The SURRI project: Developing new technologies for risk management and critical element recovery at legacy uranium production sites.

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Content:

1. Uranium (and other) mining in the Czech Republic
2. Risk management challenges
3. The SURRI project: aims, and baseline technologies
4. Current R&D
5. Future aims / challenges

U mining – generic issues

Former uranium mining and production facilities present complex remediation and rehabilitation challenges.

For uranium mining and milling tailings in particular significant risk may be generated by the presence of (a) elevated radioactivity due to uranium and daughter products, (b) potentially toxic metals and other toxic compounds, and/or (c) sulphide minerals, which may promote acid mine drainage.

This, coupled with the often-large spatial coverage of tailings and other wastes, and their susceptibility to leaching, erosion or collapse, means that sizeable areas of land are made unfit for other uses and require risk management or rehabilitation.

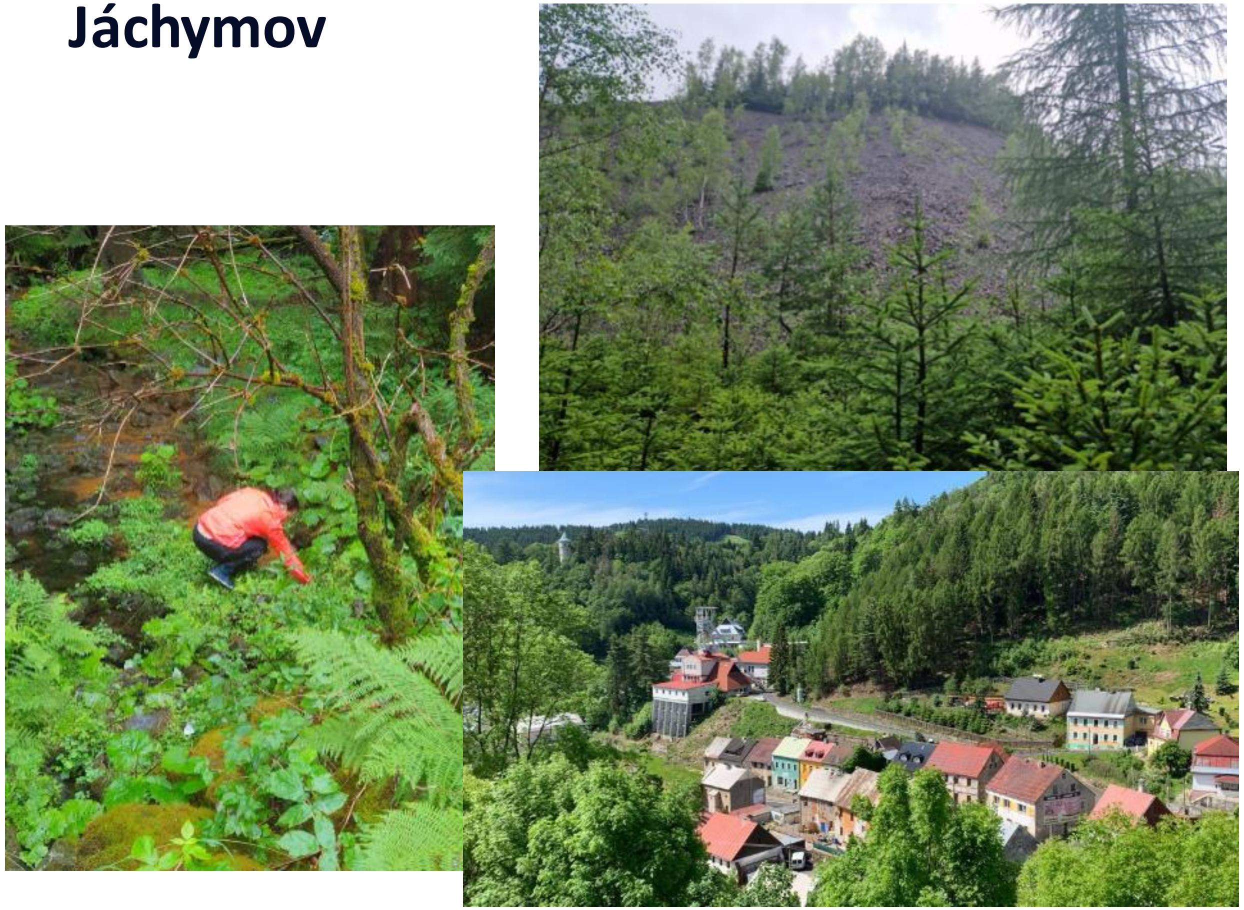
Mining in the Czech Republic

Long history of ore and U mining

- Middle Ages (13th Century onwards, Bohemia): Dominantly Ag mining, with Au and Sn.
- Mid 1800s - early 1900s: mining of pitchblende in Jáchymov (for U and Ra)
- 1946 onwards: Massive Soviet-era expansion of U extraction: From 1946 over 100,000t of uranium metal (as sorted ores and chemical concentrate) produced.

Legacy U, and potentially NORM-containing, sites have various scales and challenges…..

Jáchymov



Source: bbc.co.uk, credit: Eliot Stein

- Initially Ag mined, then Co and As, then Ra and U
- Mid-1800s: Production of U for ceramics and glass industry as a coloring agent
- Major exporter of Ra in early 20th Century
- Massive expansion in U production in post-WW2 Soviet era.
