Experience in mine remediation
Case Study Germany: Uranium Mining

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Presentation Outline

- Background
- Remediation goals, approach, technologies
- 10 Lessons
- Conclusion
Background

- 1946–1990, SDAG Wismut major U supplier of Eastern Block
- Rigorous, irresponsible operational philosophy
- Part of defense sector
- 1990, termination of production: East German U industry left behind one of the most extensive legacies within the mining sector
- “Wismut Act”: Foundation of Wismut GmbH in 1991
  - Corporate purpose: Decommissioning and remediation of former uranium mining and processing facilities
  - Federal Republic of Germany is sole owner

World Uranium Production (1946-1990) in 10^3 t

- USSR: 377
- USA: 334
- Canada: 240
- Wismut: 231
- RSA: 140
- France: 64

SDAG Wismut was a major supplier of Eastern Block.
Site setting

Climate moderate, humid
Mean annual precip. 700-1150 mm/a
Mean annual temperature 6-9 °C
Project scope

- 3,700 ha operational areas
- 9 active deep mines w/ 100+ shafts, 1 open pit
- 2 processing plants
- 325 Mm$^3$ mine waste, 60 waste dumps
- 160 Mm$^3$ tailings, 10 TMF's
- Significant radioactive and conventional emissions
- Negative corporate image
Remediation goals

- Secure public safety
- Enable future land use
- Ensure radiation protection standards
  \( H_{\text{eff}} < 1 \text{ mSv/a, incl. radon, action level and remediation goal} \)
- Ensure ecological standards (water, air, soil, biota)
- Tackle stigmatizing of regions affected by U mining
Main Activities

- Dismantling of surface structures and site clean-up
- Closure of underground mines and mine flooding
- Safekeeping of solid mine waste, especially tailings
- Effluent management
- Environmental monitoring & Maintenance
Remediation achievements

- > 90 % of physical remedial work completed
- Worldwide **unique examples** for after-use of former uranium mining areas
- **Achievement of radiological remediation** objectives
- **Significant mitigation** of residual contaminant transfer into environment

*However, active aftercare measures required, mainly water management*
Lesson 1

Sustainability Principles *

- **Reduce existing environmental impacts** to a socially accepted and reasonable level
- **Value-added reuse**, promoting regional development
- **Robust remediation solutions** requiring no or limited active after care
- **Maximum reuse of resources**
- **Long-term availability of information and know-how**, to support institutional control and public awareness

* to be applied at legacy/abandoned mine sites, see WISSYM_2011
Lesson 2

Technical Planning & Supervision

- Site characterization and site-wide Conceptual Model (CSM)
- Top-down approach, step-by-step implementation
- EIA and cost benefit optimization
- Use BAT (Best Available Technology), reflecting BEP (Best Environmental Practice)
- Adaption to site conditions
- Strict on site construction supervision, based on appropriate quality assurance (QA) programmes and adequate quality control (QC)
Lesson 3

**All-time focus on over-all decision making process**

1. **Objectives**
   - Definition of remediation objectives

2. **Criteria**
   - Definition of remediation criteria and ways to measure them

3. **Options**
   - Identification of remediation options, resources and process optimization

4. **Technology Selection**
   - Selection of remediation technologies

5. **Implementation**
   - Implementation of the remediation plan

6. **After-care**
   - Monitoring/post-remediation management

7. **Characterization**
   - Base line and site characterization

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Lesson 4

Understanding and overcoming key bottlenecks

- Responsibility and Financing
  - Critical shortage, long lead-time
  - > 9,500 permits (2017)
  - Establishment of specific management tools

- Permitting

  - ~ 50 % of funds contracted out
  - General rule: Public procurement
  - Long lead time for major investments and services

Lesson 4

Understanding and overcoming key bottlenecks

- Responsibility and Financing
  - Critical shortage, long lead-time
  - > 9,500 permits (2017)
  - Establishment of specific management tools

- Permitting

  - ~ 50 % of funds contracted out
  - General rule: Public procurement
  - Long lead time for major investments and services
Lesson 5

