NORM-related Mineral Developments in Finland

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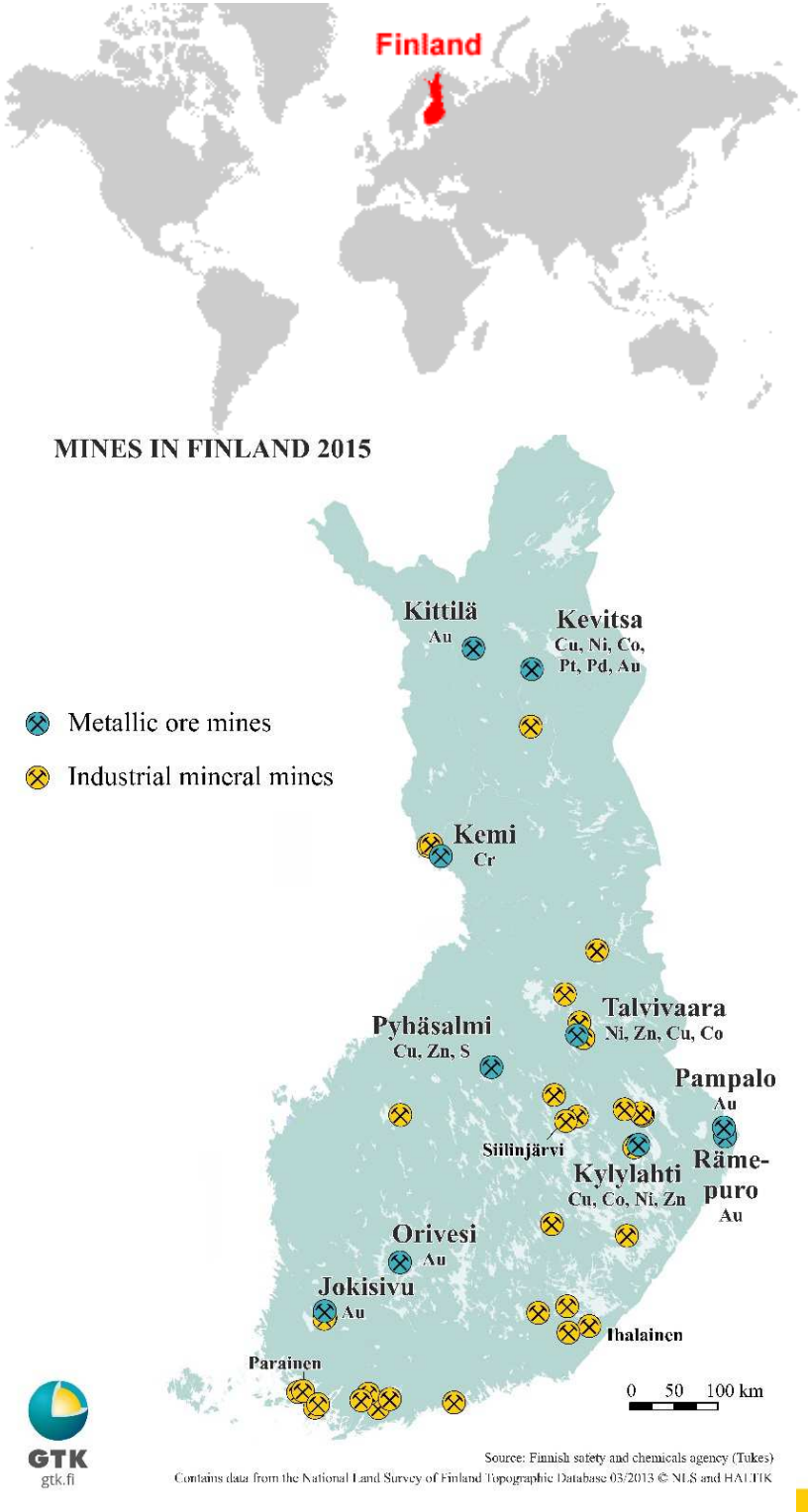
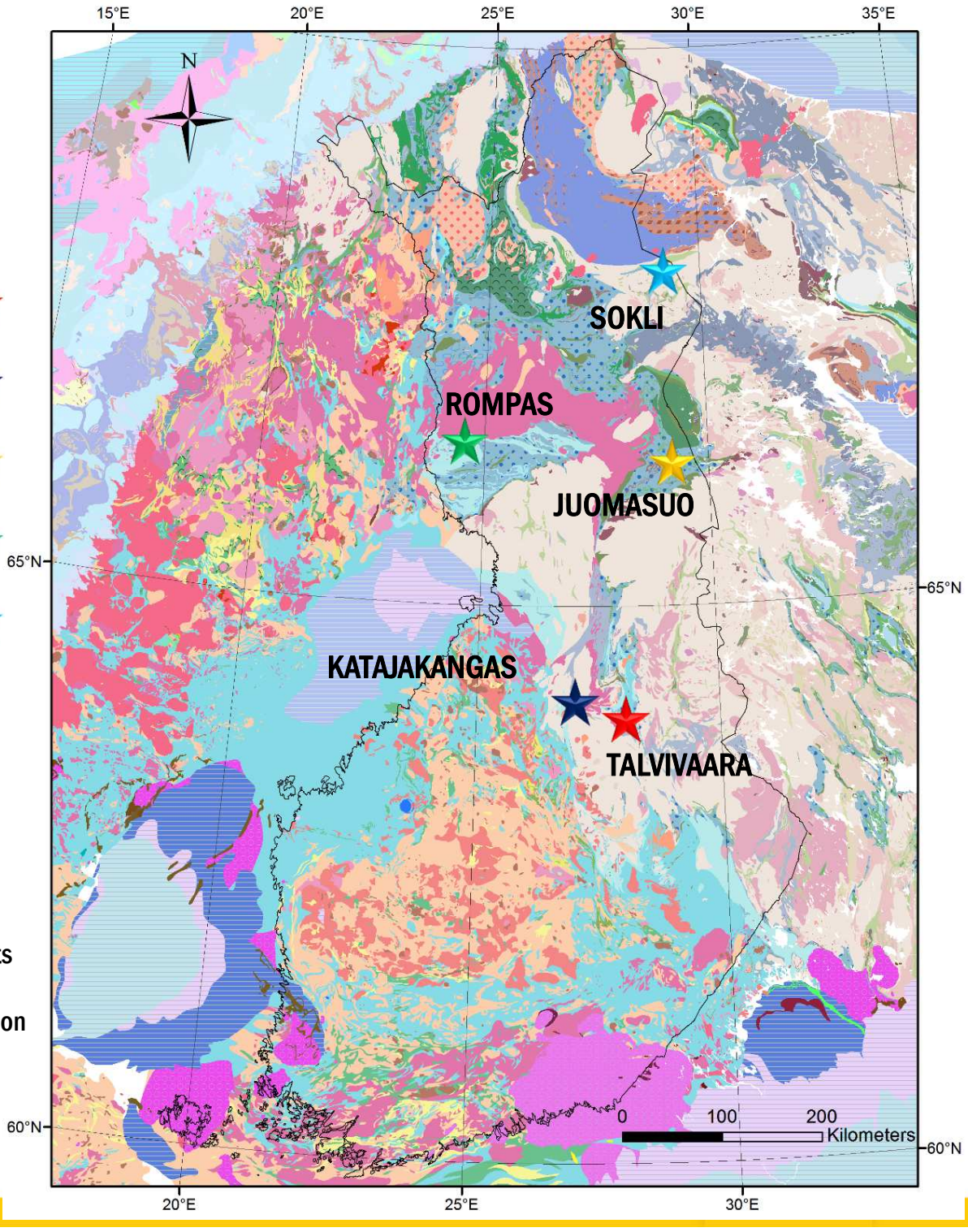
Background

