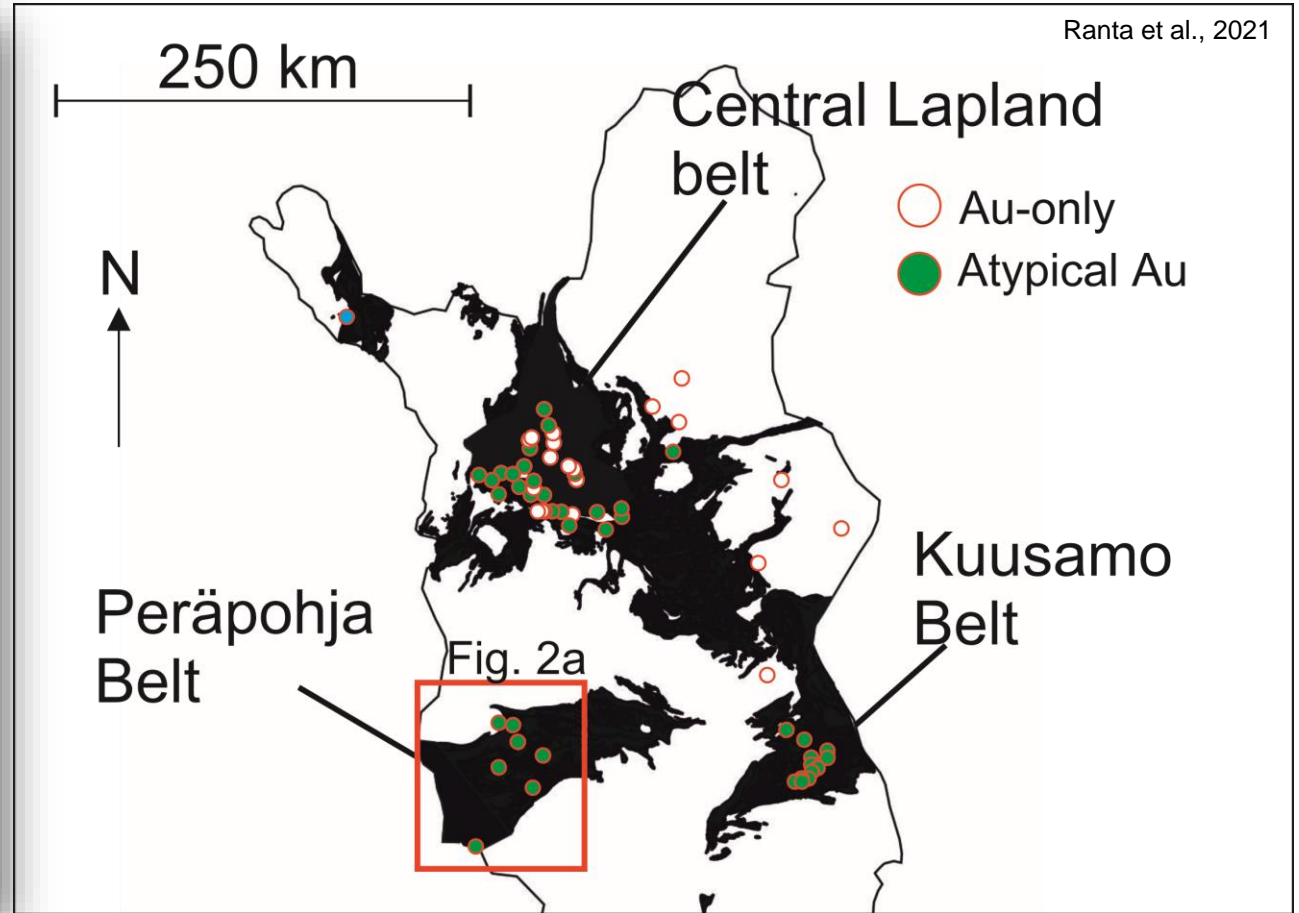


Chemical composition and boron isotopes of tourmaline as indication for ore-forming hydrothermal processes: Case studies from Paleoproterozoic atypical orogenic Au-Co deposits, Finland

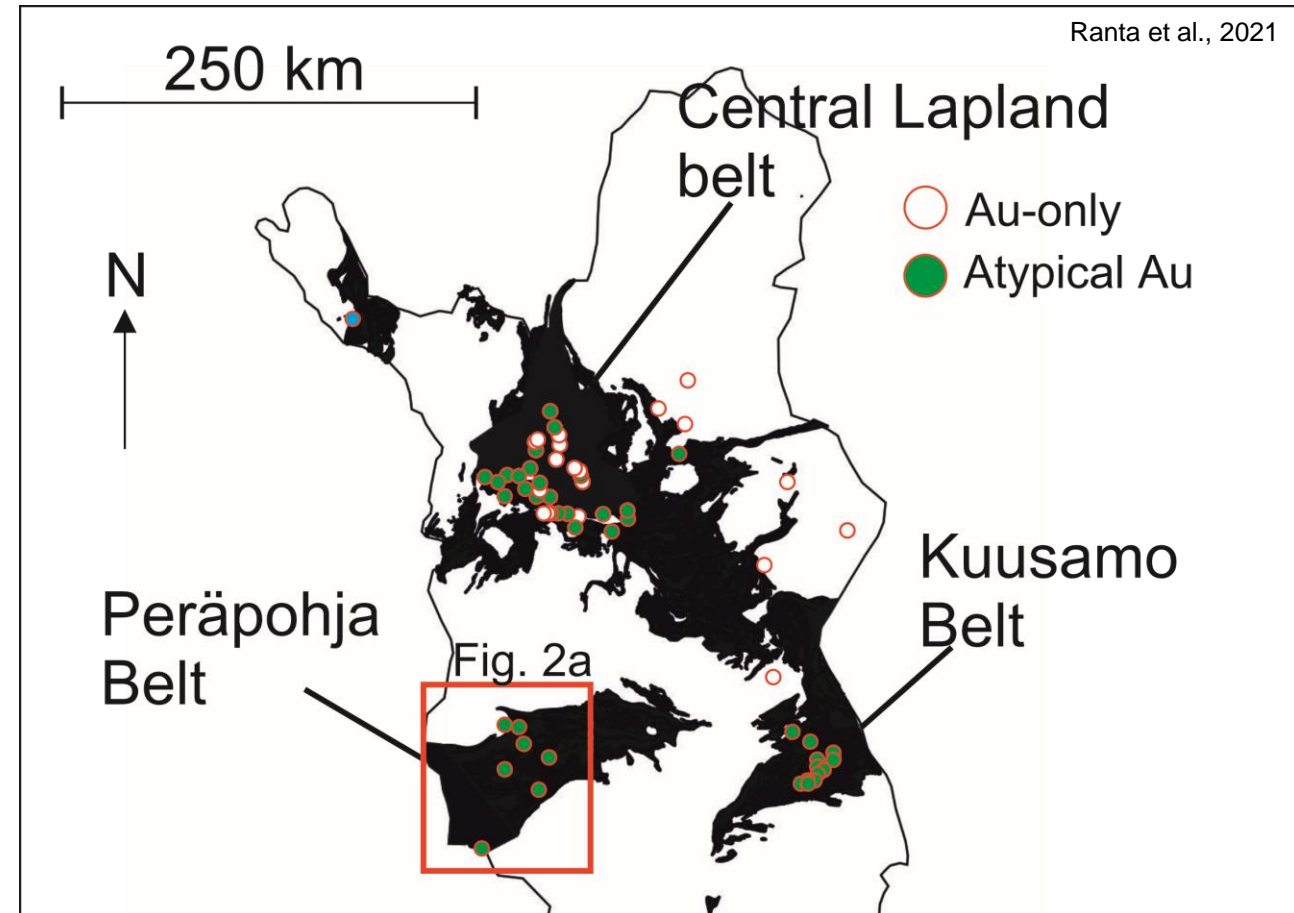
Jukka-Pekka Ranta, PhD
University of Oulu



