Heating val. 9340 KJ/kg |
| Ash content 22 % | Ash content 12 % |
| | Instantaneous production: 800 t/h per machine |

# Wirtgen test results:

18 months Surface Miner experience in Indian coal mines

- Cost saving

  0,75 US$/t

- Improved coal quality

  43 % E grade coal

  (F and G grade when

  using conventional mining)

- Improved exploitation

  7.010.000 t of additional coal

# In-Pit Crushing and Conveying Technology (IPCC)

An innovative new system for continuous mining – making mining more efficient and sustainable

# Hard rock mining in open pits: mining and haulage systems

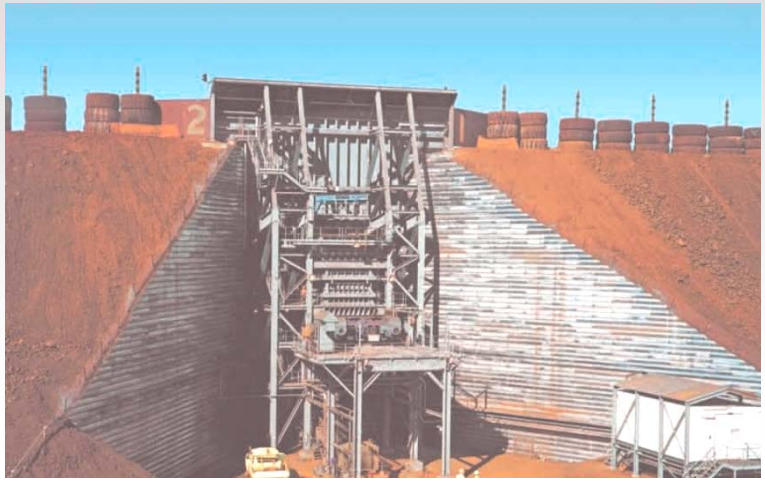
Traditional:

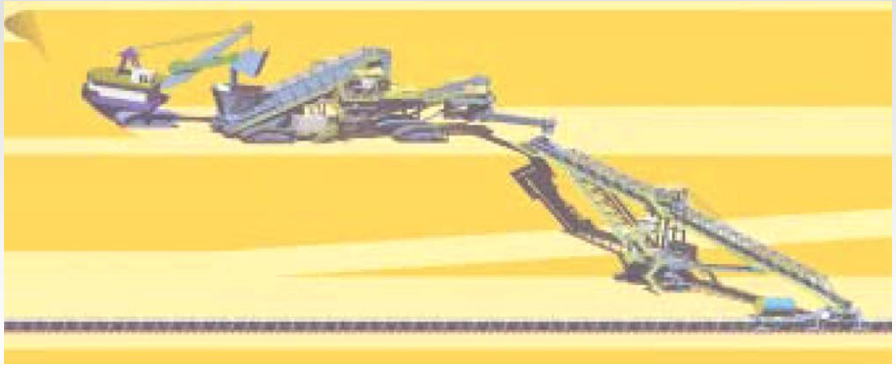
- truck and shovel
- fixed crushing station

Innovative approach:

Implementation of continuous haulage systems

- IPCC with semi-mobile crushing station
- IPCC with fully mobile crushing system





# IPCC with semi-mobile crushing system

Components:

- Shovel
- Trucks
- Hopper with feeder
- Crusher
- Belt conveyor

- Trucks are loaded at the face and travel to the crusher
- From thereon material is transported on belt conveyor

# IPCC with fully mobile crushing system

Components:

- Shovel
- Hopper with feeder
- Roller crusher (sizer or hybrid crusher)
- [Discharge boom]
- [Belt wagon]
- [Temporary hopper support]

  - Shovel at the face feeds directly into the hopper
  - Material is crushed and then transported on belt conveyor

# Relocation of Semi-mobile crusher vs. Mobile crusher

Semi-mobile crusher

- relocation possible
- three to four modules
- relocation takes several days
- transport on crawler tracks
- ramps have to be build at new location

Mobile crusher

- relocation very easy
- takes less than an hour
- transport on own crawler tracks

# Crusher selection

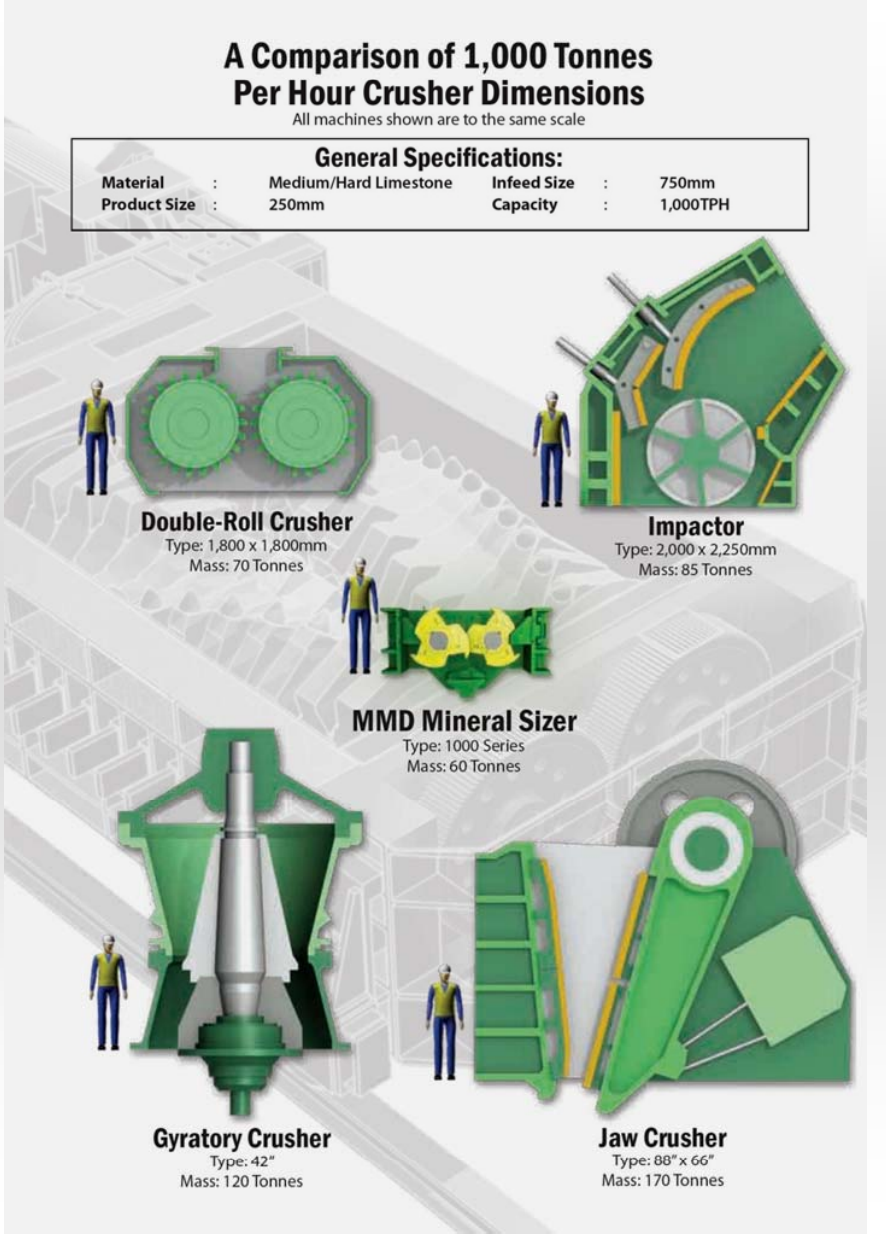
Gyratory crusher
(not suitable due to high weight and high forces)

