Uranium – from the deposit to the repository of spent nuclear fuel

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The quantity of irradiated substances produced by reactors is relatively small in terms of their volume and mass. In France, the total represents approximately 1 kilogram per person per year, of which only a few grams are high-level waste, compared with 2.5 tones of industrial waste or 6.6 tones of carbon dioxide discharged directly into the atmosphere.

1 t of natural U contain 7 kg of U$_{235}$ only
Heat from a container of waste

Containers of waste from the nuclear industry are too recent to have had time to age. They still emit excessive heat caused mainly by the decay of fission products contained therein. At the age of 5 years, the short-lived fission products contribute about 90% of the heat release and the minor actinides for only 11%. At age 35 the heat of 2350 watts fell to 700 watts, two products of fission - Cesium-137 and strontium-90 - alone emit 84% of this heat.
Nuclear waste repository Onkalo, Finland, total capacity 6 000 t of spend nuclear fuel
1. Final disposal canister
2. Bentonite buffer
3. Tunnel backfill
4. Bedrock
Detail, Nuclear waste repository Onkalo, Finland
The fission reaction and spend fuel repository are a natural products. Fermi wasn't the first. 1700 Ma year old Natural nuclear reactor, Oklo, Gabun
• Uraninite, UO₂ the most important uranium ore.
• Nuclear fuel is also UO₂
• U⁴⁺ is immobile, whereas U⁶⁺ is mobile.
• The U⁶⁺ salts and complexes are soluble in the water.
• The study of behavior on natural UO₂ could bring an important information about long-term behavior of spent nuclear fuel
Uranium deposits in CR, Bohemian massif is rich on uranium deposits. The U production rich the maximum in early sixties with 3 000 t U/year. It was 5 % of total world production. Rožná mine, total production od 20 000 t of U.
Simplified geological cross-section, Rožná deposit. Uranium ore fills tectonic zones and faults.
1 m thick calcite vein with uraninite from the level 24 penetrating the biotite-bearing gneisses.
Zone mineralization, U concentrations in ppm. XRF measurements
U concentration at the eastern margin of Bohemian Massif and the important uranium deposits. Large scale migration of U between 350 and 270 Ma and formation of U-deposits. The primary content of U in the Třebíč Massif was 50 mil t, concentration of 10g/ton. The deposit Rožná contain 25 000 t of U, concentration 2kg/ton.

air-borne gamaspectrometry.
The map of concentration of isotope U235 (left), and their daughter isotope Pb 207 (right) Note, that the concentration of the lead is uneven, and affected by secondary processes. The length of the photograph is 3 mm.
Conclusions

Uranium deposit in Rožná has formed about 270 million years ago. For more than a quarter billion years – despite all geological and climate changes, which took place in this era and time - Uranium remained stable and bound to the deposit structures. The Rožná uranium deposit provides a unique opportunity to study the migration of uranium in a real rock environment under conditions comparable to those of a planned underground repository of spent nuclear fuel. The knowledge gained during the prospection a exploration of the deposit could be used to prepare a model of NATURE ANALOGUE.
The 1.5 GA old U deposits with unusual high U-concentration is located 430 m below the recent lake. No migration of U to the surface was observed. The clay layer in the hanging wall blocked the uranium migration.
Uranium deposit as a natural analogue

In the case of uranium deposit in CR the reducing environment (e.g. appearance of Fe$^{2+}$ minerals, graphite), which give rise to the deposit via reducing of U$^{6+}$, blocked recently the oxidation of uranium and their migration.

The rock environment which is close to the environment existing at the deposits could form geochemical barrier and largely stabilized the uranium at the repository on spend nuclear fuel.

*The U deposits in the CR are probably not fully exhausted. The mining was terminated because of political and economical, not geological reasons. There is a chance to discover new recourses at the existing deposits or discovered new deposits and resources*