Ca. 2.50 – 1.90 Ga Paleoproterozoic volcano-sedimentary belts

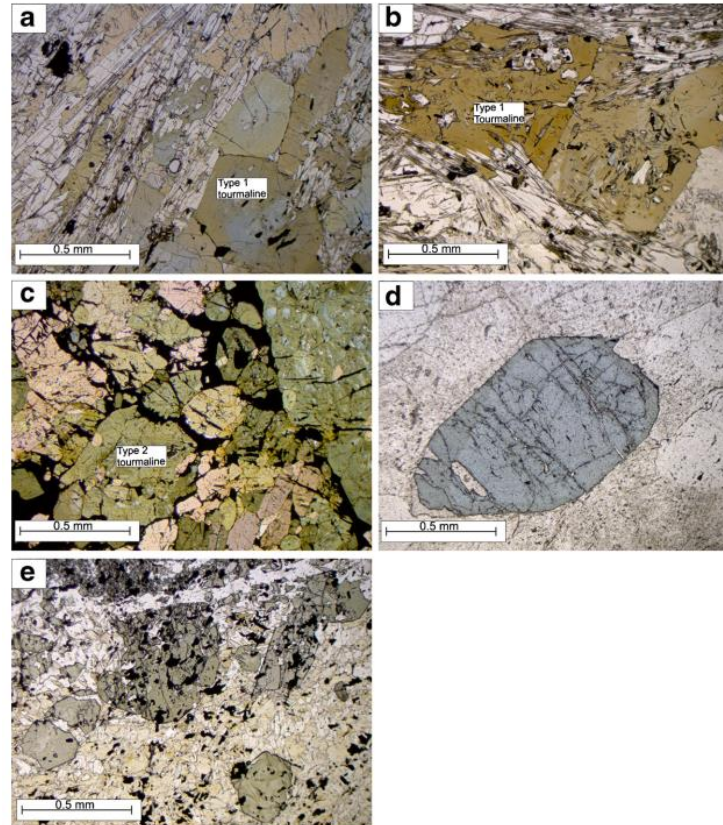


- Gold deposit with similar characteristic than **orogenic gold-only deposits**, but having significant concentration of other metals (Co, Cu, Ni, U, REE, Sb, Ag)
- Typically occurring in intracratonic settings
 - Finland (Kuusamo belt, Peräpohja belt, Central Lapland belt)
 - Sweden (Pahtohavare)
 - USA (Blackbird)
 - Australia
 - Norway
- Debate about the classification
 - IOCG
 - Skarn
 - VMS
 - "Blackbird type"
 - Orogenic

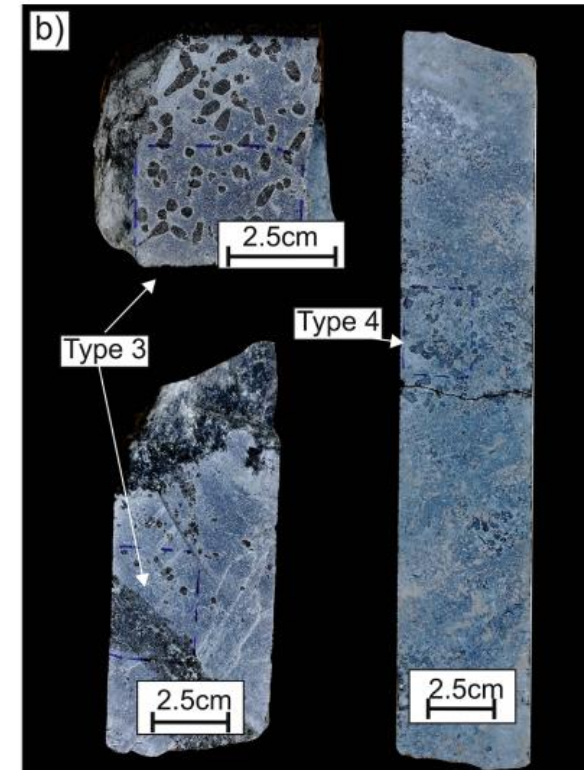




- Tourmaline is a common mineral in the Finnish Au-Co deposits
- Occurring as disseminated, bands, breccias within the mineralized rocks
- Composition of tourmaline reflects the host rock, P/T, and composition of the hydrothermal fluids
- As a major sink for boron, tourmaline B-isotope signature can be used e.g. as a proxy for mineralizing fluids



