Management of Radioactive Residues & Wastes Generated During Remediation of Uranium Production Legacy Sites in Germany

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The WISMUT Env. Remediation Project

- 1946 – 1990, Soviet-German WISMUT Company in East Germany, major uranium supplier to the Soviet Union (~ 216,000 tonnes of U)
- 1990, U production terminated (i.t.w. of German reunification)
- Legacies left behind: 300 Mio. m³ waste rock materials (65 dumps); 178 Mio. m³ rad. sludges (5 tailing management facilities; 3’700 hectares industrial areas, ...)
- Remediation funded by the German Government (7,1 b€)
- Physical work till 2028, long-term activities till 2045
WISMUT sites

Selected older U-sites beyond the Wismut project

Int. Symposium NORM VIII, Rio de Janeiro, October 18-21, 2016
Main remediation activities

- Demolition of Structures
- Mine Flooding
- Water Treatment
- WT residues Management
- Monitoring
- Stabilisation/coverage of radioactive sludges (tailings)
- Relocation/coverage of waste dumps
- Clearances/waste management

P. Schmidt: Management of radioactive residues and wastes generated during remediation at WISMUT sites
Residues and wastes generated during remediation

- Contaminated mine water, seepage and pore water
- Water treatment residues
- Scrap from demolition and dismantling
- Debris from demolition and dismantling
- Excavated soil from area clean-up and waste rock remediation

Reuse → Recycling for reuse → Sale → Long-term safe disposal
Water treatment

- At WISMUT, six water treatment facilities (WTF) in operation, with capacities from 200 – 1’150 m³/h
- Mine, seepage and pore water (U-nat: 2 - 50 mg/l; Ra-226: 1 - 5 Bq/l)
- Total annual water volume treated (2015): 17,4 Mio m³
- Main Technology: lime precipitation; at the Königstein also ion exchange
- Site-specific discharge limits: U-nat: max.300 µg/l; Ra-226: max. 800 mBq/l
# Water treatment residues

<table>
<thead>
<tr>
<th>Site</th>
<th>Type of water treated</th>
<th>Hazardous Substances of concern</th>
<th>Annual volumes of water treated (mean 2010-2014)</th>
<th>Annual volumes of residues produced (mean 2010-2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>$10^6$ m$^3$</td>
<td>%</td>
</tr>
<tr>
<td>Schlema</td>
<td>Mine water, seepage water</td>
<td>U, As, Ra-226</td>
<td>6,62</td>
<td>32,4</td>
</tr>
<tr>
<td>Ronneburg</td>
<td>Mine water</td>
<td>Heavy metals, U, As</td>
<td>6,11</td>
<td>29,9</td>
</tr>
<tr>
<td>Königstein</td>
<td>Mine water</td>
<td>U, Ra-226, heavy metals</td>
<td>3,50</td>
<td>17,1</td>
</tr>
<tr>
<td>Seelingstädt</td>
<td>Mine water, seepage water</td>
<td>U, Ra-226</td>
<td>2,18</td>
<td>10,7</td>
</tr>
<tr>
<td>Helmsdorf</td>
<td>Mine water, seepage water</td>
<td>U, As, Ra-226</td>
<td>0,97</td>
<td>4,8</td>
</tr>
<tr>
<td>Pöhla</td>
<td>Mine water</td>
<td>As, Ra-226</td>
<td>0,11</td>
<td>0,6</td>
</tr>
<tr>
<td>Andere 2)</td>
<td>Diverse</td>
<td>Diverse</td>
<td>0,95</td>
<td>4,6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>20,45</td>
<td>100,0</td>
</tr>
</tbody>
</table>

2015: 30'000 t precipitates; ...100 Bq/g $^{238}$U, ...40 Bq/g $^{226}$Ra
40 t extracted uranium

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WTF Schlema-Alberoda

- 1150 m³/h capacity
- discharge limits: max. 200 µg/l U-nat; max. 300 mBq/l Ra-226
WTF Königstein:
- 500 m³/h capacity
- mean discharge limits: 300 µg/l U-nat; 400 m Bq/l Ra-226
Management of WT residues (waste)

