Remediation of Cretaceous Sediments affected by uranium in-situ leaching (ISL) in the Czech Republic
NATO SPS Study "Prevention and Remediation Issues in Selected Industrial Sectors"
Ljubljana, 17 – 22 July 2007

Geological map of the Czech Republic

MINISTRY OF ENVIRONMENT, CZECH REPUBLIC
Prague 2007
History of deep mining

1978
start of mining at Hamr I

1982
start of mining at Křížany I

1990 - 2003
end of mining and liquidation of Křížany

1993 – 2004
end of mining and liquidation of Hamr
History of chemical mining

1966 - 1967

1st leaching experiments

1974

beginning of chemical mining

1996

start of the remediation
Uranium production

1967 - 1996
more than 27 000 t of uranium
deep mining - 11 600 t
chemical mining - 15 800 t
Stráž - chemical treatment plant and tailings ponds
Schematic cross-section of the area

- **Ralsko**
- Leaching fields
- Hydrobarrier Stráž
- Drainage system
- Hamr I mine

**Layers and Water Levels:**
- Turonian aquifer
- Low Turonian semiaquitard
- Cenomanian aquifer
- Crystaline shists

**Water Levels:**
- Cenomanian piezometric level
- Water level

**Contamination Levels:**
- Weak (0.5 - 20 g/l)
- Strong (20 - 100 g/l)
Principle of hydrobarriére

- Leaching fields
- Centomanian water level
- Strongly concentrated solutions
- Hydrobarriére
- Cleaning
- Uranium separation
- Discharge
- Hamr I mine
- Drainage
Piezometric heads
Before HB construction

- Ralsko
- leaching fields
- HAMR deep mine
- water level in cenomanian aquifer
- contamination
- water level in turonian aquifer
- cenomanian aquifer
- semi-permeable layer
- turonian aquifer
Piezometric heads
Before operation of evaporation station

Ralsko
leaching fields
HAMR deep mine

water level in v cenomanian aquifer
water level in turonian aquifer
contamination
semi-permeable layer
cenomanian aquifer
turonian aquifer
Piezometric heads
Current situation – evaporation station at work

Ralsko
leaching fields
HAMR deep mine

water level in v cenomanian aquifer
contamination
water level in turonian aquifer
cenomanian aquifer
semi-permeable layer
turonian aquifer
Piezometric heads
During remediation – Hamr mine flooded

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Ralsko

leaching fields

HAMR deep mine

During remediation – Hamr mine flooded
Piezometric heads
At the end of remediation process

Ralsko
leaching fields
HAMR deep mine

cenomanian aquifer
semi-permeable layer
turonian aquifer

water level in
cenomanian aquifer
contamination
water level in
turonian aquifer
During chemical leaching

8,000 technological wells were drilled

Area of leaching fields: 628 ha

Chemicals consumption:

- $\text{H}_2\text{SO}_4$: 4,100,000 t
- $\text{HNO}_3$: 320,000 t
- $\text{NH}_4^+$: 111,000 t
- HF: 16,000 t
Scheme of leaching fields

- Injection wells
- Pipelines
- Pumping wells
- Permeable Turonian horizon
- Non-permeable lower Turonian horizon
- Fucoid sandstone
- Friable sandstone
- Wash-out horizon
- Fresh-water sediments
- Uranium ore
Present extent of contamination

Influenced volume of groundwater - cca 300 mil. m³

Amount of TDS - 4,8 mil. t

There of:

\[ \text{SO}_4^{2-} \] - 3,9 mil. t
\[ \text{Al} \] - 420 000 t
\[ \text{Fe} \] - 110 000 t
\[ \text{NH}_4^+ \] - 90 000 t
Present extent of contamination

Stráž fault
model boundary
tectonic lines
leaching fields
cross-section
3 g/l limit
8 g/l limit

TDS concentration [g/l]
< 3
3 - 8
8 - 15
15 - 30
30 - 50
50 - 80
> 80
Reaching of safe state in the underground

From the ground it is necessary to remove cca 3,7 mil. t of contaminants
Scheme of present remedial technologies
Capacity of present remedial technologies for withdrawing of contamination

Production and reprocessing of alum:
  up to 35 000 t TDS per year

Neutralization:
  up to 30 000 t TDS per year

Present remediation well net

End of remediation 2100
Realisation of new remedial technologies

II. stage of aluminium sulphate production - end of 2007

Another neutralisation station - end of 2012

Neutralisation of mother liquor - end of 2009
Complete scheme of remedial technologies

- **Chemical Station**: Water is treated through filtration and neutralization processes.
- **Evaporator**: Water is concentrated through evaporation.
- **Alum Crystallization**: Alum is produced as a result of crystallization of aluminium sulphate.
- **Neutralization ML**: Further water is treated through neutralization of ML.
- **Aluminium Sulphate Production**: Alum is produced for further use in fertilizers.
- **Filter Cake**: Filter cakes are collected and disposed of in tailings ponds.

**Key Components**:
- **Neutralisation NDS 10**: Initial neutralization process.
- **Neutralisation NDS 6**: Secondary neutralization process.
- **Distillate**: Cleaned water is collected as distillate.
- **Tailings Pond**: Filter cakes are disposed of in this pond.
- **Control Element**: Elements for monitoring are placed at strategic points.

**Geological Layers**:
- **Ploučnice River**
- **Turonian Aquifer**
- **Cenomanian Aquifer**
- **Aquitard**
- **Lower Beds**
Capacity of complete remedial technologies for liquidation of contamination

Neutralisation:
up to 110 000 t TDS per year

Production and reprocessing of alum and mother liquor liquidation:
up to 80 000 t TDS per year

Completed remediation well net

End of remediation 2035
Thank you for your attention