Ranta et al., 2017

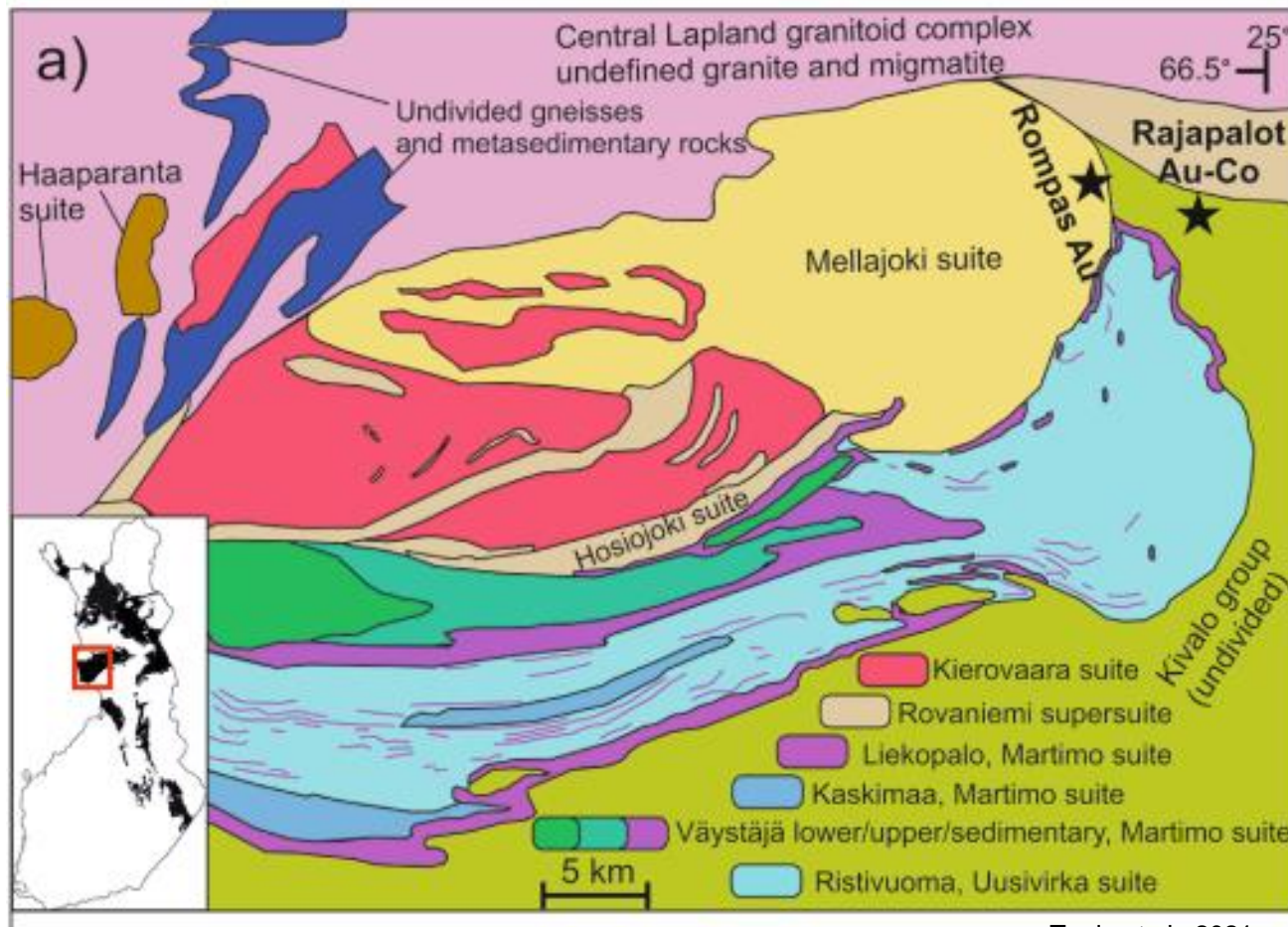


Tapio et al., 2021



Case Rajapalot Au-Co deposit

- > 1 million oz Au-Co deposit located in Arctic circle in northern Finland
- Discovered initially 2008 as Au-U rich rocks were found from the area with best hand sample containing over 30 000 g/t of gold

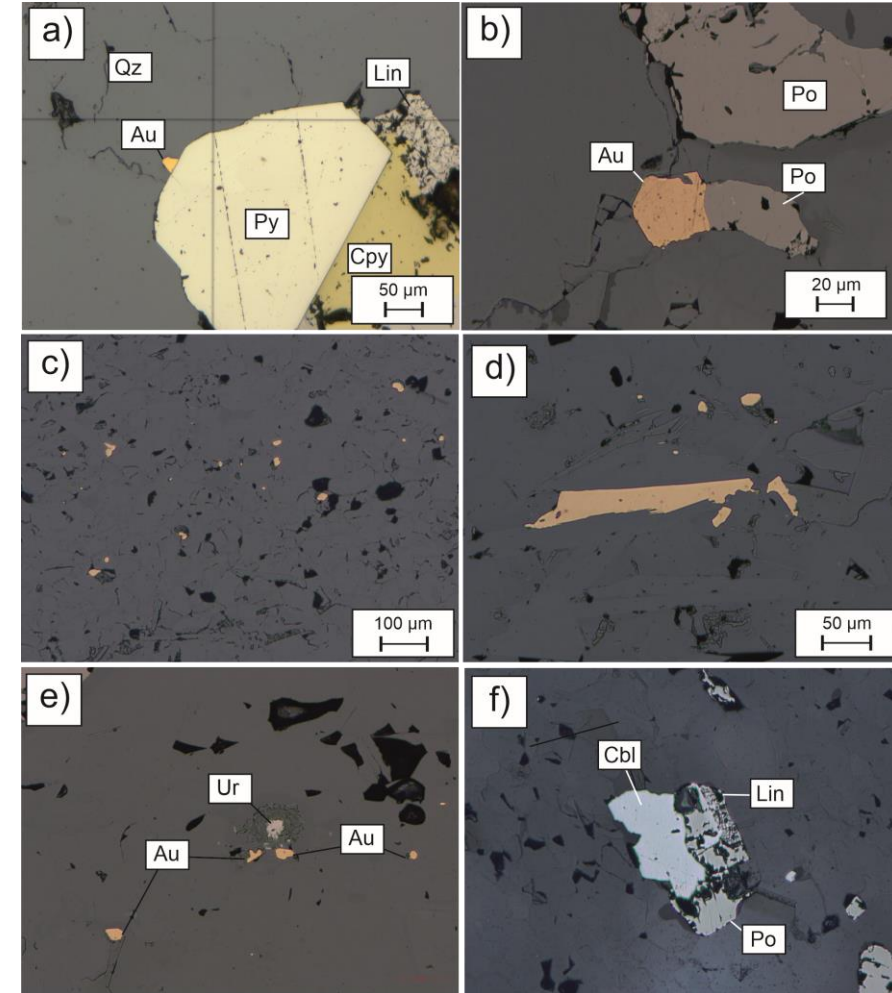
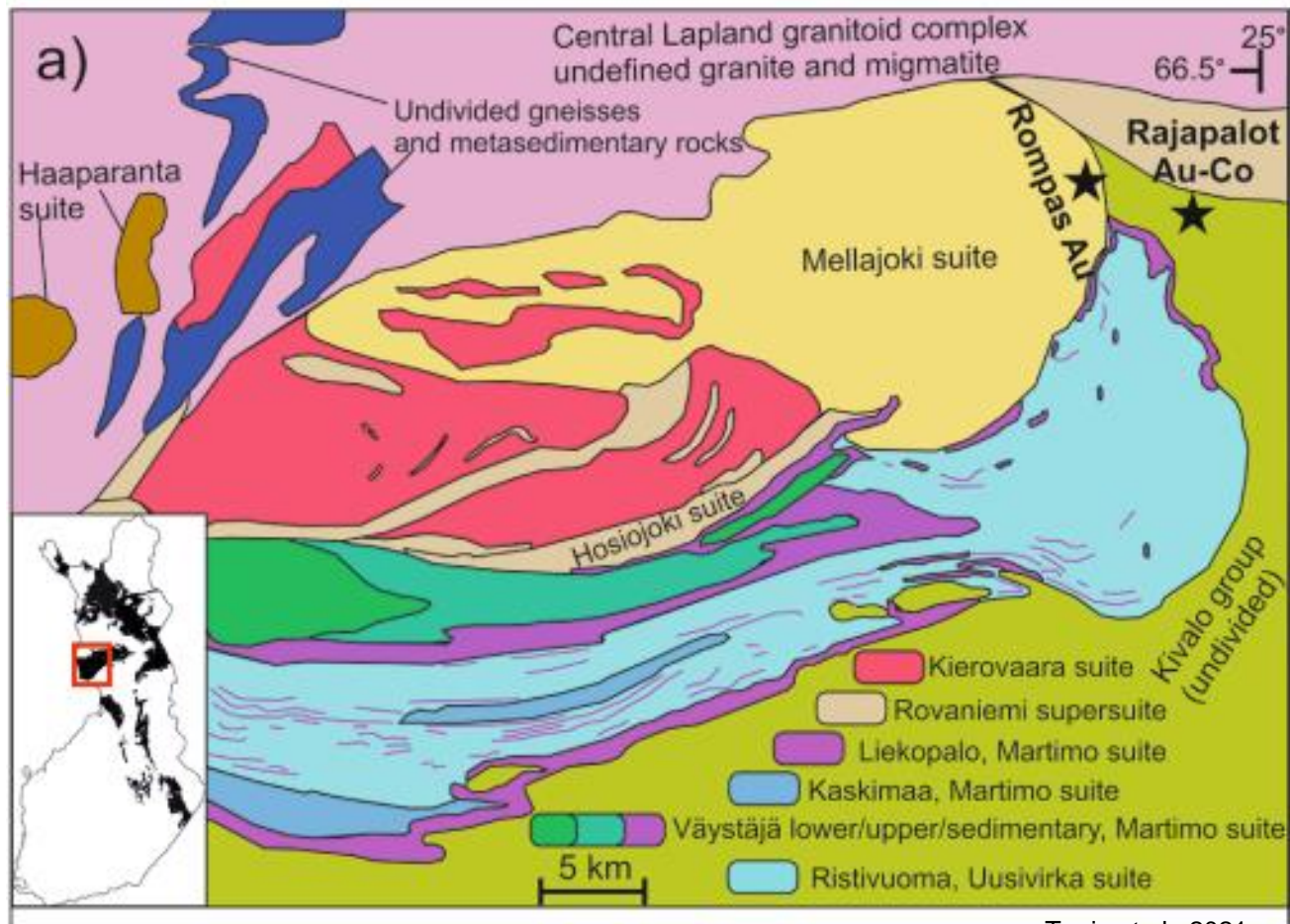