Jaw crusher
(not suitable due to high weight)

Double roller crusher
Suitable for mobile equipment

Compact sizer
Suitable for mobile equipment

Hybrid crusher
Suitable for mobile equipment



# Sandvik studies:
# IPCC system vs. Truck and shovel

## PROs:

- Smaller truck fleet
- Lower maintenance costs
- Lower costs for material transport out of the pit
- Lower carbon footprint of the mine
- Reduction of manpower
- Can completely replace truck haulage

## CONs:

- Higher initial costs
- Less flexible
- Advanced planning needed

# Favourable conditions for IPCC systems

- New mining operations
- High-capacity mines (>10Mt/y)

- Operations focusing on automation and safety
- Operations focusing on energy efficiency

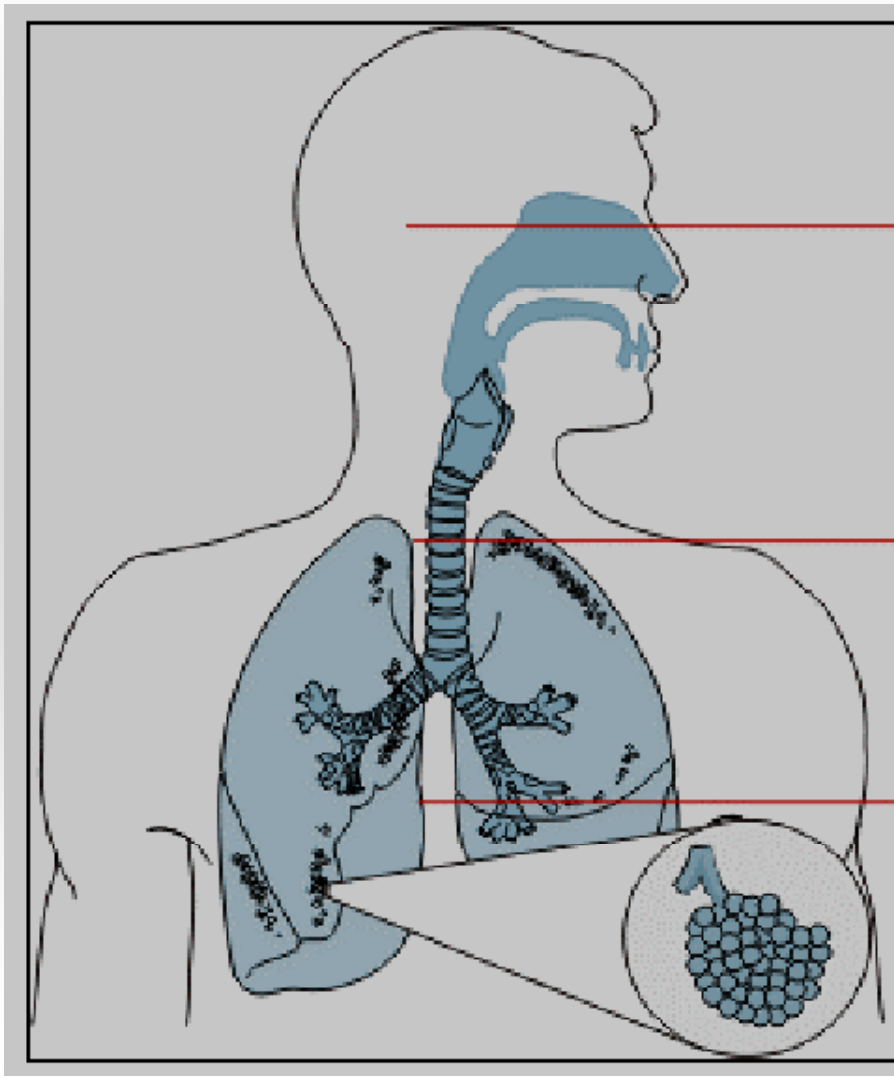
- Electricity prince (€/kWh) less than 25% of diesel price (€/l)
- Long truck cycle time (>30 minutes)

- Regions with restrictions on dust generation and with restricted availability of water
- Regions with restricted availability of manpower

# Dust and particulate matter

Air pollution by solid particles caused by surface mines.

# Impact of Dust on Human Beings



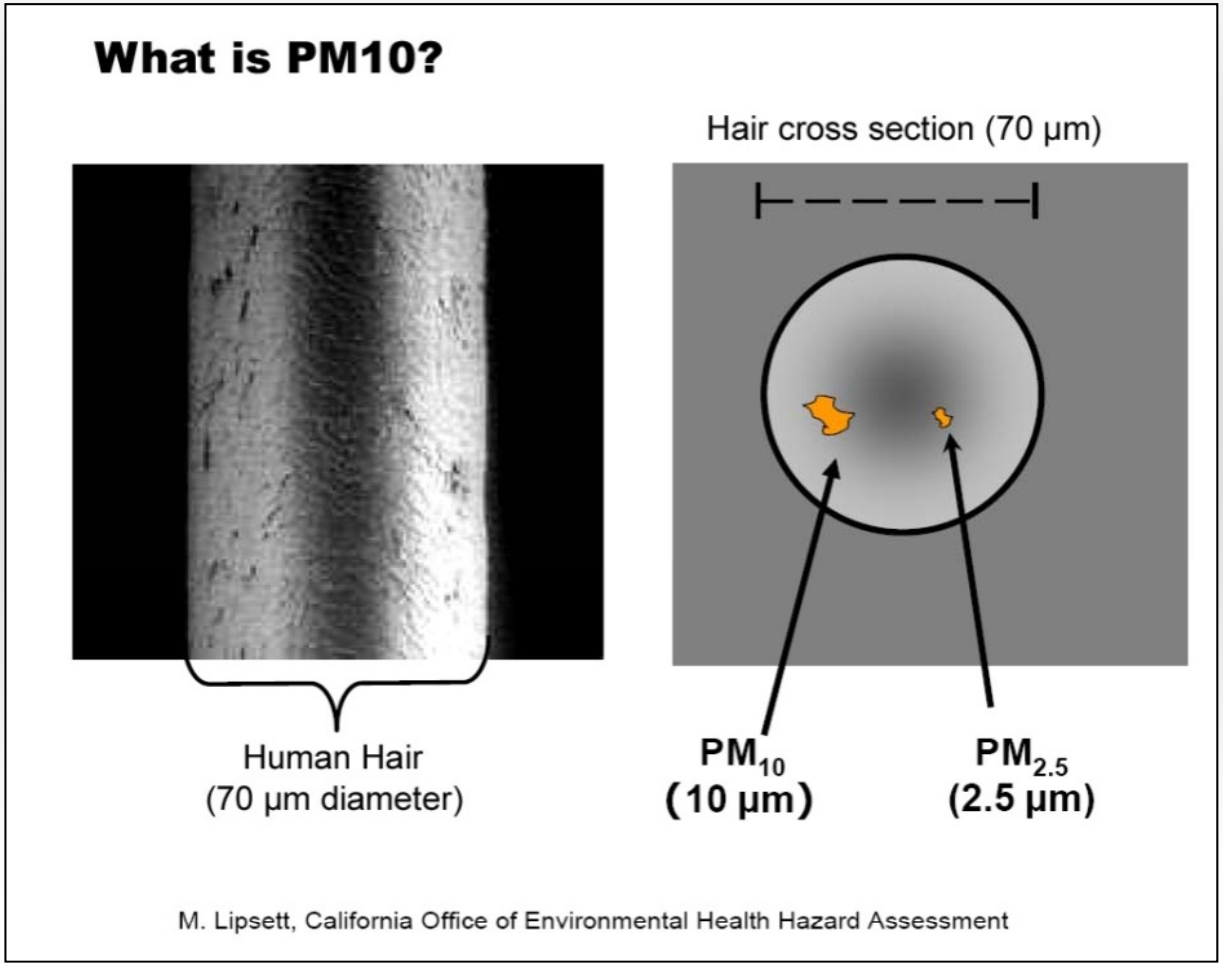
| location of impact | particle size |
|---|---|
| nose | 5 -10 µm |
| mouth | |
| wind pipe | 5 - 5 µm |
| bronchus | 2 - 3 µm |
| bronchioles | 1 - 2 µm |
| alveoli | 0.1 - 1 µm |