- NORM-bearing wastes and materials used as mortar and plaster in local construction projects

Major legacy issues around tailings and contaminated building materials

Straz Pod Ralskem

- Soviet-era *in situ* acid leach (and undergound) mining of Cretaceous sandstone-hosted U deposit
- Area of leaching fields: 628ha
- Between 1967 and 2000 the mine produced over 16 000 tonnes U via injection of 4.1 million tonnes of sulphuric acid, 315 000 t of nitric acid, 112 000 t of ammonia, 26 000 t of hydrofluoric acid, and 1400 t of hydrochloric acid

Now: Groundwater protection (P&T), coupled with U separation and storage or sale. Target end-date: 2037?

Remediation goal (ca. 2 billion Euro): restore leaching fields and protect upper Turonian aquifer
(plus sustainably manage treatment residues)

Non-U mining sites (NORM? + critical element recovery?)

Zlaty Hory
Cu and Au mine

Kutna Hora
Ag and Zn mine

The SURRI project

Horizon Europe Twinning Project, commenced Jan 2023

Key Research Aim: develop new integrated (and more sustainable) risk management methods for legacy uranium mining and production sites (and other sites with uraniferous, thoriated, or NORM-containing wastes) in Eastern Europe (with specific focus on Czech Republic)

Table 1: Contaminants of concern, elements for recovery and re-use, and circular economy applications

Contaminants of concern	Critical elements for recovery	Circular economy applications
Radiotoxic elements: U, Ra, Rn, Th, ^{210}Pb Co-contaminants: Acidity, Ni, Cu, As, Pb, Zn, Se, Ge, Hg, W	Rare Earth Elements (REE) Critical elements: Co, Cu, Sb Noble metals: Au, Ag, Pd, Pt, Ru Radioactive: U	Bulk supply for renewables sector, green economy etc. Nanocatalysts, metal:organic for green chemical applications, photoelectronics, semiconductors, remediation