Photos: Courtesy of Mawson Oy



Case Rajapalot Au-Co deposit

- In 2012 discovery of the Rajapalot area with Au-Co 8 km east from the initial Au-U discoveries

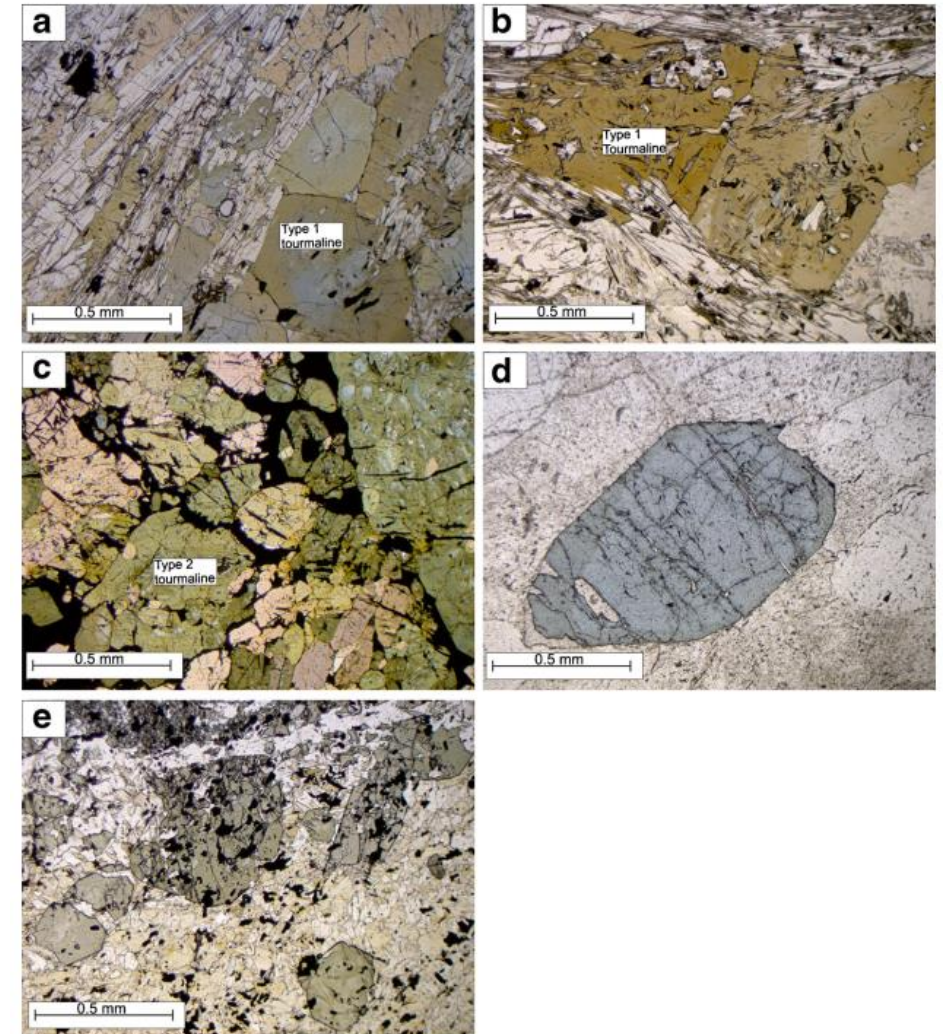
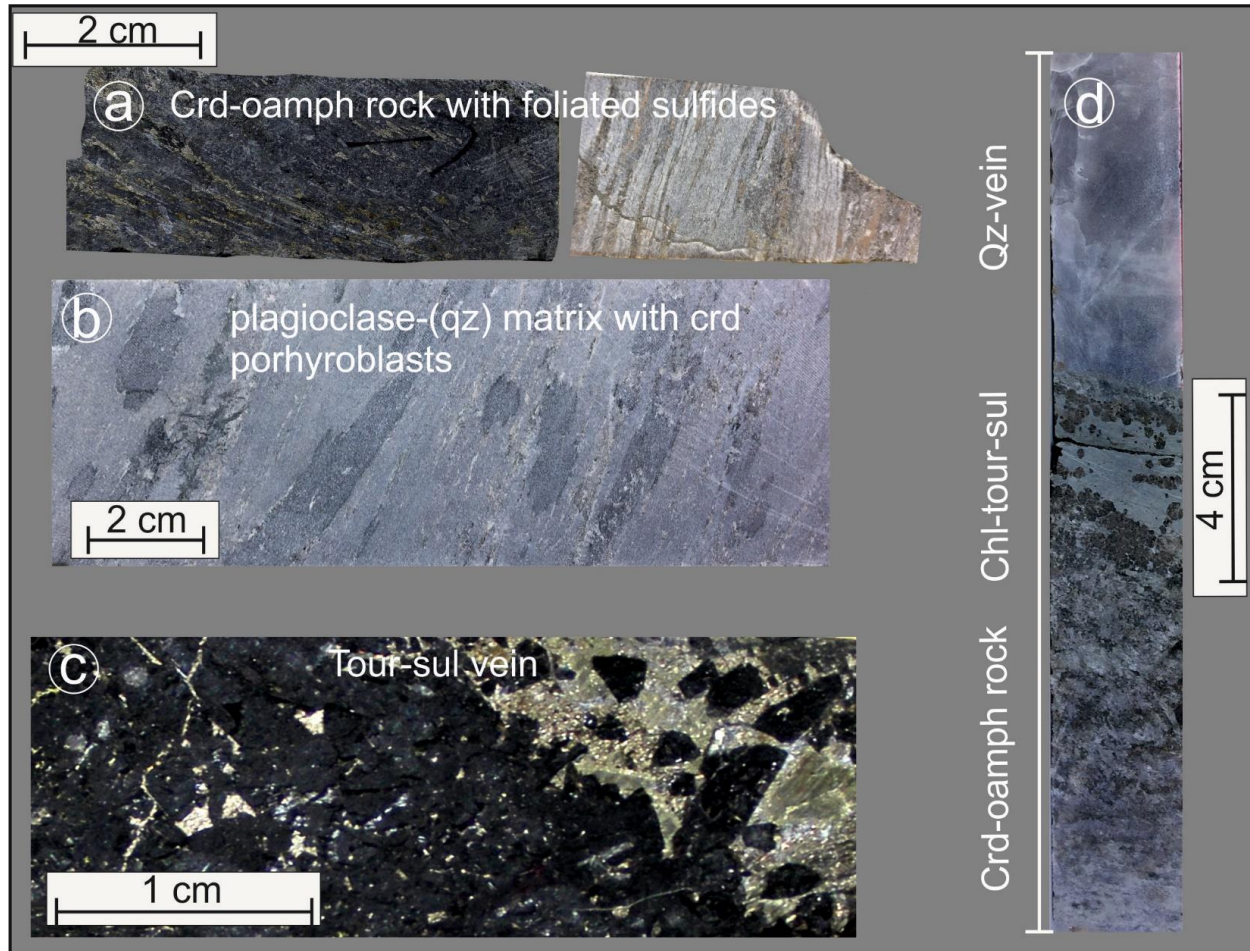


