Backfilling = back stowing of rooms and galleries after the extraction of mineral salts for safety reasons

⇒ Protection of surface
• Prevention of large subsidence of the surface in urban areas with sensitive infrastructure constructions and facilities
• Prevention of rock bursts and strong seismic events in urban areas
• Save the integrity of the barrier horizons against ground water in the cap rock

⇒ Technical measures
• Improvement of mine ventilation
• Prevention of mine fires and the formation of dangerous gases and dusts
• Prevention or minimization of inflows of mine water

⇒ Optimized utilization of the resources of the mine
Development of subsidence on surface in a mining field of Sondershausen

Graph showing the development of subsidence over time from 1980 to 2008. Key events:
- **1982/83**: Start of salt mining
- **1991**: Start of backfilling
Backfilling with mineral industrial wastes

- Application in Germany since the 1990`s
- Use of the material properties of the wastes/waste mixtures for backfilling

⇒ Natural resources (e.g. sand, gravel, soil) can be substituted
⇒ Protection of resources and energy
⇒ Reduction of waste disposal (on surface and in underground)

✓ In accordance with the main target of the „Closed Substance Cycle and Waste Management Act“ of Germany (priority of waste recycling over waste disposal)

✓ Approval as a form of recycling by the European Court (in case of obligation for backfilling)
**Backfilling Ordinance**

- Regulates the recycling of wastes in companies controlled by the mining authorities
- Ensures a high quality recycling by priority of metal reclaiming (fixing of maximum metal contents, e.g. 50 % Fe, 10 % Zn and Pb, 1 % Cu)
- Definition of material requirements for the waste (= limiting values for harmful substances in dry matter and eluate)

⇒ **Serious restrictions for backfilling with industrial wastes in special geological formations like ore or coal**

⇒ **Limiting values are not valid for salt mines with an accepted long-term safety proof, because they**

  - meet the safety requirements of underground depots in Germany
  - offer a total enclosure and permanent isolation of waste materials from biosphere after the end of operation and sealing the facility
Backfilling methods

**Waste from salt processing**
- Waste salts (like NaCl)
- Clay sludges
- Brines and solutions

**Waste from other industrial processes**
- Products from flue gas purification
- Foundry sands
- Sludges
- Construction waste

**Industrial waste**

**Underground backfilling**
- Drop backfilling
- Hydromechanical backfilling
- Backfilling by Big Bags
- Flushing backfilling
- Backfilling by viscous slurry

**Backfilling room**
- Backfilling room

**Brine cavern**
- Brine cavern
Drop backfilling

- For wastes without further treatment (low content of hazardous substances, adequate geomechanical properties)
  - Construction waste, contaminated soil, furnace lining, slags
- Can be sprinkled with water or saline solutions to prevent dust formation
- Transport by containers down the shaft
- Underground transport by special vehicles (LHD, trucks, belt conveyor)
**Backfilling by Big Bags**

- For wastes already packaged by the producer or by the operator of the backfilling mine on-site (low content of hazardous substances, sufficient density and compression behaviour)
  - Foundry sands, boiler slags, industrial salts, waste blasting material
- Products of mixing plants
  - Dusts, ashes or fine grained bulk material mixed with liquids or slurries to improve the compression behaviour
- Cemented mixed products (e.g. addition of binders like cement)
Big Bags installed in layers and covered with fine salt to reduce pores
Hydromechanical backfilling

- For finely grained and grained wastes
  - Mining wastes from salt processing (flotation and leaching residues)
  - Dusts, ashes + products of chemical flue gas treatment from waste incineration, sewage incineration and waste to energy plants
  - Foundry sands, boiler slags, industrial salts
  - Filtercake and Sludge (e.g. from industrial water purification)

- For liquid mining wastes or inorganic industrial brines (chemical similar to mining brines)

- 2 different technologies:
  - Flushing backfilling: flowable suspension
  - Backfilling by viscous slurry: pumpable suspension with higher viscosity
Technology of flushing backfilling

- Adding of a concentrated salt brine to a mixture of solid wastes produces an flowable suspension

- Transport in pipelines from surface to backfilling room by use of the geodesic difference in height

- Salt brine: transporting medium + reactant for the setting process

- Excess transporting solution drains backfilling material by means of semi-permeable dam constructions

- Collecting the excess salt brine in a brine-collecting basin at a deeper point of the mine

- Salt brine is transported back to surface and used again as mixing liquid
Flushing backfilling material is flowing out of the transportation pipe

Central brine-collecting basin near the shaft
Backfilling by viscous slurry versus flushing backfilling

• No or only low excess of mixing liquid required
  (normally 40 - 55 % solids : 60 - 45 % salt brine)

• No brine drainage system necessary, small amounts of excess transporting solution are removed by weathering and admitted by excavation disturbed zone

• High saturation of the pore liquid ⇒ can be used also for sensitive host rocks

• Higher viscosity requires the installation of high performance pumps (e.g. plunger pumps)

• Mixing process can be carried out on surface or in the underground

• New technology: application for stabilization of brine filled caverns
Phase 1: Examination of the waste properties

- Preparation of a chemical declaration analysis according to fixed standards
- Determination of essential physical parameters (densities, grain size distribution)
- Investigation of hazardous waste properties (e.g. flammability)
- Investigation of the gas forming behaviour (e.g. hydrogen, ammonia)
- Examination of the waste as to its characteristics as a binder in contact with brines
- Evaluating the waste according to legal instructions concerning waste management (Backfilling Order), industrial hygiene and chemicals (Ordinance on Hazardous Substances, Health Protection Ordinance for Mining)
Verification of the Suitability for Backfilling in Laboratory Scale

Preparation of an expert opinion II

Phase 2: Evaluation of the waste as a component of a mix design

• Preparation of exemplary mix designs with the waste in laboratory scale, testing of the processing properties
• Examination of qualifying for backfilling under aspects of building physics (density, compression strength)
• Determination of the properties regarding mining safety (tolerance of backfilling materials among one another, hydrogen formation, behaviour against host rock)
• Evaluation of aspects of work protection of the backfilling mixtures
⇒ **Certification:**

- No dangers arising from the harmful substances in the waste during production and processing of backfilling material
- Wastes show the same characteristics as building material as the natural resources they substitute
**Backfilling with industrial wastes**

**Backfilling of rooms and galleries:**
- Salt mine Sondershausen (GSES mbH)
- Salt mines Bleicherode and Sollstedt (NDH-E mbH)
- Salt mine Teutschenthal (GTS mbH & Co. KG)
- Salt mine Unterbreizbach (K+S Kali GmbH)
- Salt Mine Stetten (Wacker Chemie GmbH)
- Salt Mine Heilbronn/Kochendorf (Südwest Salz AG)

**Backfilling of brine filled caverns:**
- NaCl-filled caverns in Staßfurt (Minex GmbH, Soda plant)

**Underground disposal**
- Salt mine Sondershausen (GSES mbH)
Thank you for your attention!