- No uranium production
- 45 mines in operation
  - Marbles, industrial minerals, nickel, zinc, copper, chromium and gold
- 4 nuclear power reactors in operation, 1 unit under construction and 1 unit planned
  - Final disposal of the spent nuclear fuel is planned to start in 2020's
- Known uranium occurrences are of relatively low grade, small and uneconomic for exploitation
- Several mine development and exploration projects focused on U-bearing polymetallic mineral resources



Uraniferous polymetallic deposits in Finland

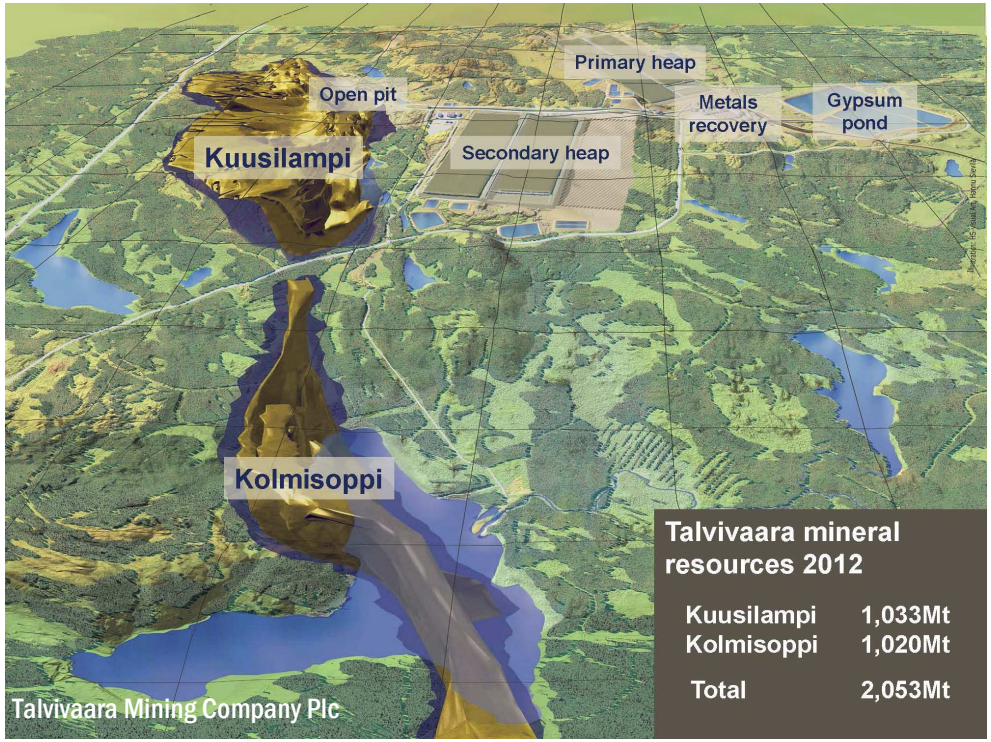
- Talvivaara Ni-Zn-Cu-Co deposit
- Katajakangas Nb-REE deposit
- Juomasuo Au-Co deposit
- Rompas gold prospect
- Sokli phosphorus deposit