# Average speed of dust settlement

| | Diameter of Particles | velocity of dust settlement | | |
|---|---|---|---|---|
| | (µm) | (mm/s) | m/min | m/h |
| | 200 | 1200 | 72 | 4320.0 |
| | 100 | 300 | 18 | 1080.0 |
| | 50 | 70 | 4,2 | 252.0 |
| PM 10 | 10 | 3 | 0,18 | 10.8 |
| | 5 | 0.7 | 0,042 | 2.52 |
| | 1 | 0.03 | 0,0018 | 0.108 |
| | 0,5 | 0.007 | 0,00042 | 0.0252 |

# What is $PM_{10}$?

Particle diameter < 10 µm



# Wind speed by which dry particles (dust) are lifted from the ground

| diameter of particles (μ m) | wind speed (m/s) | | |
|---|---|---|---|
| | Granite | Silika | Coal |
| 10-35 | 4 | 3 | 3 |
| 35-75 | 6 | 5 | 4 |
| 75-105 | 7 | 6 | 5 |

9 m/s ≅ Force 5

Note: particle size ≠ aggregated

sand blast function at high wind speed

# Dust sources in open pits

**Source type:**

- Area — diffuse dust discharge of exposed surface
- Fixt — conveyor belt transfer points, bucket wheel excavator, spreader, coal bunker etc.

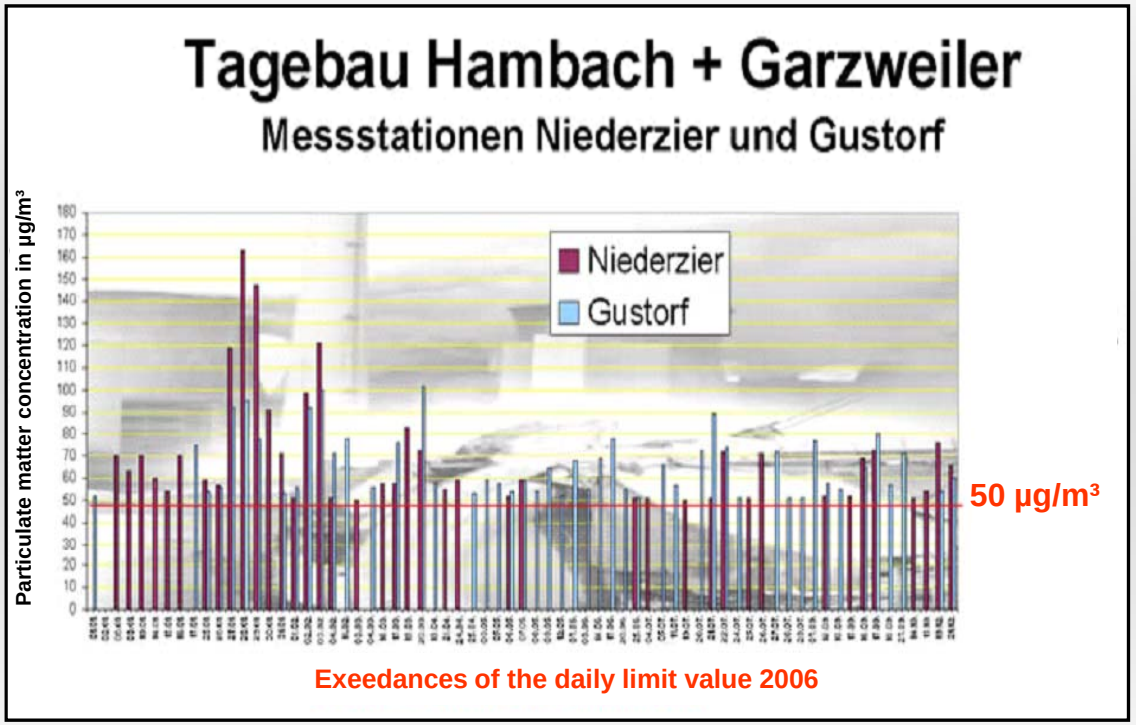
- Mobile — vehicles
- Linear — roads, conveyor belts

# Typical average $PM_{10}$- concentrations in Germany

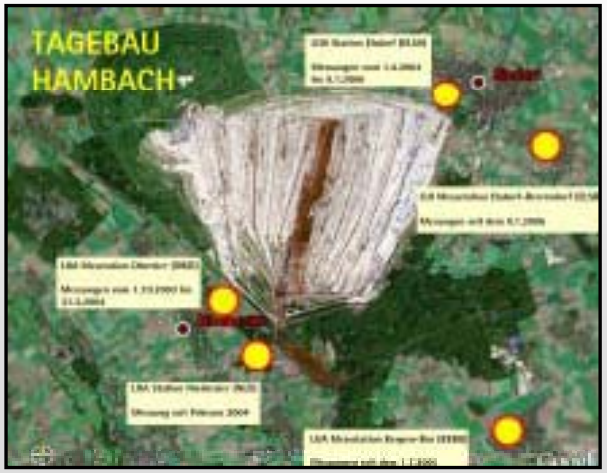
| | rural areas | urban areas | traffic areas | industrial areas |
|---|---|---|---|---|
| Annual average [µg/m³] | 10 – 18 | 20 – 30 | 30 – 45 | 30 – 40 |
| **EU directive** | **40 µg/m³** | | | |
| Number of days > 50µg/m³ | 0 – 5 | 5 – 20 | 15 – 100 | 50 – 90 |
| **EU directive** | **35** | | | |
| Highest daily [µg/m³] | 50 – 70 | 60 – 100 | 70 – 150 | 100 – 200 |

Source: Association of German Engineers (VDI)