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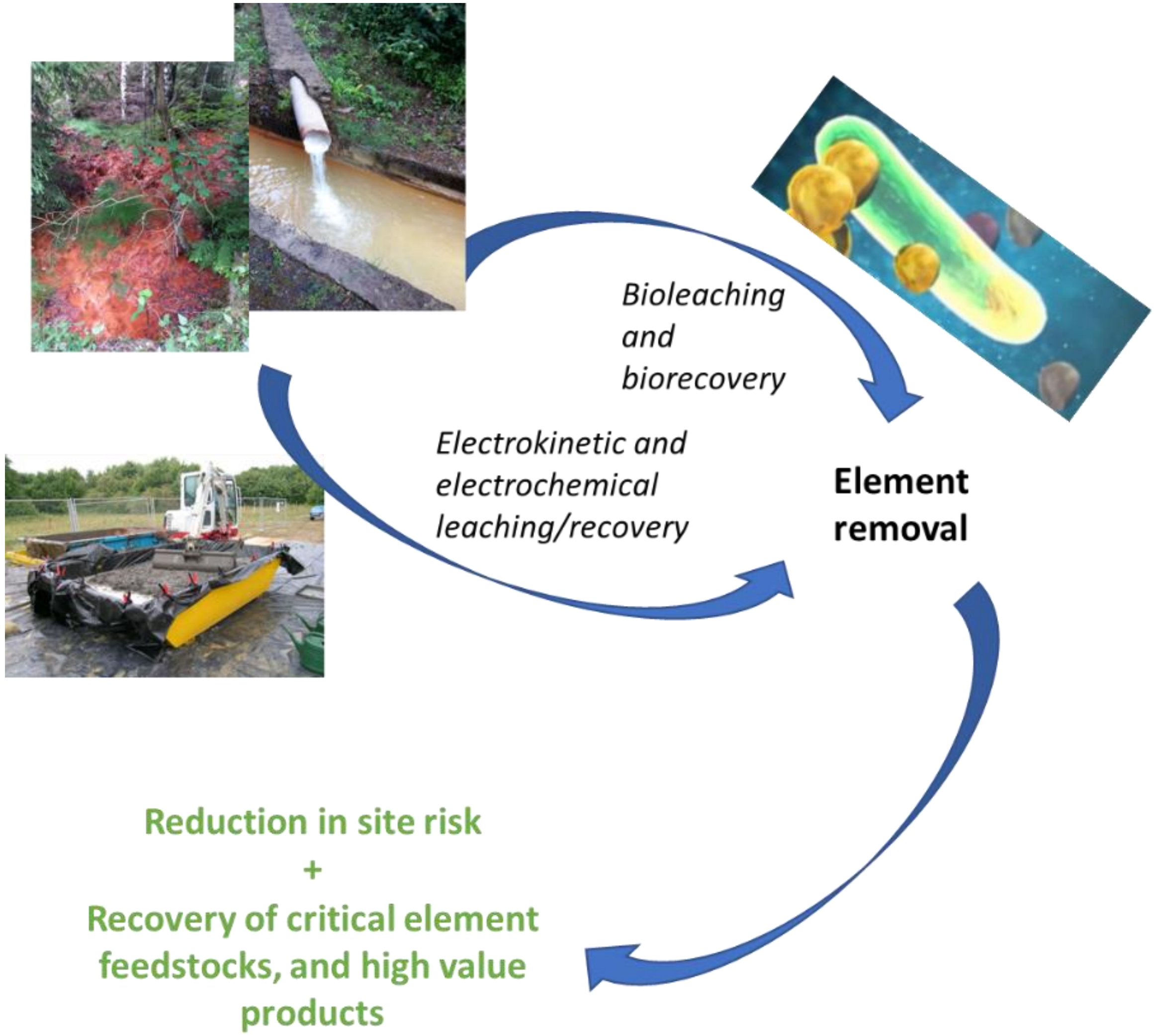
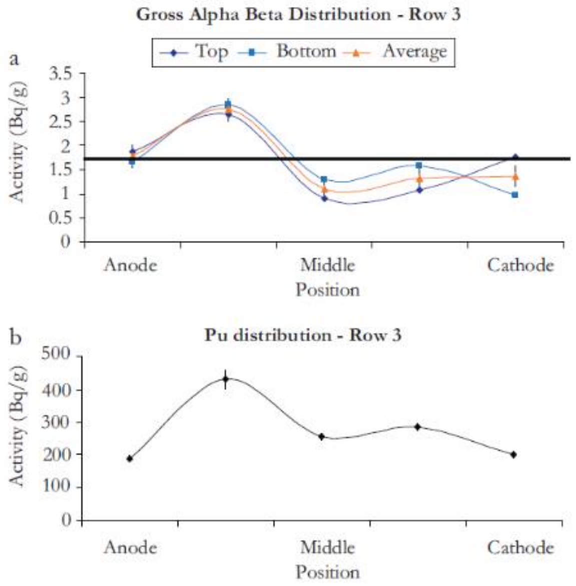
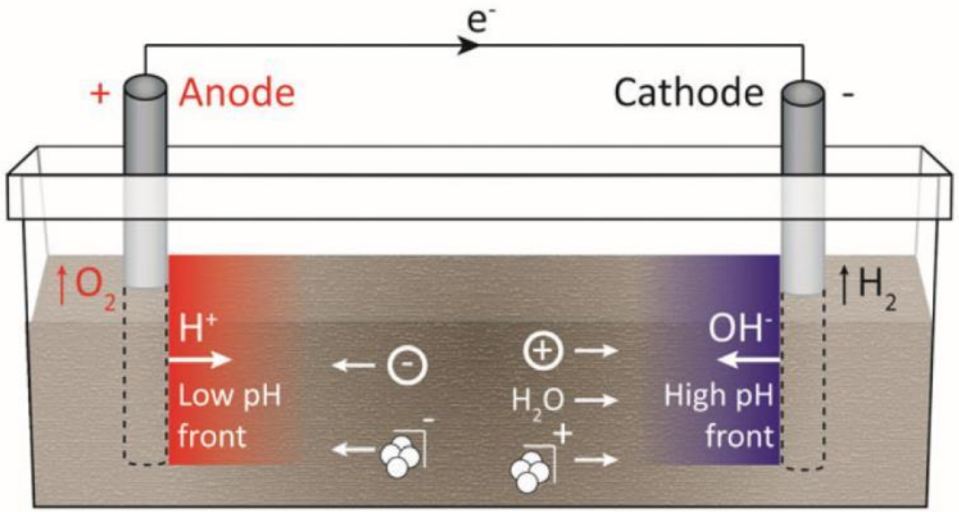
Baseline technologies