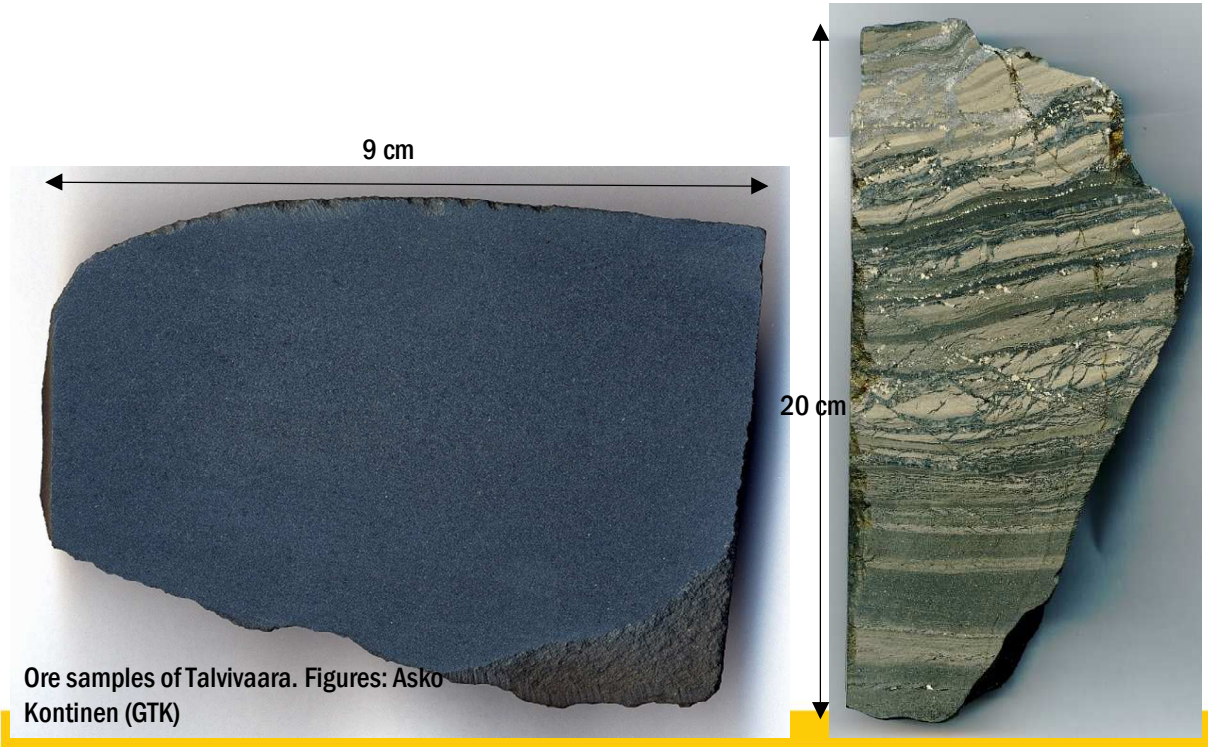


Uraniferous polymetallic mineral deposits in Finland on the geological map of the Fennoscandian Shield (geology is based on Koistinen et al., 2001).

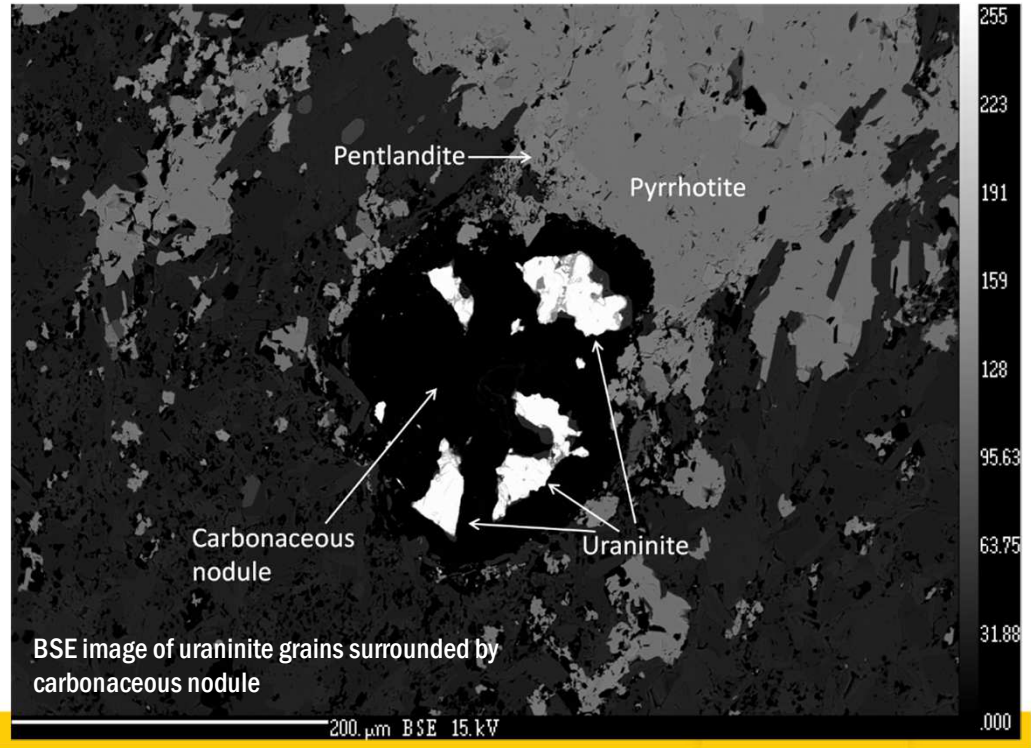
Talvivaara nickel deposit

- Black schist-hosted Ni-Zn-Cu-Co deposit
- Low-grade, large-tonnage ore deposit averaging 17 ppm U
- Significant part of uranium incorporated in uraninite (UO_2)
- Uraninite typically enclosed in globular carbonaceous nodules





