Remediation of an Uranium Mining Waste Rock Dump in Slovenia

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History of Uranium Mining in Slovenia

- Žirovski Vrh Uranium Mine (RUŽV)
  - Uranium mineralisation found in 1960
  - ore exploitation started 1982
  - yellow cake production from 1984
  - production ceased unplanned in 1990
- Uranium mineralisation in sandstone formation
  - Prospected reserves 16000 t U3O8, average conc. 0.084%
  - production 1982 to 1990: 452 t U3O8
- remediation of underground mine, mine waste rock and tailings pile
  - planned until 2010
  - Total costs of ca. 86.3 Mio €

Mine waste rock pile Jazbec

- Characterisation (August 2008)
  - 7 ha surface area
  - 1.91 Mio t rocks (0.51 ppm U3O8), 0.205 Mio t low grade ore (221 ppm U3O8)
  - 48.000 t sludge from water treatment (red mud; 25 ppm U3O8)
- Problems
  - not fully operational drainage system at the pile bottom
  - Groundwater inflow to pile from bedrock - contaminant release
  - Water management
    - Surface water discharge through a concrete culvert below pile
    - Rainfalls (0.1 1800 mm/a) with torrential characteristics
  - Contouring of pile difficult due to
    - limited area at the dam toe
    - Radiological problems during excavation of piled material (red mud - high Thorium content)
    - Steep slopes requiring geotechnical stabilisation measures

Location

- Žirovski Vrh
  - 45 km west from capital Ljubljana

Location – Mining objects

- Underground mine
- Mine waste rock pile
- Tailings pond
- Concrete channel below Jazbec
- Drainage Tunnel
- Borst
- Paleo-Landslide
- Retention pond
- Mine adit
- Channel adit

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Culvert: Collection of seepage (surface) waters
Concept for mine waste rock pile remediation
- Relocation of mine waste rocks from smaller piles
  - 470000 t in total, sieved and partly re-used
    - underground mine backfilling,
    - track construction, Drainage material for contouring tailings pile
  - Revegetation of the footprint area
- Test cover sites for determination of covering technology
- Covering of mine waste rock pile Jazbec
- Winning of cover material at the Jaka site (owned by RZV)
- Cover thickness [m] and material k f-value [m/s]
- Vegetation layer: Humus, k f-value 1 × 10–5
- Storage layer: Jaka: 0/63mm, k f-value 1 × 10–7
- Protection layer: Jaka: 0/63mm, k f-value 5 × 10–8
- Sealing layer: Clayey sand, k f-value 5 × 10–9

Geotechnical aspects
- Steep slopes → stability of cover layers
  - Short slope length
  - Slope lining with rocks
  - Additional drainage elements in cover layers to discharge interflow
- Steep slopes → stability of cover layers
  - Long slope length
  - Slope lining with rocks
  - Additional drainage elements in cover layers to discharge interflow

Uranium release in seepage and surface waters
- Outflow from culvert
  - Significant load reduction
  - But: increased concentration due to less dilution
- Uranium-Load
  - Average U-concentration
  - Measuring point: Pile surface water included
  - Measuring point: Pile surface water excluded

Lessons learned and long-term activities
- Site specific remediation solution
  - Re-use and relocation of waste rock material to central pile
  - Reshaping with spatial restrictions → geotechnical stabilization measures
    - stone lining, gabions
  - Cover test plot to determine
    - cover design and technology
    - Applicability of cover material
    - QA/QC parameters and procedures
  - ET-cover with locally available material
  - Management of surface and seepage waters, cover interflow
- Radioactive legacy → necessary long-term monitoring and maintenance requiring
  - Funding
  - Record keeping

Thank you for your attention!