Sale of extracted uranium
- At a break-even price to a nuclear sector company; monitored by EURATOM,

Solidification and Immobilisation
- Sludge separation, dewatering (thickening, filter press)
- Embedding into a cement-based matrix
  
  (site-specific technologies to meet final disposal criteria, to consider the geo-/hydro-chemical and mechanical conditions)

Long-term safe disposal
- Engineered facilities
- In: waste rock piles, beach areas of tailings MF, mines
Residues from the Schlema water treatment plant

Pressing; cement mixing; filling in bigbags and disposal at an engineered facility at waste rock pile #371
Water treatment residues at the Königstein site

Sludge separation

Waste dump Schüsselgrund, disposal of WT residues

Transport of separated uranium for sale

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Metallic scrap

- 260,000 t of metallic scrap
- Contamination: … 50 Bq/cm² surface total activity (TAA)
- Different nuclide vectors (rad. equilibrium, tailings, radon progenies, U concentrate)

Options:

- Unrestricted reuse (TAA < 0.05 Bq/cm²)
- Restricted reuse (smelting; TAA < 0.5 Bq/cm²),
- Safe disposal (TAA > 0.5 Bq/cm²), as for WT residues
- Reuse after de-contamination (clearance measurements)
- Re-use after separation (clearance measurement)
Decontamination of metallic scrap

Scrap shear

Decontamination facility
(abrasion mill; only for “core” scrap)
Decontamination of metallic scrap in combination with clearance measurements

Recent example (2014/2015):

- Demolition of the shaft complex #388/390, Königstein site
- Decontamination of surfaces by a water-jet system
- From 4’230 tons of metallic scrap, almost 2’020 tons could be released for smelting
Separation by clearance measurements

Re-use of lowly NORM-contaminated metallic scrap for smelting

Clearance criteria: Surface Total Alpha Activity \( TAA = 0,5 \text{ Bq/cm}^2 \)

Requires a special measurement methodology for clearance

WISMUT approach: screening measurements of the beta surface activity; calibration against alpha activity, statistical data interpretation; QA (lab)
Comparison of the TAA reference value (0,5 Bq/cm²) with the upper limit of the confidence interval (95 % confidence value)

TAA mean value = 0,11 Bq/cm²
Upper confidence limit = 0,14 Bq/cm²

Frequency distributions of TAA values for a heap of scrap metal at WISMUT
Excavated soil from area and waste rock pile remediation

- 14.5 Mio t (cumulative total at end of clean-up)
- U-238: 0.2 – 10 Bq/g; Ra-226: 0.2 – 10 Bq/g

Relocation to other waste dumps; disposal at Tailings facilities

Reuse options – limited!

- Only inside of WISMUT
- Refilling of the Lichtenberg open pit
- Contouring of surfaces of covered tailings ponds

Blending with inert material / dilution / use of material outside of WISMUT is not allowed (0.2 Bq/g classification level)
Tailings management facility Culmitzsch:

- Use of waste rock material from dump „Nordhalde“
- Contouring; construction of a hilly surface contour
- Drainage, two final discharge channels
Non-metallic waste from demolition (debris…)

- 14.5 Mio t (cumulative total at end of clean-up)
- U-238: 0.2 – 10 Bq/g; Ra-226: 0.2 – 10 Bq/g

Disposal
- non-contaminated waste: at landfills
- contaminated waste at WISMUT disposal sites (tailings ponds, rock piles)
- no enhanced efforts for separation
  (space is available, easy to get approval from mining authorities; cost-effective)

Approach is on that score different to approaches at D&D of nuclear facilities

Limited reuse (fill material, for slope stabilization)
Summary and conclusions

- Remediation of uranium productions legacy sites generates enormous amounts of “new” residues and wastes
- For their management, WISMUT has developed site and process specific solutions
- WISMUT benefits from available space for disposal
- Whenever possible, decontamination / recycling and re-use of material is envisaged (regulatory requirements)
- However, blending of material and its reuse out-side of WISMUT is not permitted
- Nonetheless, WISMUT case study provides ample basis for sharing experiences on the management of large amounts of residues and waste with elevated natural radioactivity
Many thanks for your attention …

and a warm „Glück Auf“