# Particulate matter monitoring




Source: *BUND*



Source: *BUND*

# Major parameters affecting the particulate matter dispersion

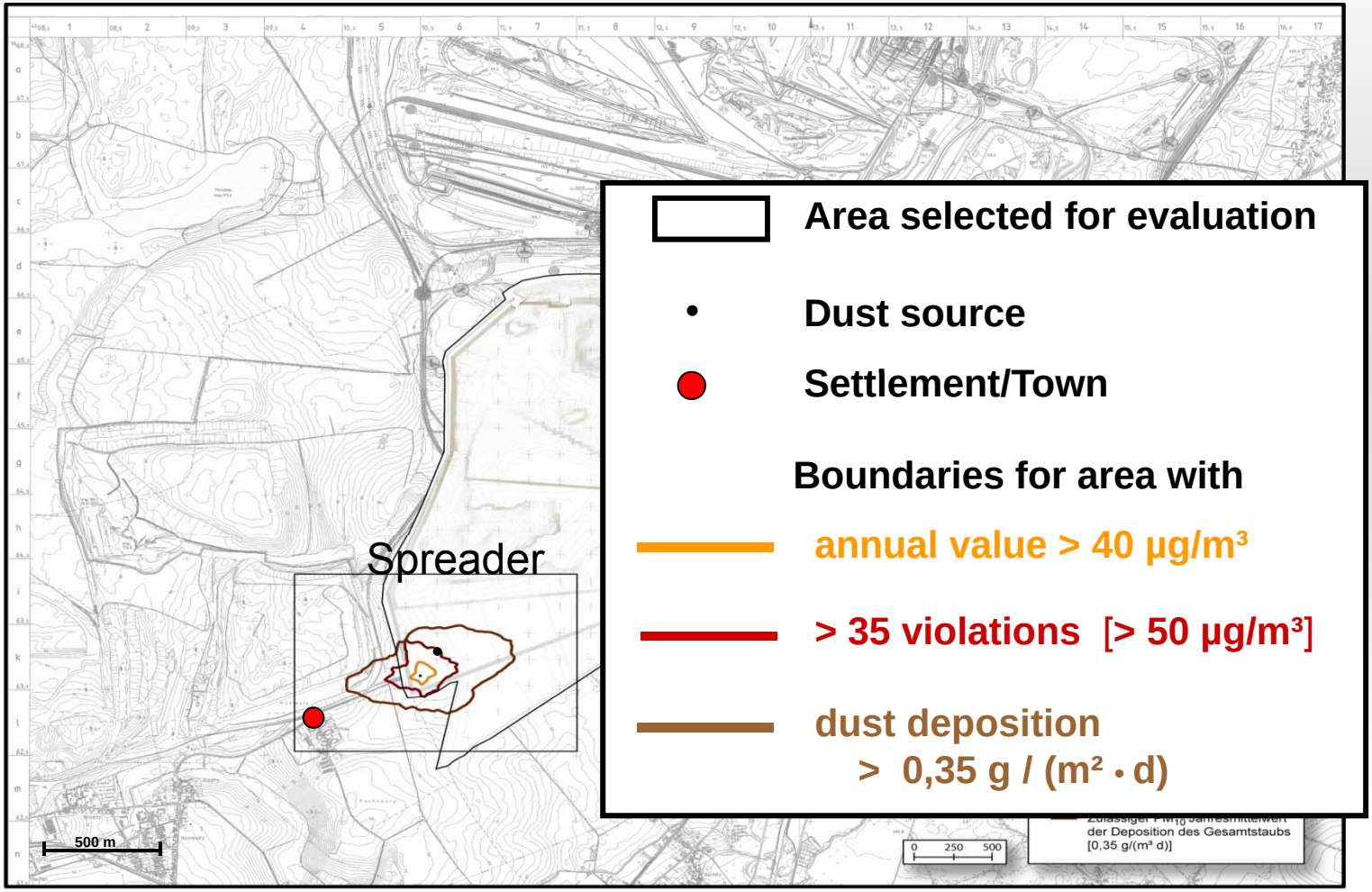
- Strength of source (emission rate, measured or calculated)
- Elevation of emitting source
- Terrain structure, DTM (fix or variable over time)
- Meteorology (historical data)

  Wind direction

  Wind speed

  Atmospheric turbulence

# Example of a PM-forecast by dispersion calculations




Source: R. Böhner

# Dust reduction measures

Application of water at a bucket wheel escavator

Watersprayer at the open pit edge

Water sprayer at the coal bunker in the Hambach lignite open pit

Conveyor belt enclosure

Intermediate greening

Vehicle cleaning station

Pictures: RWE Power

# Preventing dust immissions

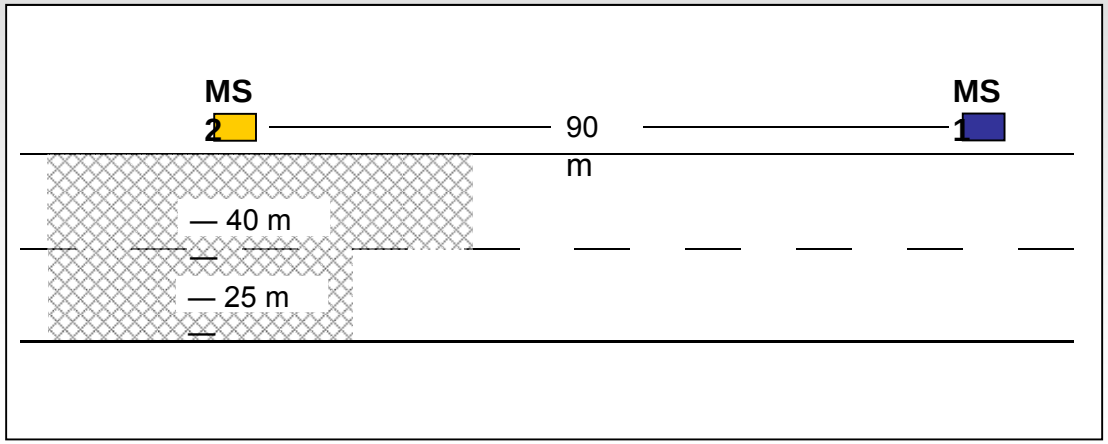
Using $MgCl_2$-brine to prevent dust emissions.

- Deliquescence: slow evaporation
- Anti-freezing characteristics: will not freeze till -33 °C