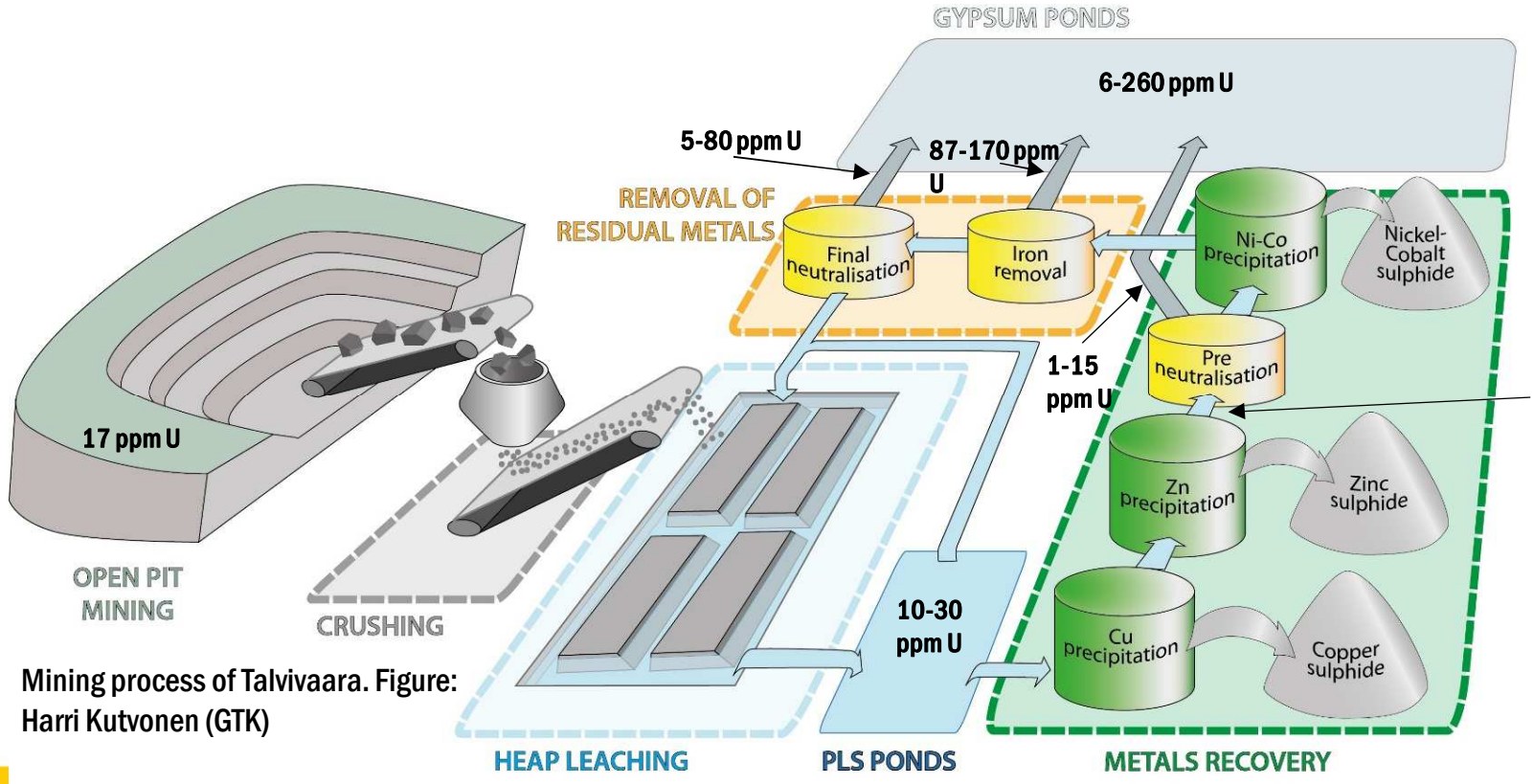
Ore samples of Talvivaara. Figures: Asko Kontinen (GTK)



BSE image of uraninite grains surrounded by carbonaceous nodule

Exploitation of the Talvivaara deposit

- Production from the Talvivaara deposit commenced in 2008
- Production process includes open pit mining, crushing, heap leaching, metals recovery and removal of metals having no value
- Leach solution (PLS) percolates to the bottom of the leach pads
  - PLS is re-circulated through the heap or fed to metals recovery
  - Cu, Zn, Ni and Co are precipitated from the PLS



U extraction plant, between Zn precipitation & pre neutralisation of the PLS

Mining process of Talvivaara. Figure: Harri Kutvonen (GTK)

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Mining wastes at Talvivaara

- Leached ore
  - After two years of primary leaching, the ore is reclaimed and re-stacked for secondary leaching
  - Secondary heaps are final disposal sites for the leached ore
- Gypsum pond wastes
  - After the metals have been recovered, the solution is purified and returned to irrigate the heaps
  - During removal of residual metals, unwanted metals are precipitated as hydroxides with gypsum
    - Resulting slurry is directed to gypsum waste ponds
- Waste rock

Gypsum waste pond at Talvivaara. Figure: Hanna Tuovinen (STUK).