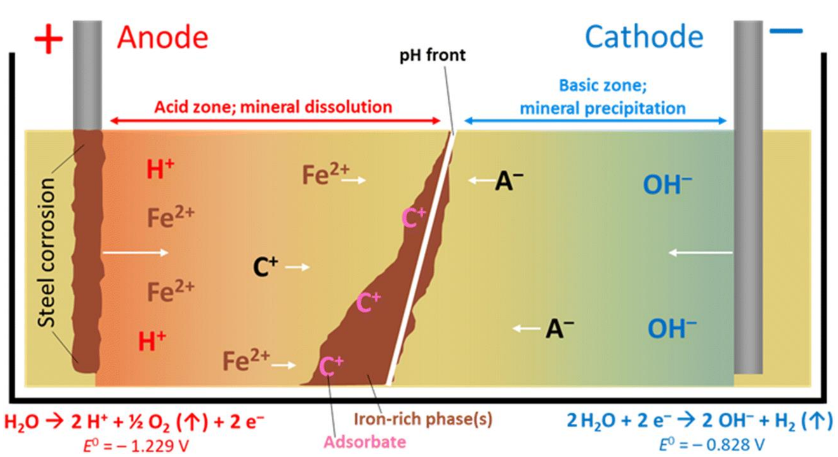


The SURRI project
Electrokinetic and electrochemical methods

Agnew et al., 2011





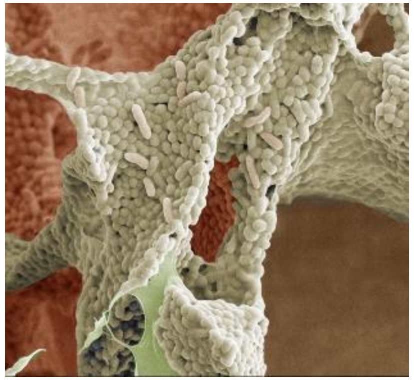


TRANSCEND

Purkis et al., 2023

The SURRI project
Current R&D

- Electrokinetic treatment of tailings and residues / precipitates
- Critical metal recovery from effluents (chemically and biologically)
- Microbial characterisation for bioremediation / biorecovery processes
- Phyto-recovery techniques