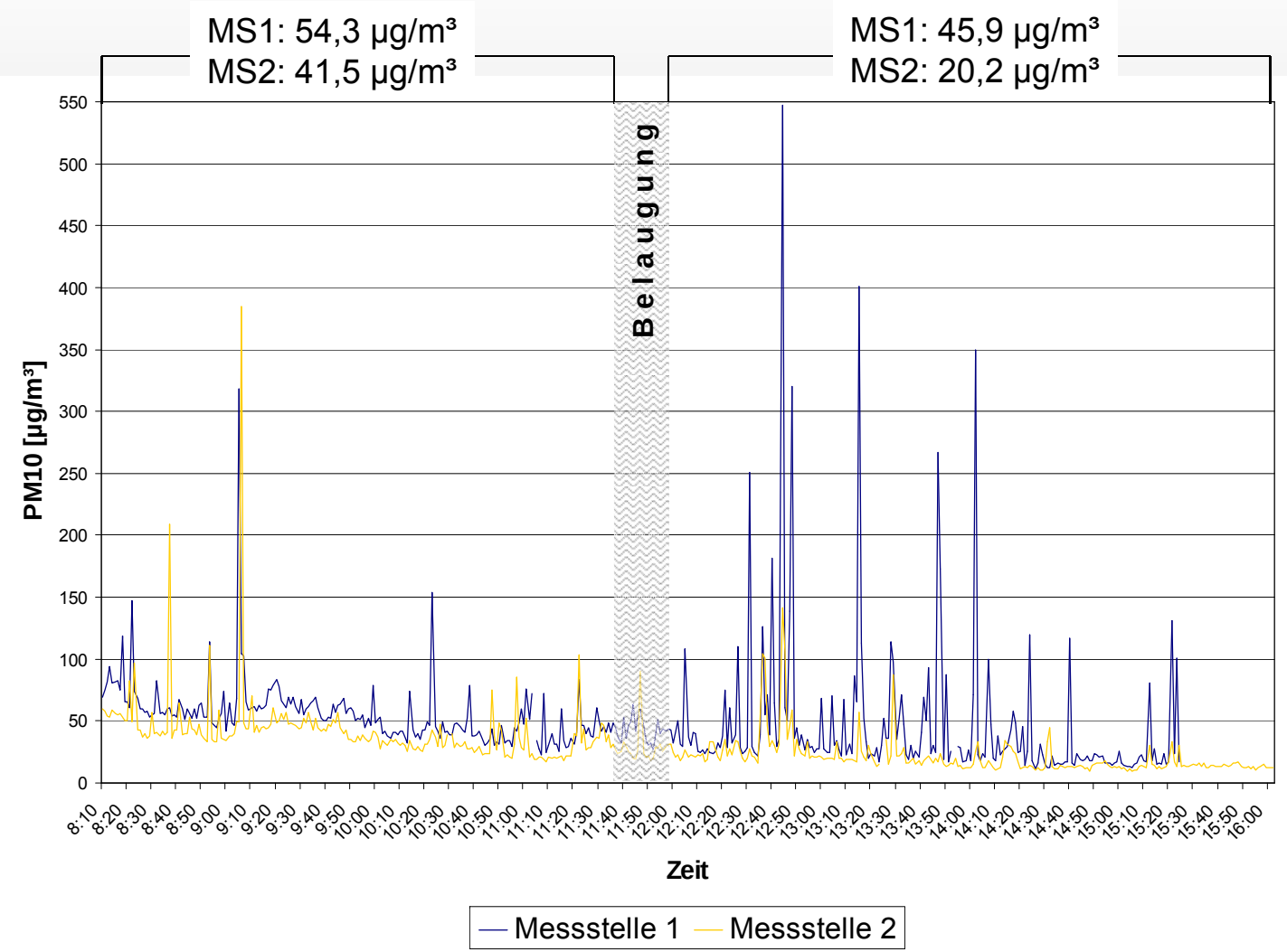
# Preventing dust immissions

Test 2: roadway

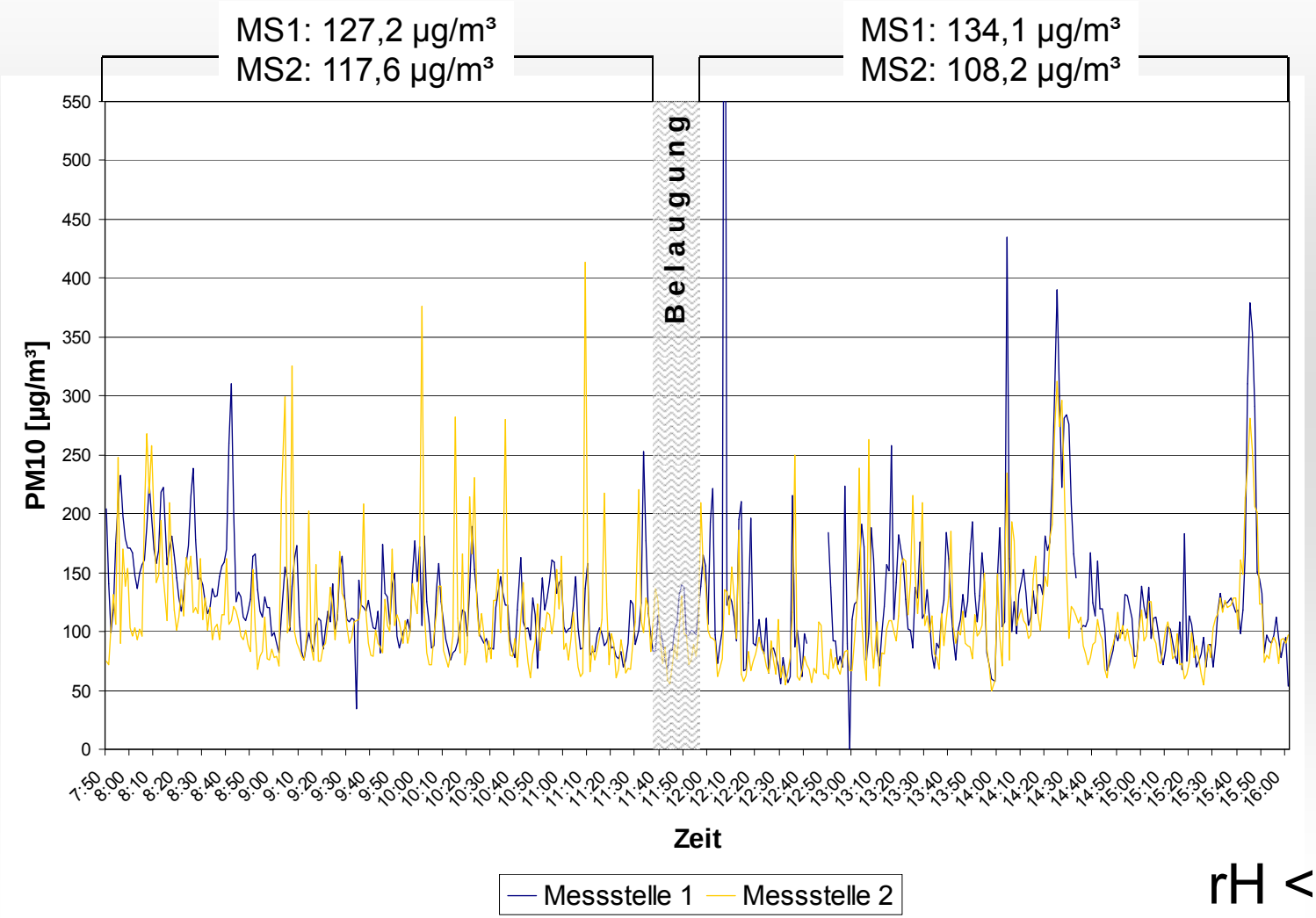
- No belt conveyor
- High traffic
- Distance 90m



# Testing the brine at measuring point 2



# Testing the brine at measuring point 2




rH < 30 %

# Preventing dust immissions

- $MgCl_2$-brine lowers the $PM_{10}$-conzentration near roadways
- Effect only measurable if rH > 30%
- Effect measurable up to 7 hours

- Water lowers the $PM_{10}$-conzentration even better, but evaporates very fast (depending on conditions)

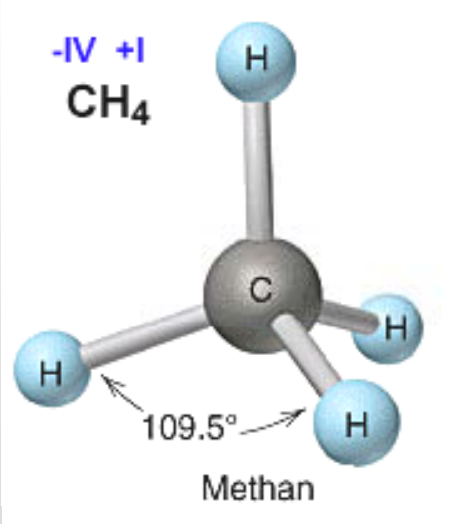
**BUT:**

- Dosing of brine difficult, no suitable machines available
- $PM_{10}$-conzentration depends very much on the speed of the vehicle, not on the type of the vehicle (car, LHD, truck, etc.)