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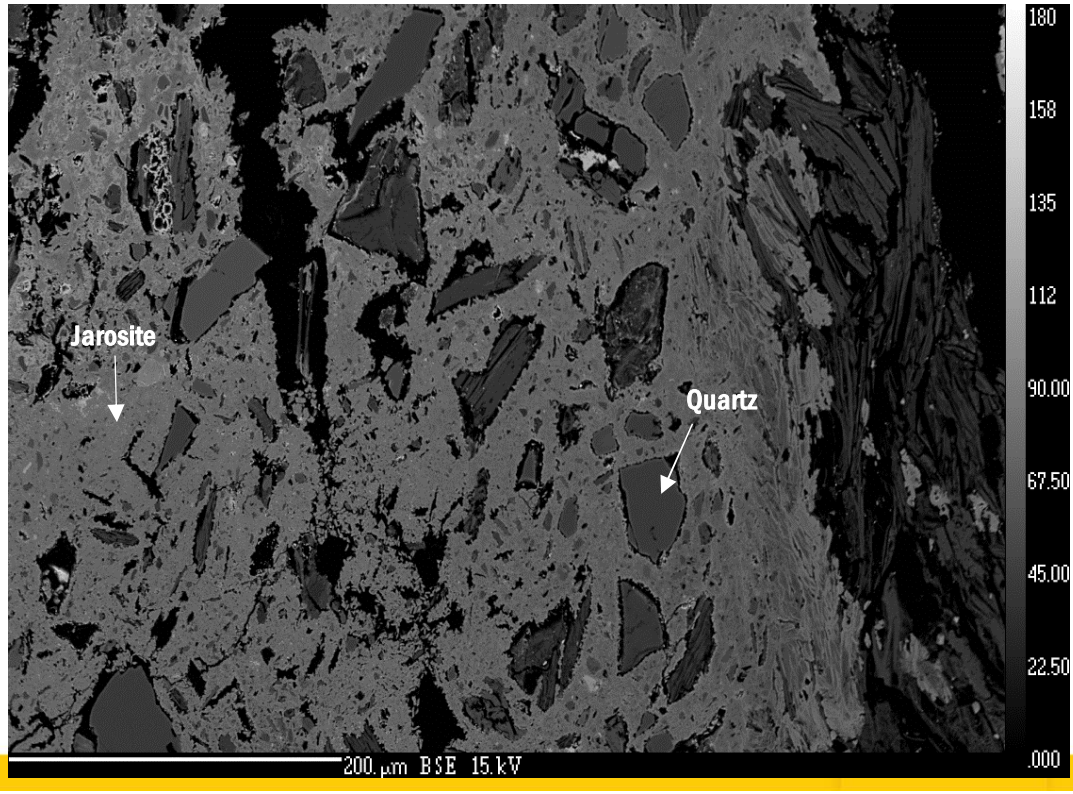
Behavior of U in mining process of Talvivaara

- Large proportion of uranium in the ore dissolves in the PLS during heap leaching
  - Acidic and oxidative conditions of heap leaching are favorable for oxidative dissolution of uraninite
- Uranium mostly ends up in the gypsum pond wastes
  - Uranium in gypsum wastes is mostly derived from iron removal
  - Activity concentrations of U-238 in the gypsum pond wastes between 58 Bq/kg and 3375 Bq/kg
    - Partly exceeding activity concentration 1000 Bq/kg of the U-238 radionuclide

Heap leach stacking at Talvivaara in 2009.

Other radionuclides in the Talvivaara process

- Uranium daughter nuclides (Ra-226, Pb-210 and Po-210) mostly remain in the heaps
  - Probably associated with secondary sulphate minerals, jarosite and gypsum
  - High sulphate concentrations in the acidic PLS may limit the solubility of Ra
- Thorium and progeny (Th-232, Th-228, Ra-228) are also mainly retained in the heaps



BSE image of jarosite (light grey), cementing silicate grains in the leached ore of Talvivaara after two years heap leaching.

By-product recovery of uranium at Talvivaara

- Uranium partly ends up in the Ni-Co sulfide concentrate
  - Uranium residuals are extracted from the Ni-Co concentrate at the Norilsk Nickel Harjavalta refinery
- In 2010, Talvivaara Mining Company announced plans to recover uranium as a by-product
  - During 2011-2013, the uranium solvent extraction plant was built as a new unit in the metals recovery complex of Talvivaara
  - Approval of the licensing process for uranium production still pending