Ranta et al., 2021

Case Rajapalot Au-Co deposit



- Tourmaline is abundant mineral within and adjacent to the mineralized interval

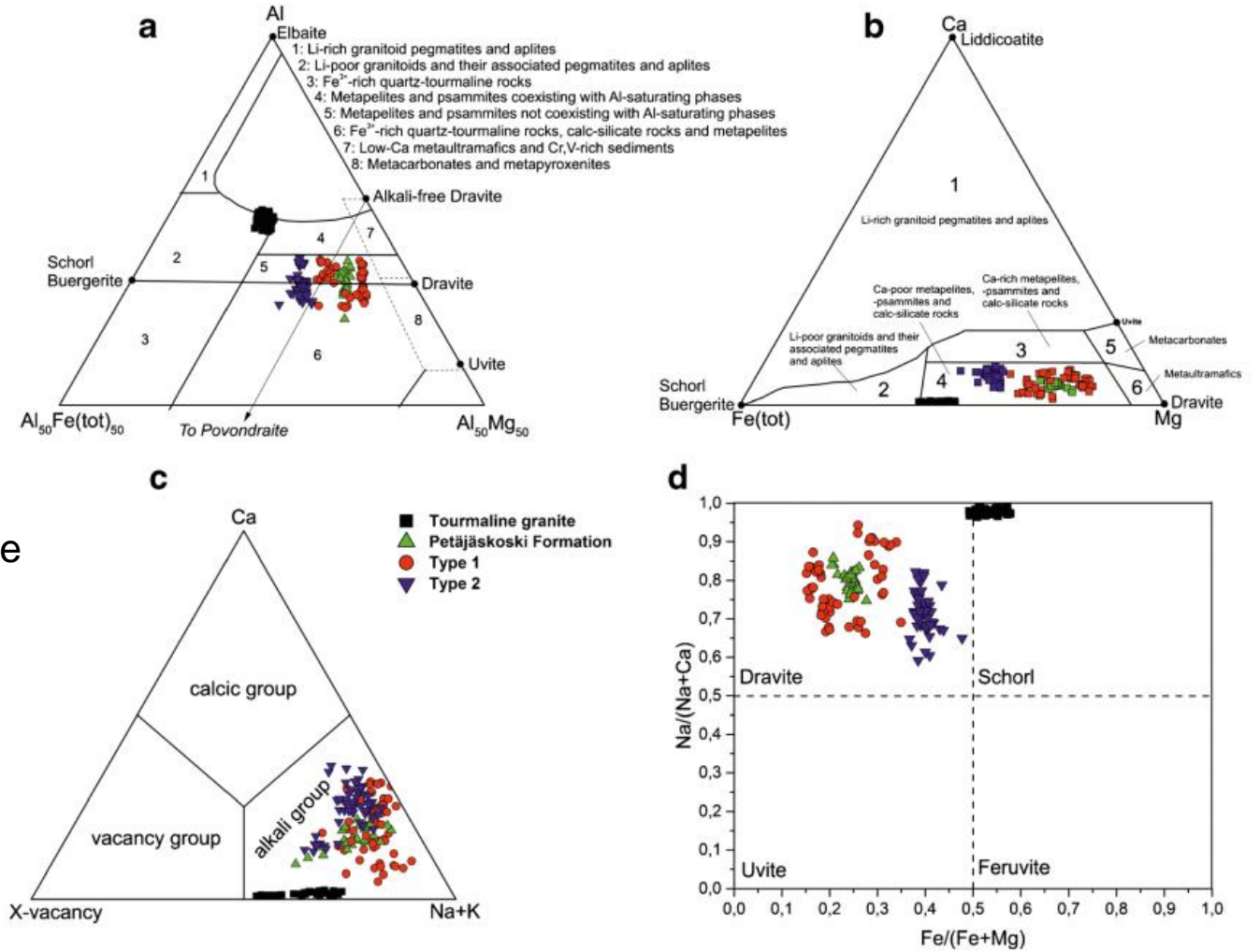


Ranta et al., 2017

Ranta et al., 2018



Case Rajapalot Au-Co deposit



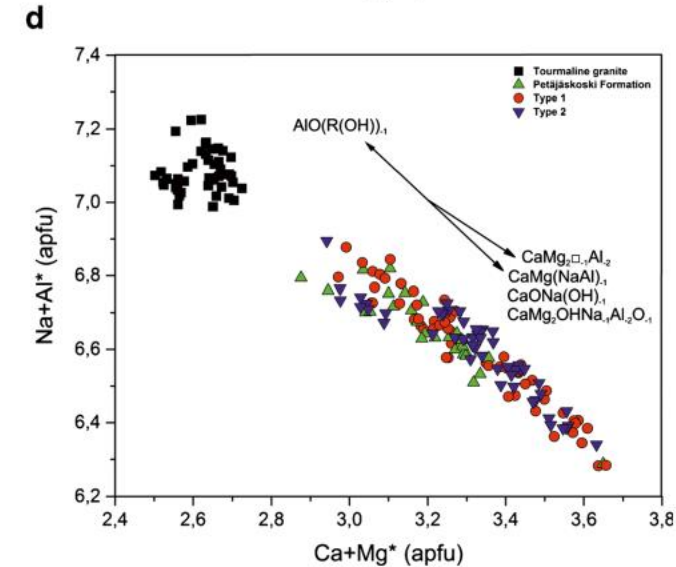
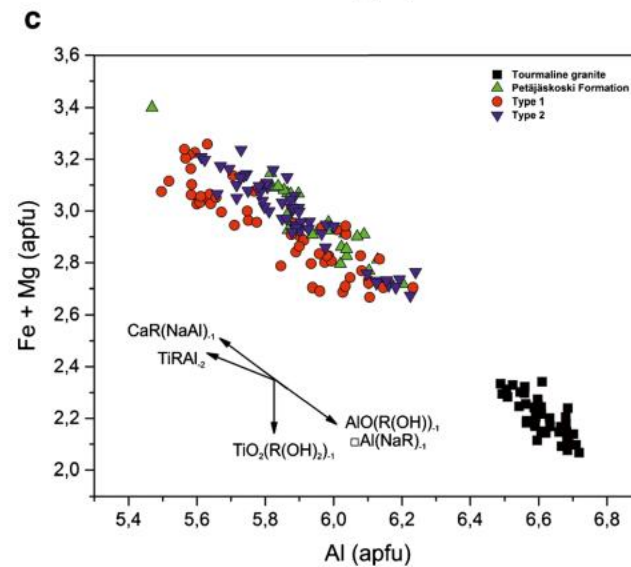
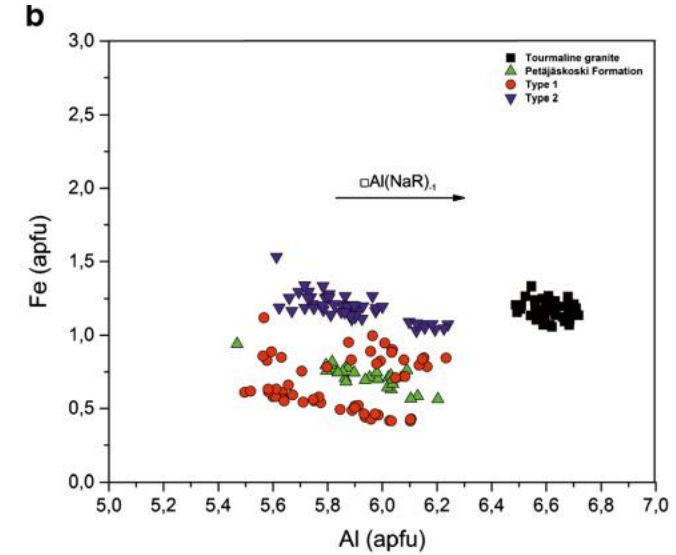
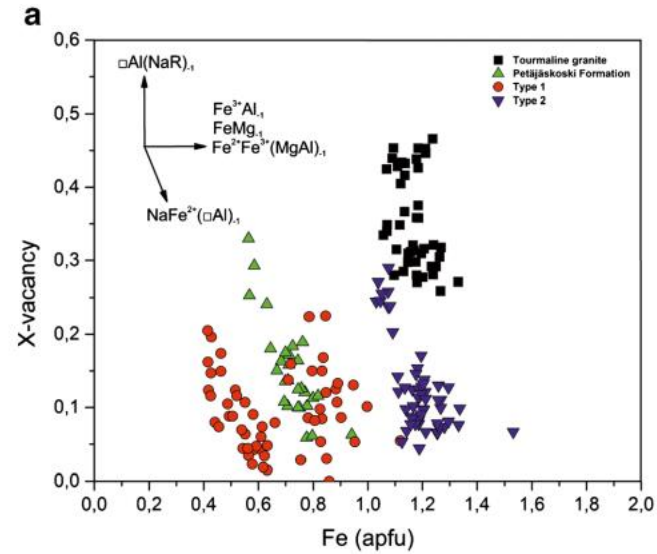
- Tourmaline is abundant mineral within and adjacent to the mineralized intervals
- Tourmaline belongs to alkali-group and can be classified as dravite

Ranta et al., 2017



Case Rajapalot Au-Co deposit

- Using compositional data (EPMA), elemental substitution trends can be investigated
- Commonly in oxidizing settings Fe^{3+} replaces Al^{3+} in tourmaline