# CBM

- Coal Bed Methane
- Gas generated by coalification
- ~90-95% methane;

  rest mostly nitrogen and carbon dioxide




Source: biokurs.de

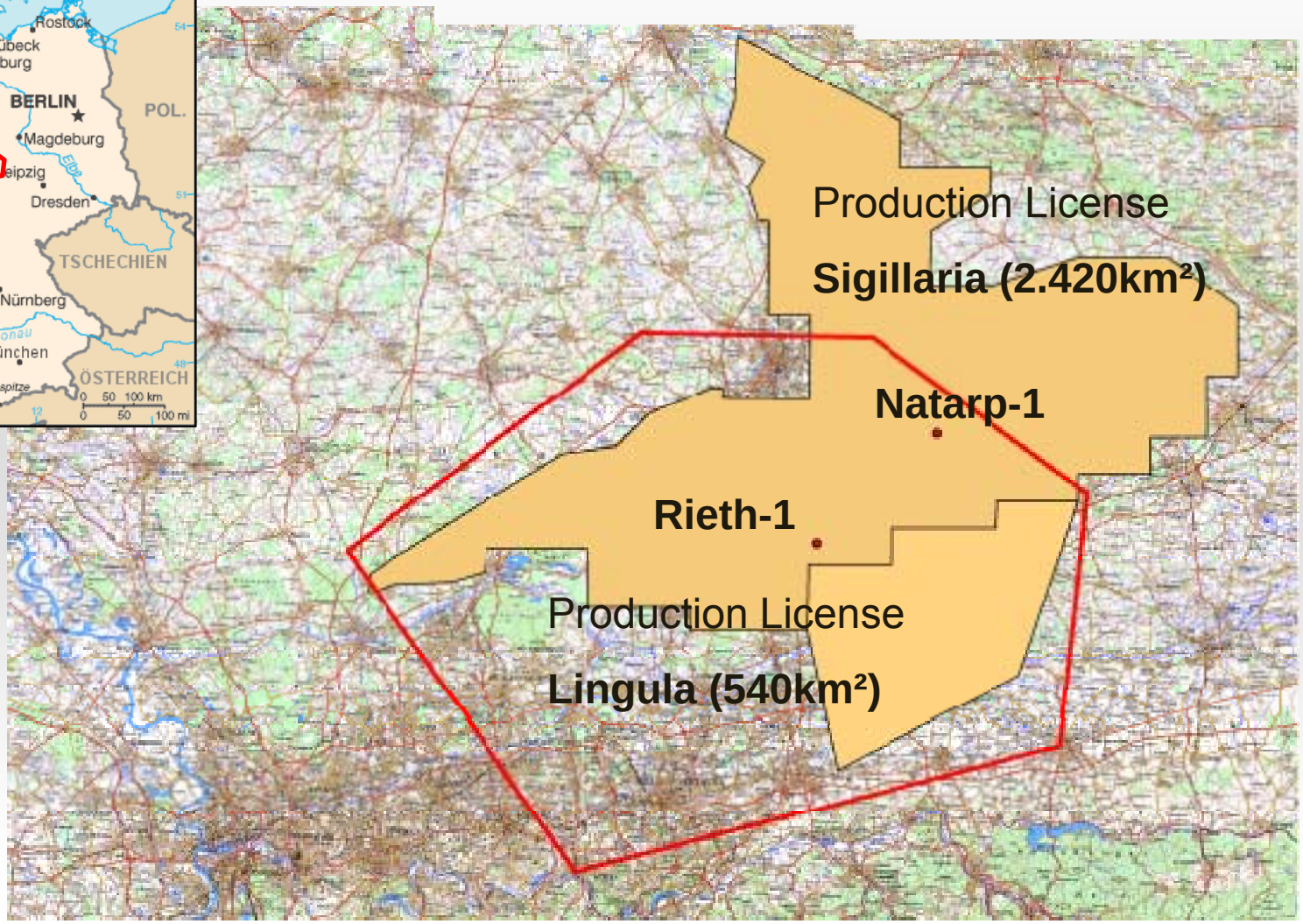
## Steps to “mine” CBM

- Raise the permeability of the coal (=stimulation)
- Lower the pressure in the deposit by pumping out water

  (pressure in the deposit must be lower than the pressure of desorption)

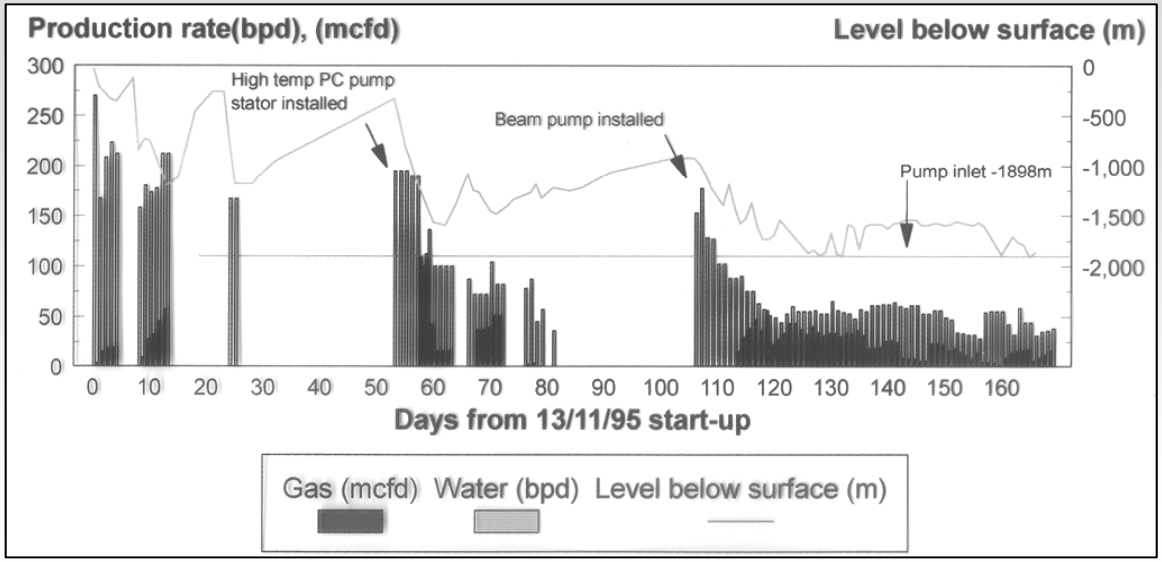
➡ gas starts to migrate and can be pumped out