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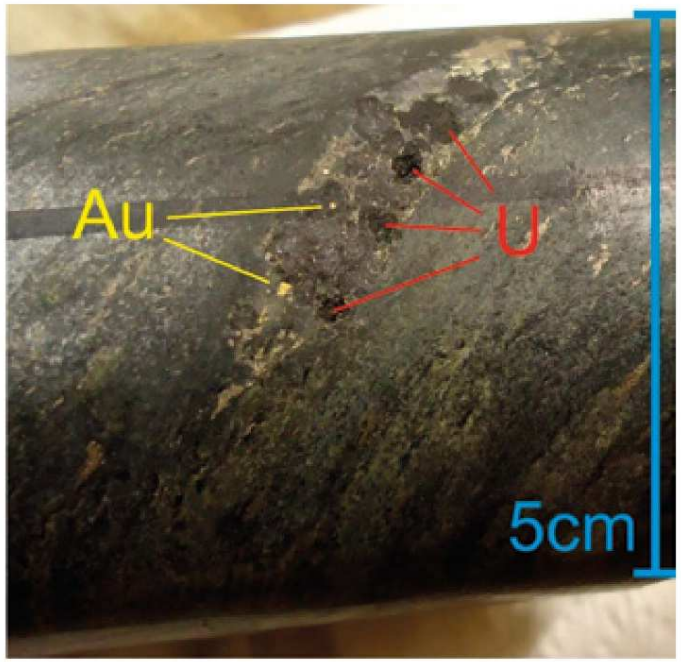
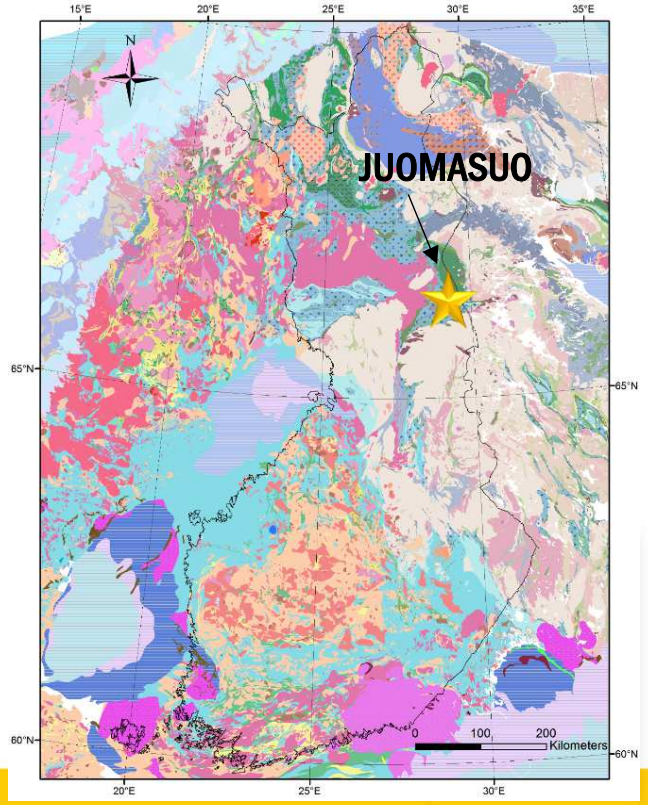
Juomasuo gold deposit

- Au-Co deposit, hosted by metamorphosed volcanic-sedimentary rocks
- Averaging 4.6 ppm Au and 158 ppm U
- Uraninite is the main uranium mineral
  - Uraninite found together with gold in fracture fillings and shear seams
  - Erratically distributed throughout the gold lodes

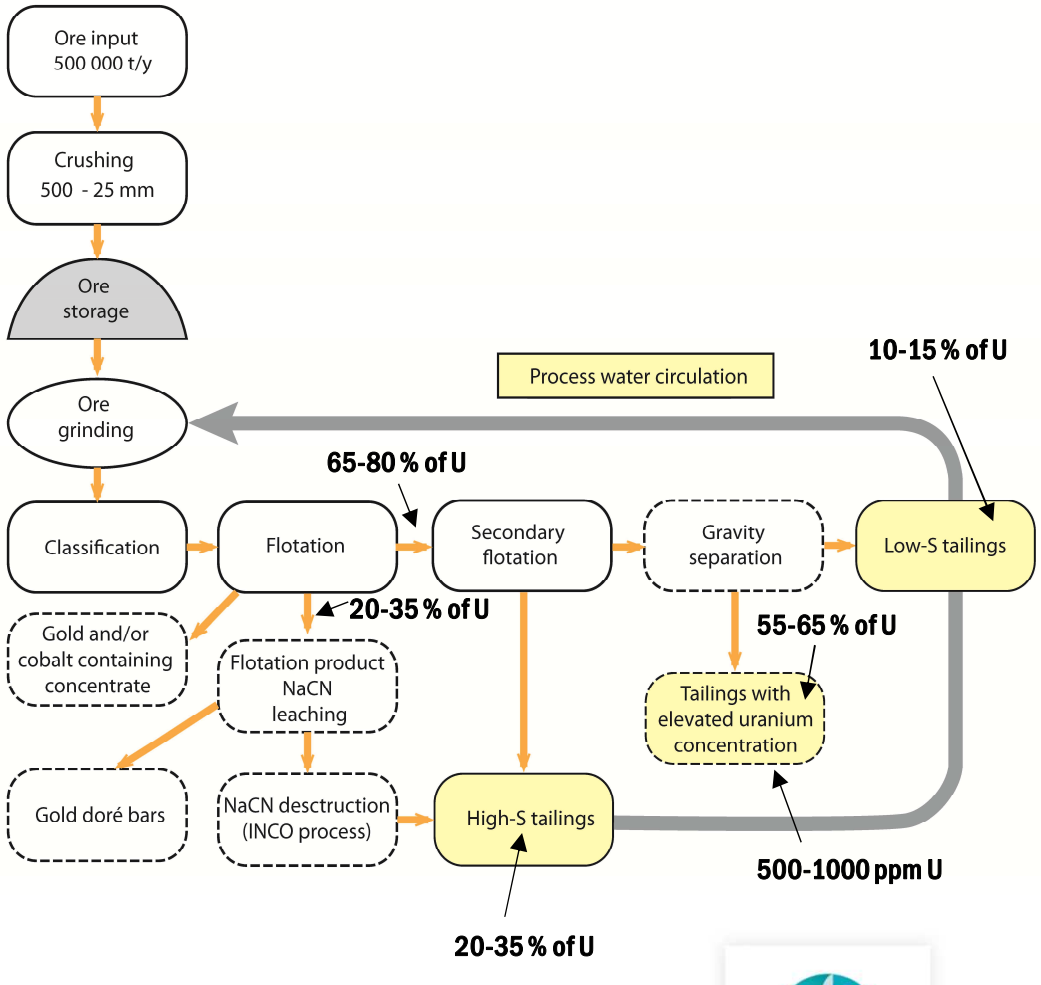


Uraninite and gold grains in drill core of Juomasuo. Figure: Dragon Mining Ltd.