The SURRI project
Current R&D

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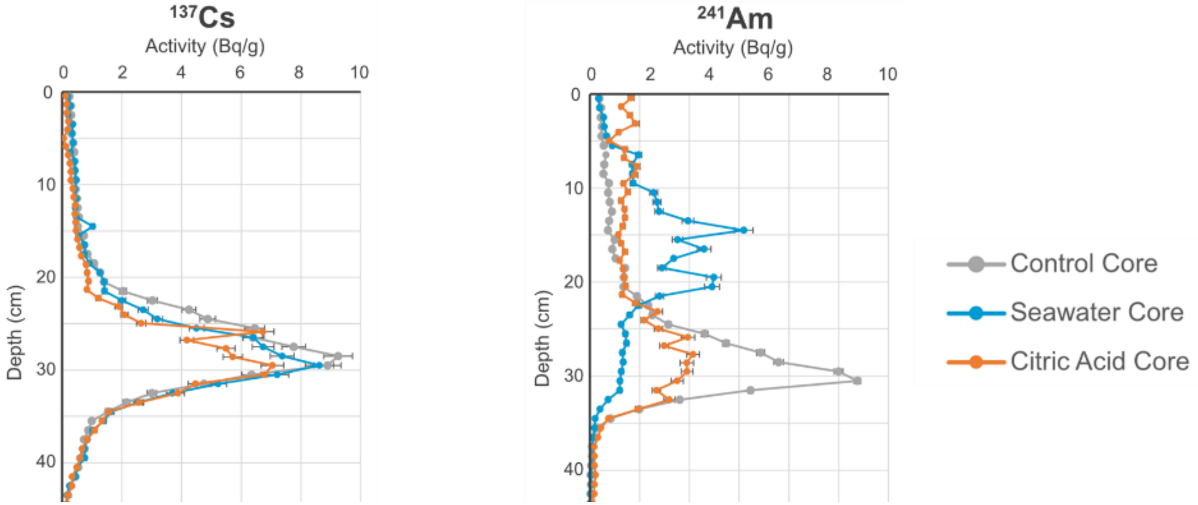
Unpublished data, courtesy of Shaun Hemming, University of Southampton



Application to U and critical element recovery?

The SURRI project
Current R&D

- Electrokinetic treatment of tailings and residues / precipitates
- **Critical metal recovery from effluents (chemically and biologically)**
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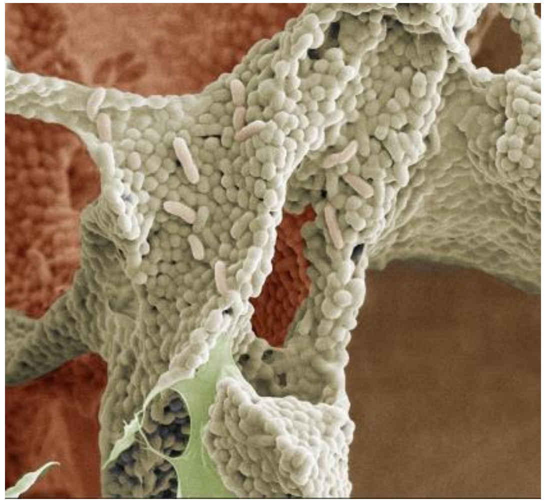
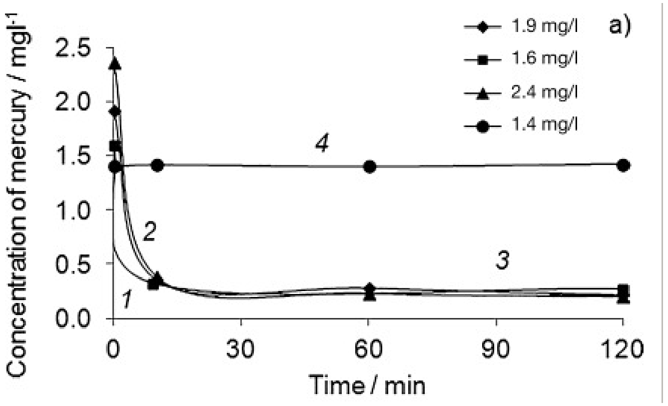
- Phyto-recovery techniques