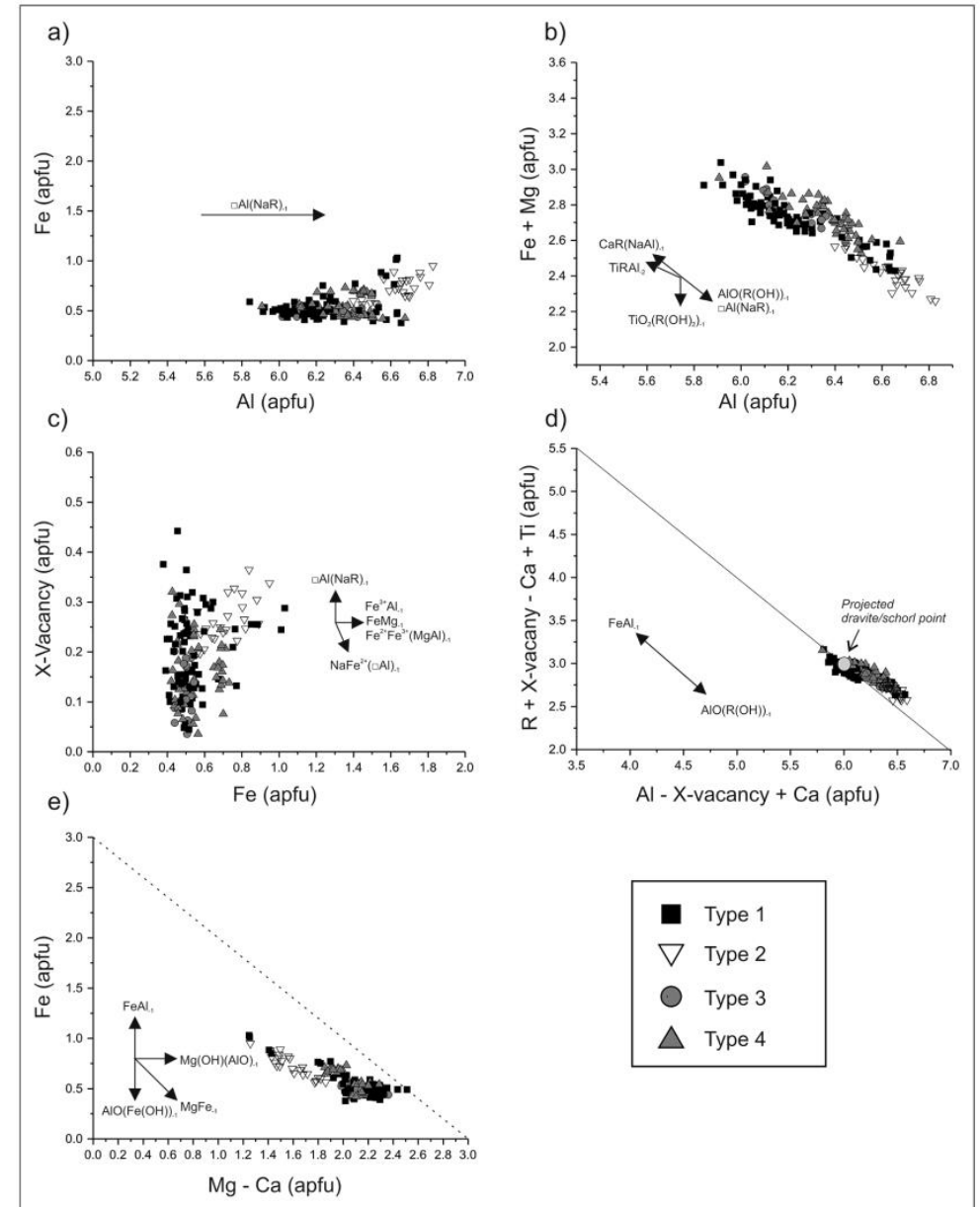


Ranta et al., 2017



Case Rajapalot Au-Co deposit

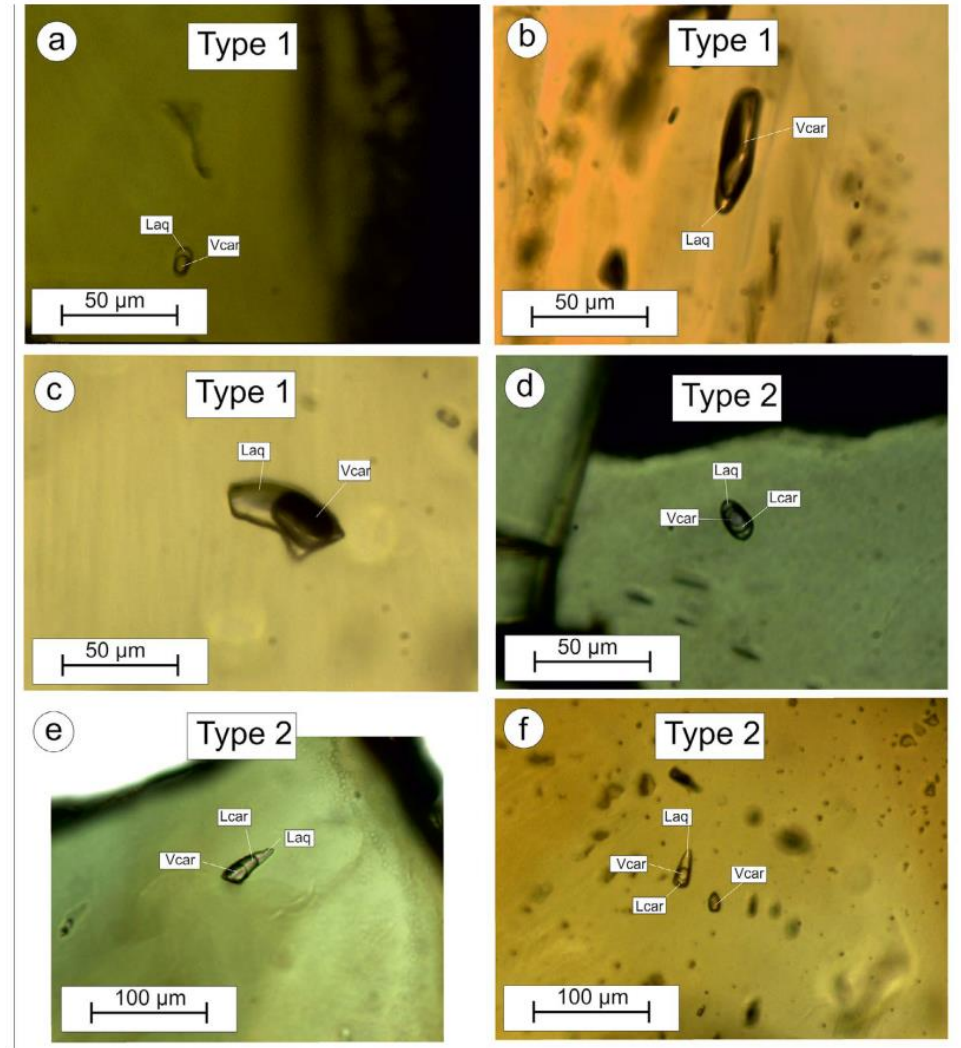
- No indications of FeAl_{-1} substitution observed





Case Rajapalot Au-Co deposit