# Joint CBM-project “Ruhr“ (1992-1998)

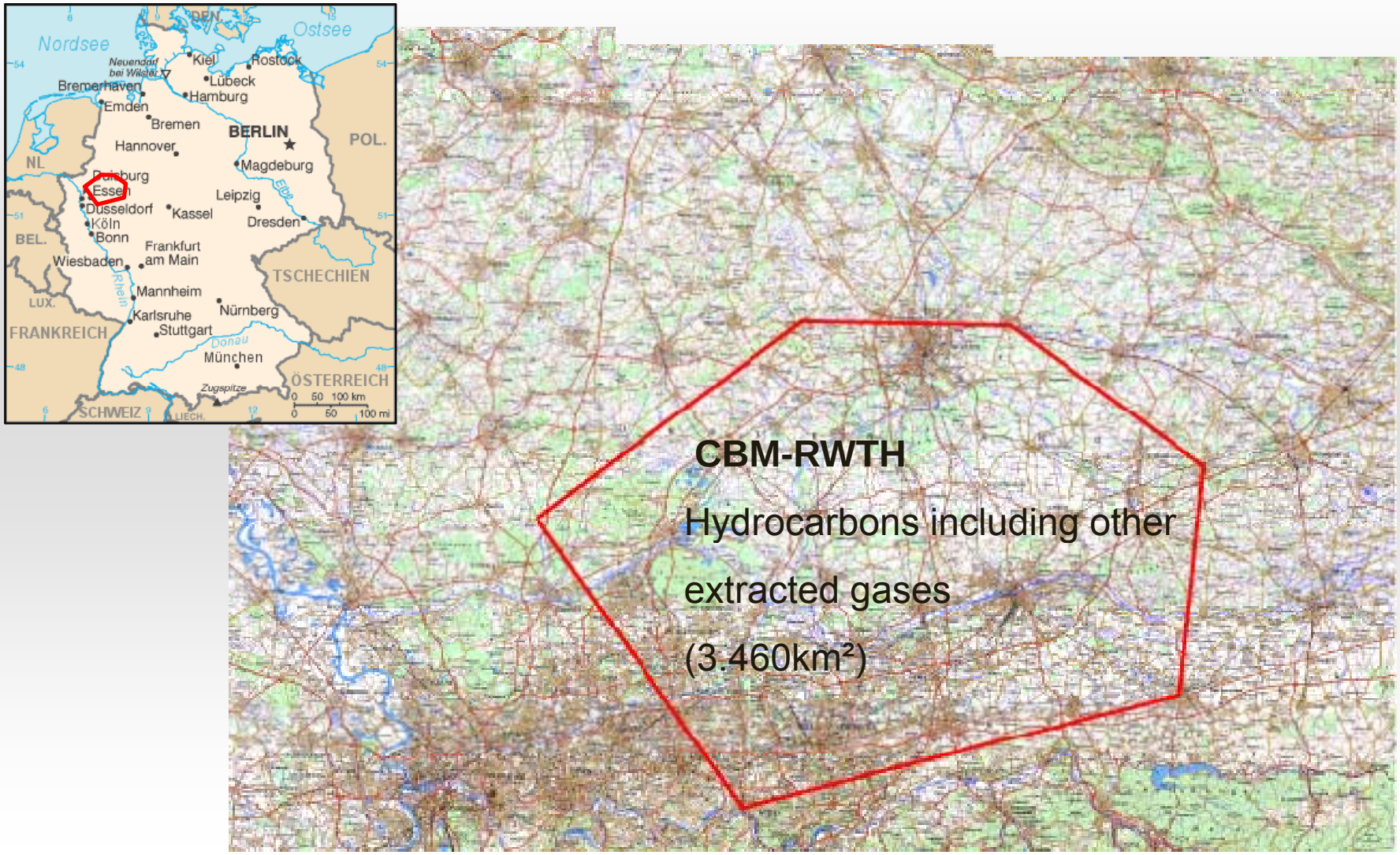


# **Drilling Site** – Stimulation by hydraulic fracturing

Drilling location: Natarp-1 (1995/96)



# Scientific Exploration License “CBM-RWTH“



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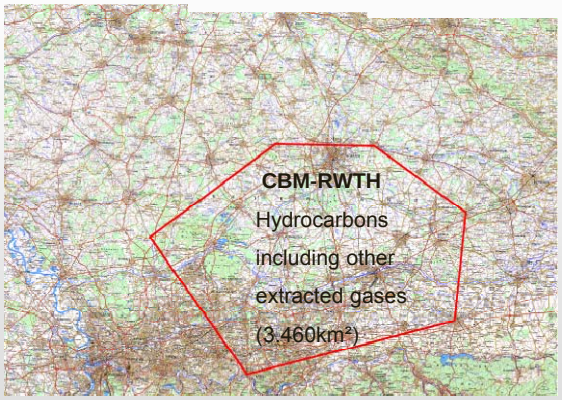


- Start in 2007
- Project of RWTH Aachen University / Minegas / State NRW
- Feasibility study (currently in progress)
- Tests and laboratory simulation
- Pilot CBM-well

# Thank you for your attention!

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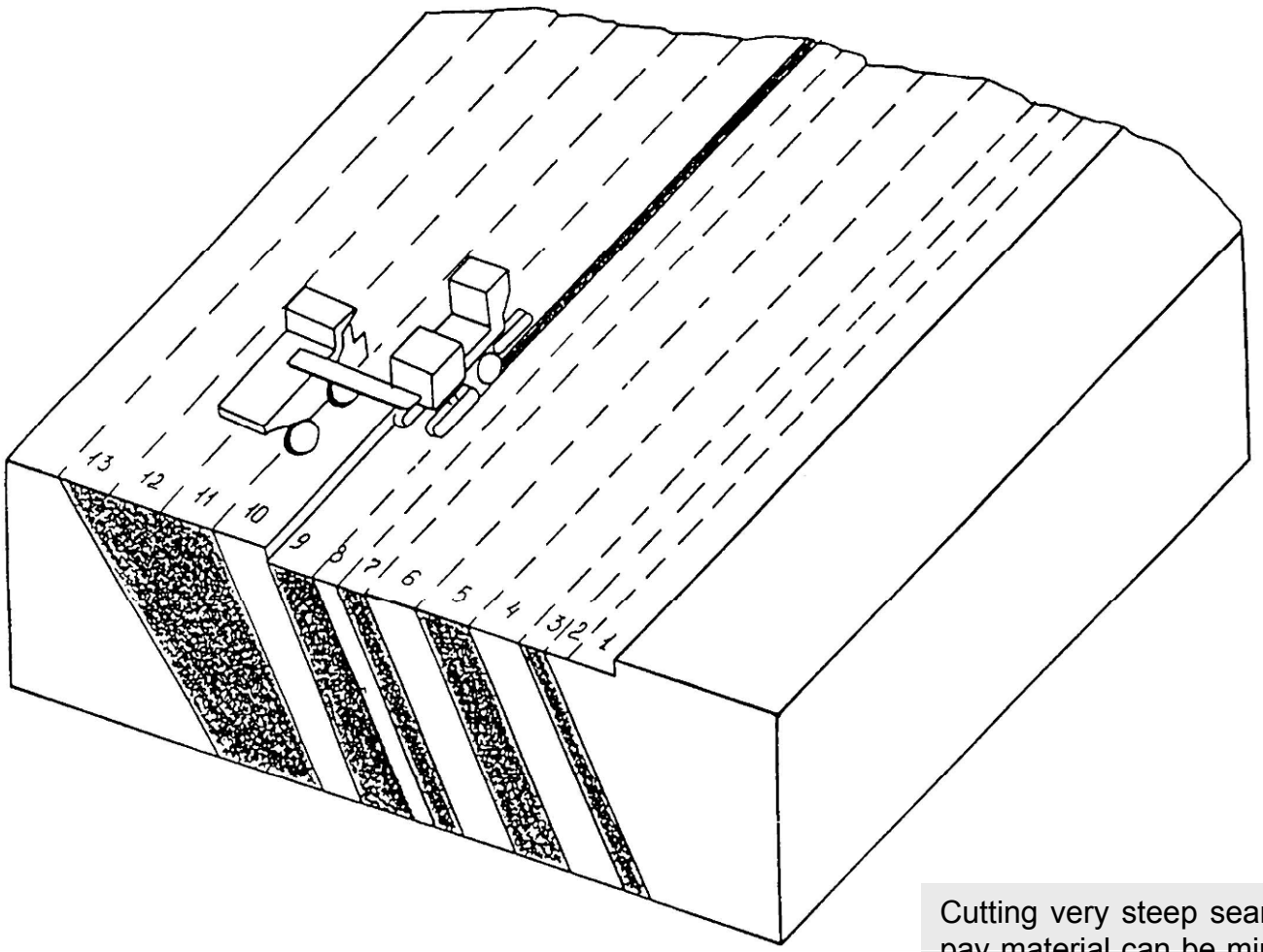
# Selective mining of steep seams