Juomasuo production process

- Dragon Mining has investigated the possibility of developing a gold mine
  - Currently no plans for recovering U as a by-product
- Planned process includes mining, crushing, grinding, flotation, cyanide leaching of Au and tailings management
- Most of the U ends up in the tailings during flotation
  - If U-rich tailings were to be separated, about 60 % of the U in the ore ends up in the U-rich tailings
  - Activity concentrations of U-238 and Ra-226 in the U-rich tailings more than 1000 Bq/kg



Processing block flow diagram of the Juomasuo gold mine project. Background figure: Dragon Mining

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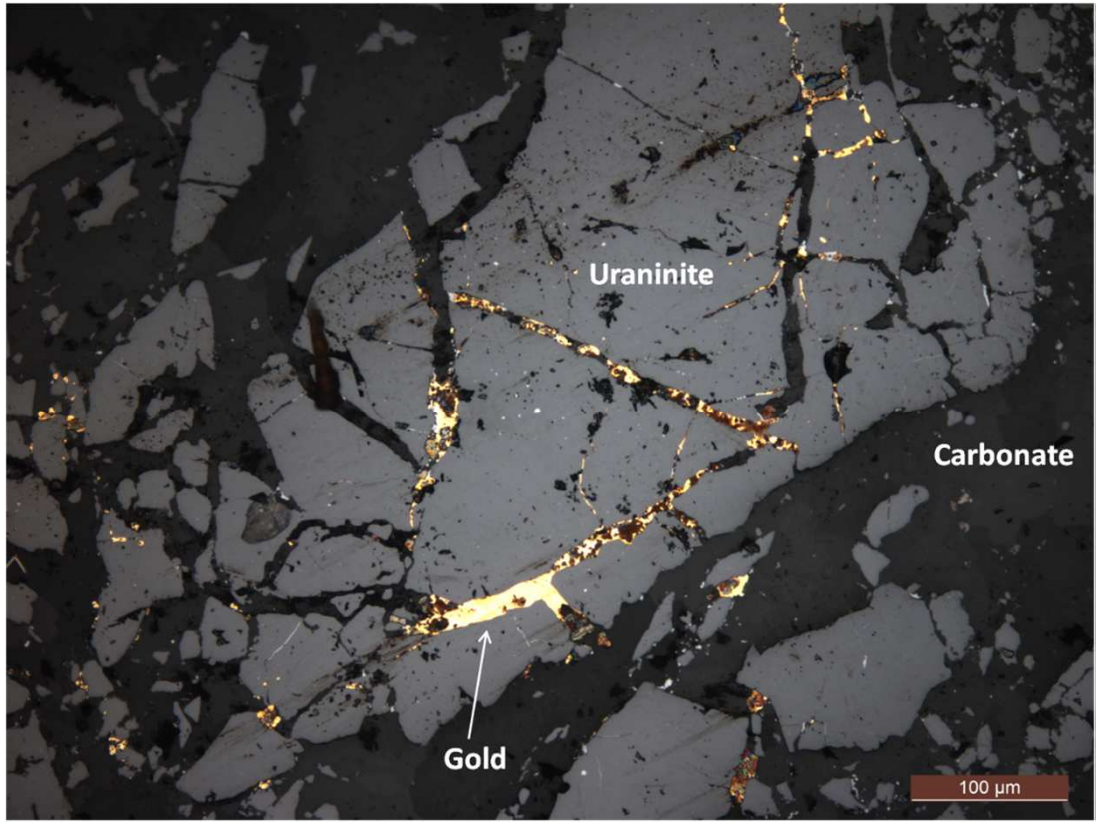
Rompas gold prospect

- Exploration project by Mawson Resources
- Vein-type gold and uranium mineralization, hosted by carbonate veins in mafic metavolcanic rocks
- Gold minerals as small pockets, having up to several thousands of g/t Au and up to tens of wt% U
  - Gold intimately associated with uraninite, typically in microfractures of uraninite
- NORM aspect due to association of gold with uranium



Gold in microfractures of uraninite, Rompas (reflected light).

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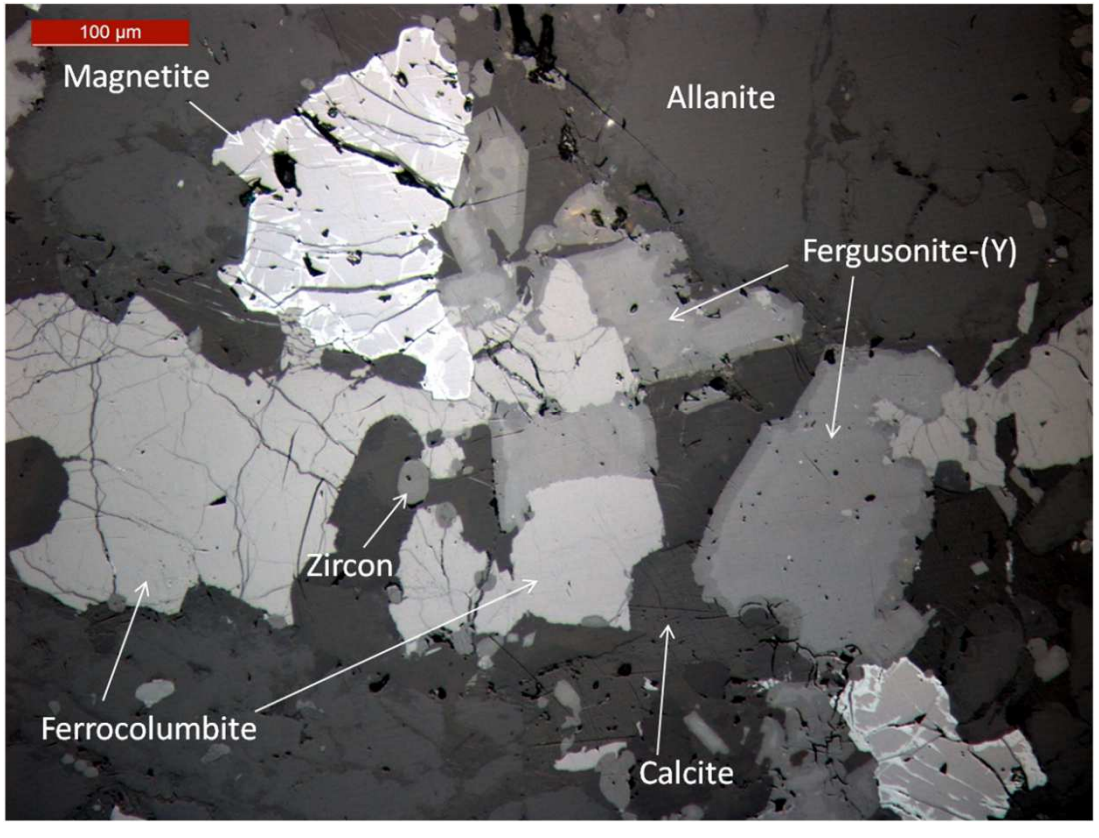
Katajakangas Nb-REE deposit