Key assets: Infrastructure and personnel

- To partially act independently from market
- To ensure institutional capabilities

Challenges:

- **Personnel**: Necessary workforce reduction vs. retaining key qualifications
  - Maintain a stable workforce at operator and management level
  - Adaption to changing skill-sets, training, etc.
- **Infrastructure**: Remediation mandate („Dismantling“) vs. temporal demand for remedial work
  - Masterplan needed
Lesson 6

Water management

- **Key relevance** for mine closure projects, crucial pre-requisite for proper and on-schedule project implementation
  - Interdependence with all activities & aspects
  - Large number of potential pitfalls
  - Longevity of effects
  - Key performance indicator for remediation success
  - Key cost factor
- Variability / extreme events challenge for long term rational decision making (“the average does not exist”)
- Misjudgements may lead to substantial delays, cost increase, loss of prestige
- **Holistic approach** needed
Lesson 7

Mine flooding

- Flooding w/ natural GW-inflow, stepwise, controlled, monitored
- All five UG mines **flooded to the maximum level possible** (‘Qualified high inundation level’)
  - **Suppress** ongoing ARD generation & metal leaching
  - **Energy saving**, but also minimization of GW inflow
  - **Triggering stratification and natural attenuation** (NA)
- Leaving mines “open/ unflooded” no valid option, due to running cost for dewatering, ventilation, mine safety, etc.
- Water treatment also necessary for dewatered status
- 2014, one fully-flooded UG mine released from active treatment
Lesson 7

Water treatment

- Despite implementation of sophisticated encapsulation/cover strategies, long-term water treatment **inevitable** at 6 out of 7 sites
- **Biggest long term burden**
- Main contaminants: U, As, Ra-226, Fe, other metals
- Modified HDS lime precipitation
- Adaption due to changes in flow rates and compositions, also increasing demands regarding **cleaning performance**
- Passive approaches **did not meet design expectations**
- **In-situ measures** (source term control) have restricted applicability
Lesson 8

Gaining value from mine water

- **U recovery** at one mine site, no longer economic
- Some potential for Sc and REE (R&D), but **key obstacles** for full-scale implementation
  - Significant up-front and operating cost vs. restricted total mass
  - Energy balance of production
  - Lack of costumers of concentrates
  - Conflicting trends with remediation (concentrations, fluxes)
  - The “radiation label” is incredibly sticky
- Value-added conditioning of residues technically not feasible/ uneconomic
- Potential for recovery of geothermal energy very limited
Lesson 9

Gaining value from former mine land or tailings reprocessing

- **Main after-use**: Re-forestation, grass land
  - Others: Small scale business, recreation, renewables
  - Restricted after-use at sites with remaining contaminants

- **Some income** from land purchase/lease, but only partially compensating after-care cost

- **Why no tailings reprocessing?**
  - No net benefit (early attempts been dropped)
  - Additional operational risks and emissions
  - Tailings stay hazardous
  - No alternative, safer storage site available
Stakeholder involvement

- **Early and consistent stakeholder consultation** key to success for overall process
- Overcoming conflicts with private or public landowners
- Public expectations often driven by non-technical perceptions

**Approach**

- **Transparency**, in particular disclose of environmental data
- **Trust and credibility**, to be gained from the public
- **Targeted involvement** of key stakeholders (local municipalities, NGO’s)

Lesson 10
What can WISMUT offer to the International Mining Community?

- Internationally accepted benchmarking project for Mine Closure and remediation of radioactive waste
  - Proven & standardized technologies and workflows
  - State-of-the-art approaches to EIA, Monitoring, Data & Know-how management
  - Well-documented case histories
  - Multitude of knowledge sharing activities
Conclusions

- **International benchmarking project** for mine remediation
- **Balancing** of ecological, economic and social interests necessary for sustainable remediation solutions
- **Keys to success** of the WISMUT programme:
  - Strong and decisive **political motivation**
  - Retaining **valuable skills**
  - Immediate and stable **funding**
  - Recognition of **non-technical factors**
- **Long term surveillance and monitoring (LTSM) activities** necessary to ensure sustainability of remediation results
We’ve done it. Successfully.