Cutting very steep seams or pockets of pay material can be mined as shown on the adjacent drawing.

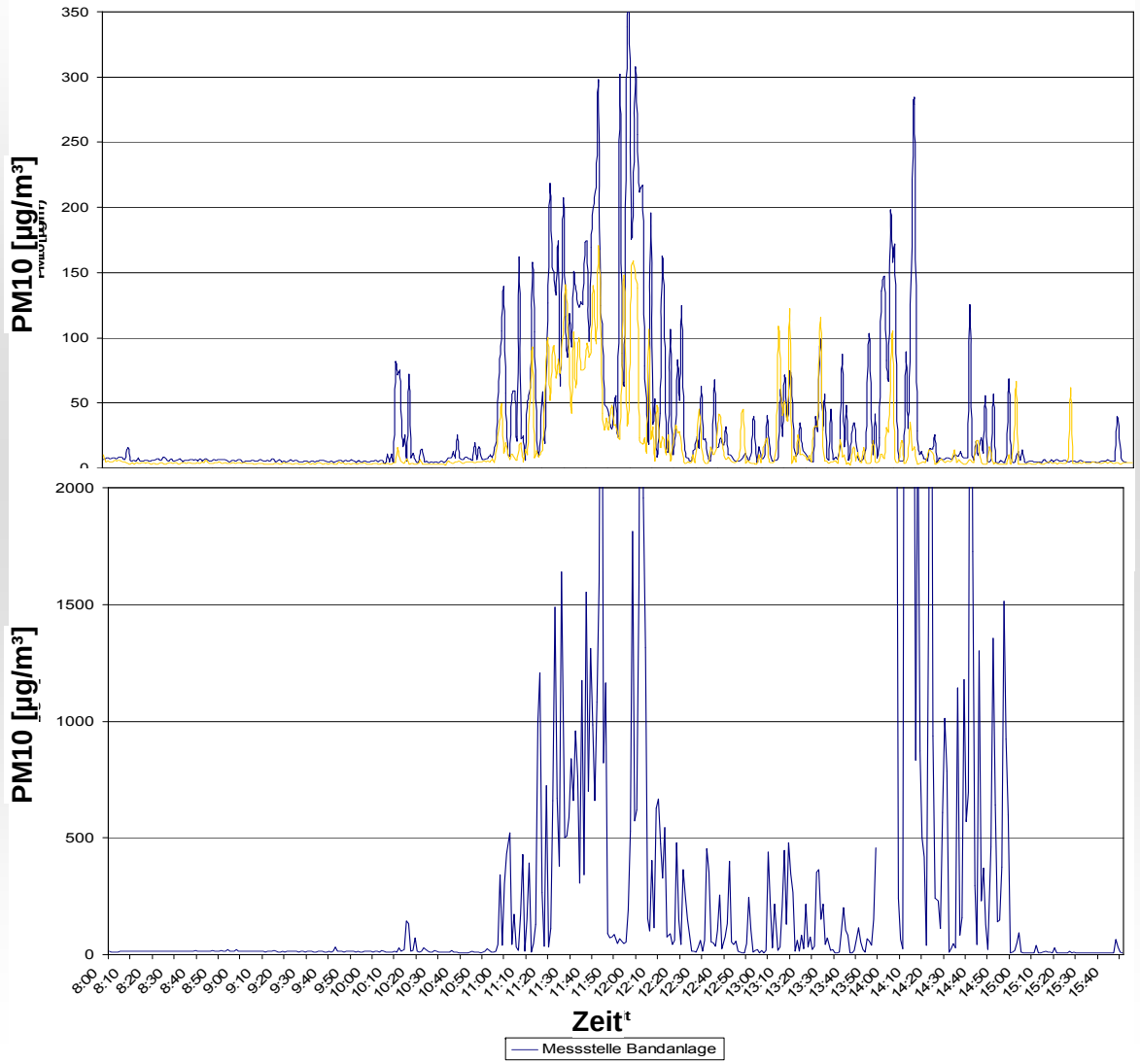
# Variation of grain size

# Classification of Indian Coal Qualities

| Grade | UHV Range (k cal/kg) | A+Mo Range (percent) | Gross CV (k cal/kg) of high moisture non-coking coals at 5% moisture |
|---|---|---|---|
| A | Exceeding 6200 | Upto 19.6 | Exceeding 6454 |
| B | Exceeding 5600 but not exceeding 6200 | +19.6 and upto 23.9 | Exceeding 6049 but not exceeding 6454 |
| C | Exceeding 4940 but not exceeding 5600 | +23.9 and upto 28.7 | Exceeding 5597 but not exceeding 6049 |
| D | Exceeding 4200 but not exceeding 4940 | +28.7 and upto 34.1 | Exceeding 5089 but not exceeding 5597 |
| E | Exceeding 3360 but not exceeding 4200 | +34.1 and upto 40.1 | Exceeding 4524 but not exceeding 5089 |
| F | Exceeding 2400 but not exceeding 3360 | +40.1 and upto 47.1 | Exceeding 3865 but not exceeding 4524 |
| G | Exceeding 1300 but not exceeding 3400 | +47.1 and upto 55.1 | Exceeding 3113 but not exceeding 3865 |

UHV (Useful heat value) is determined by the formula: UHV = 8900 - 138 (A + Mo)

A = ash percentage, Mo = moisture percentage

# Concentrations of PM10:

Near the road and near the belt conveyor (slide 41)