- Rare metal (Nb, REE, Zr, Ta) hydrothermal mineralization
- Fergusonite, ferrocolumbite, allanite and zircon as the main ore minerals
  - Fine-grained, silicified zones hosted by granite
  - Mineralized zones have several hundreds of ppm U and Th
  - Fergusonite is the dominant host to uranium, and allanite to thorium
- Exploration permit by Otanmäki Mine Oy
- NORM aspect due to association of Nb and REE with U and Th



The main ore minerals of the Katajakangas Nb-REE ore under reflected light. Sample KAT-012-1, drill hole Katajakangas 12, depth: 31.80 m.

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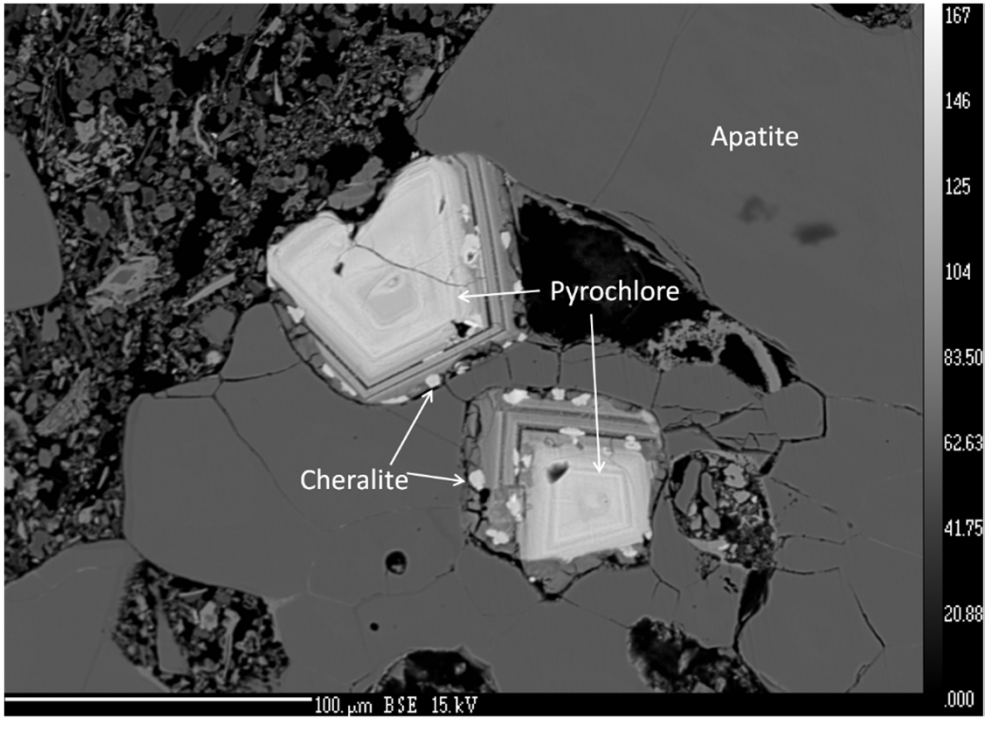
Sokli phosphorus deposit

- Phosphorus ore hosted by weathered zone of carbonatite
- Apatite as the main ore mineral
- NORM aspect; ore enriched in U & Th
  - Average U-238 activity concentration 310 Bq/kg, ranging between 100-1000 Bq/kg
    - Most U bound to pyrochlore-group minerals
  - Average Th-232 activity concentration 533 Bq/kg, ranging between 200-1700 Bq/kg
    - Th mostly incorporated in pyrochlore-group and monazite-group minerals
- Yara has planned to undertake phosphate mining in Sokli
  - Currently no plans for recovering U as a by-product



BSE image of Th-bearing pyrochlore crystals as inclusions in apatite, the Sokli regolithic phosphate ore.

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Summary

- No uranium exploration or production in Finland
- No economic uranium deposits
- Uraniferous polymetallic deposits with regulatory aspect of NORM
  - NORM mining wastes may be generated
  - NORM controlled by Radiation and Nuclear Safety Authority (STUK)
- Uranium solvent extraction plant built at Talvivaara, licensing process for U production unfinished

Thank You! – Questions?