- Na values indicate that the tourmaline crystallizing fluids were not highly saline (confirmed by FI study of tourmaline)

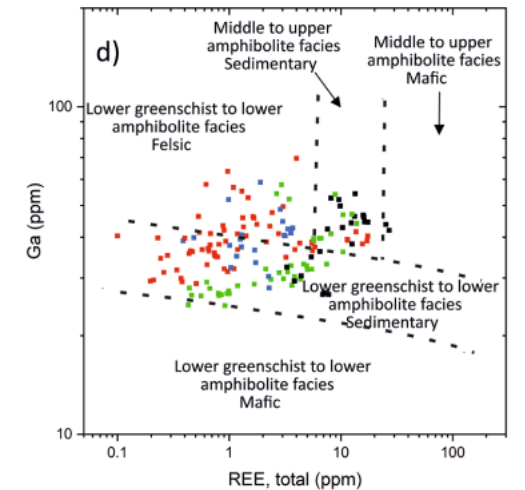
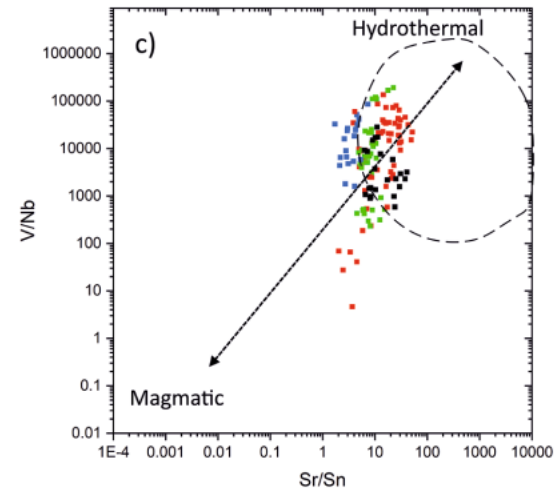
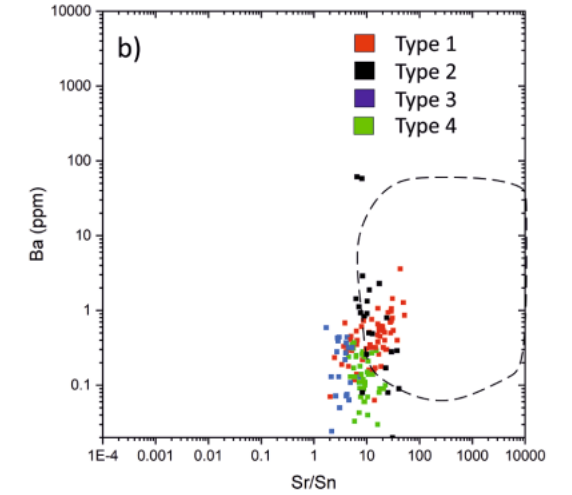
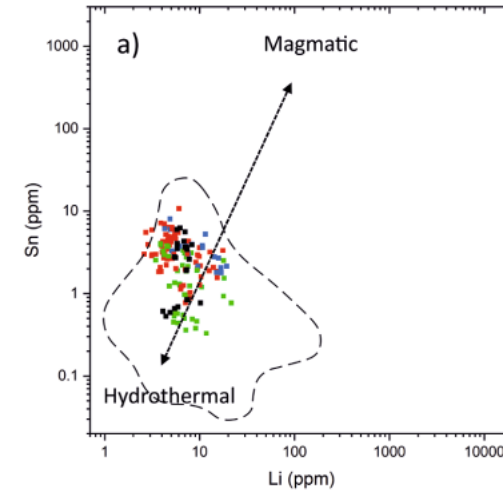