Al-Jwaid et al., 2018





Source: Katok et al., 2012 and 2013

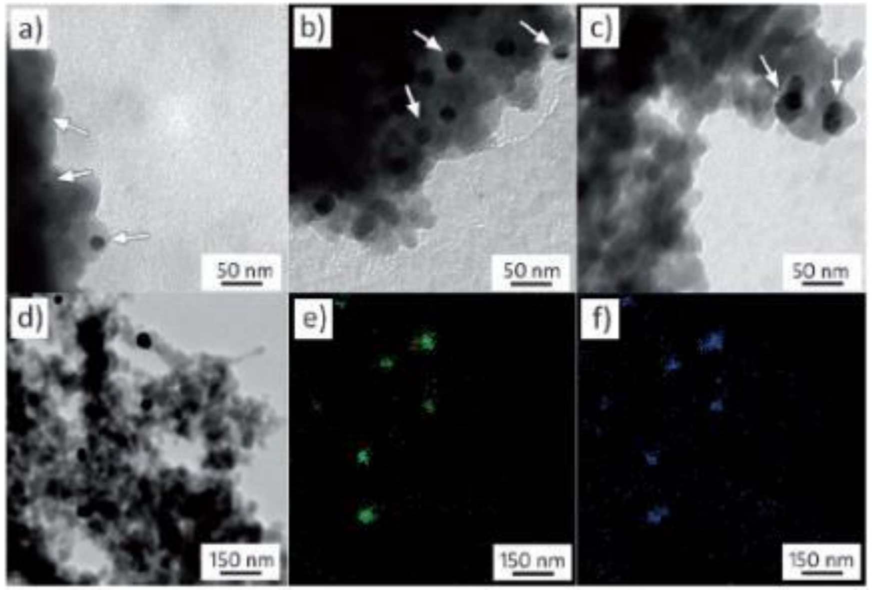


Figure 1. Modification of C-120 type silica (specific surface area 114 $m^2 g^{-1}$) using triethoxysilane generates silicon hydride groups. These are subsequently used to reduce a silver nitrate solution to AgNPs, which are affixed to the top of silica. TEM images reveal the distribution of near-spherical AgNPs, appearing as darker contrast particles (white arrows) against the fused silica substrate, with particle sizes averaging a) 11 nm, b) 31 nm, and c) 45 nm. d) EDX mapping analysis reveals the corresponding location of silver and mercury in the TEM image for the e) Ag (L_α peak) and f) Hg (M_α peak) after their reaction and shows that the distribution of Hg correlates only to the location of AgNPs.

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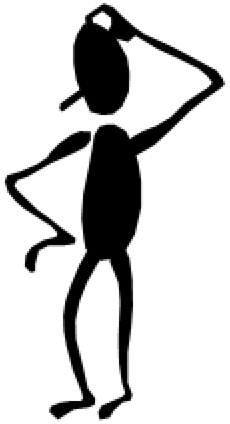
The SURRI project
Future aims and challenges

- Targeted element recovery, from complex media
- Integration of technologies (inc. immobilisation tech.)
- Scalable treatment methods – process economics, sustainability and scale
- Moving beyond proof of concept

Thank you / Děkuju moc

Any questions?



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