Ranta et al., 2018



Case Rajapalot Au-Co deposit

- LA-SC-ICP-MS in-situ trace elements can be used to further look at the characteristics of tourmaline species

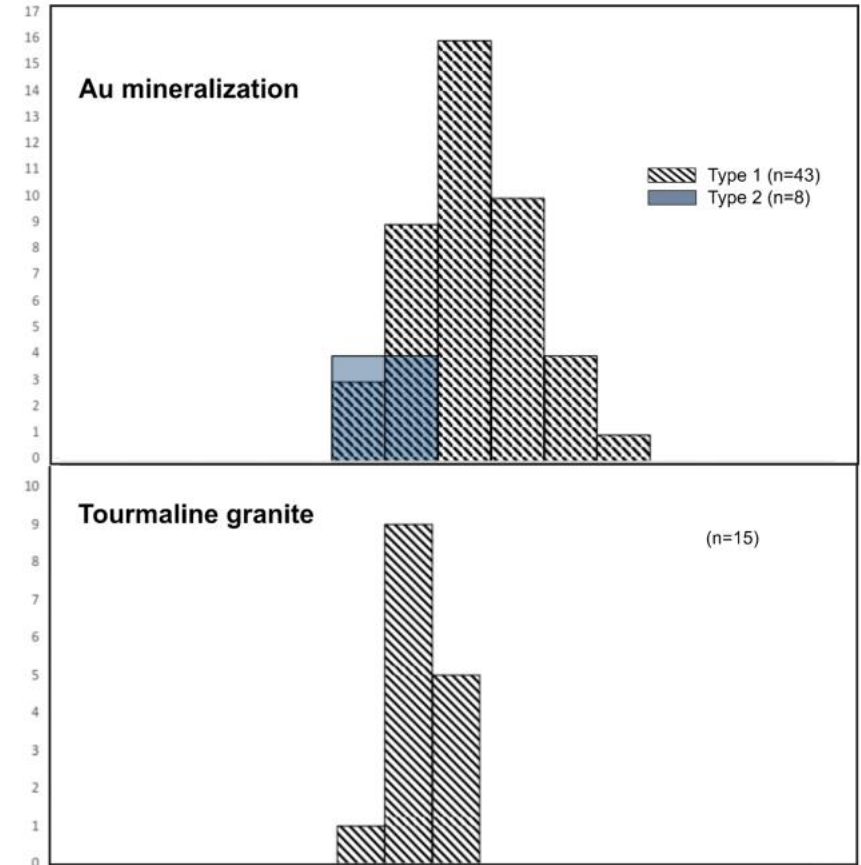


Tapiro et al., 2021



Case Rajapalot Au-Co deposit

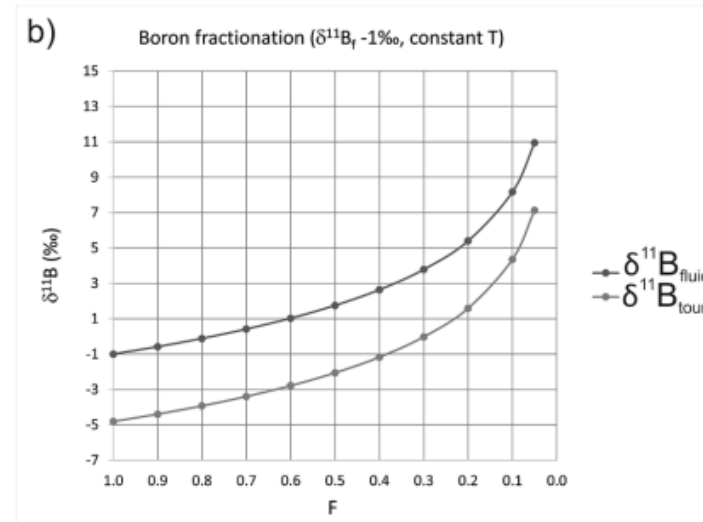
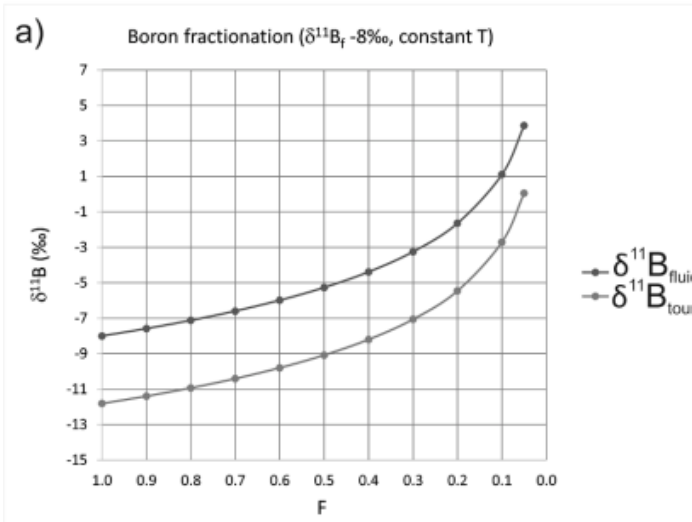
- Mineralization related tourmaline shows similar boron isotope signature with 1.78 Ga tourmaline rich pegmatitic granite within the area.
- Gold mineralization is dated ca. 1.78 Ga (molybdenite Re-Os)



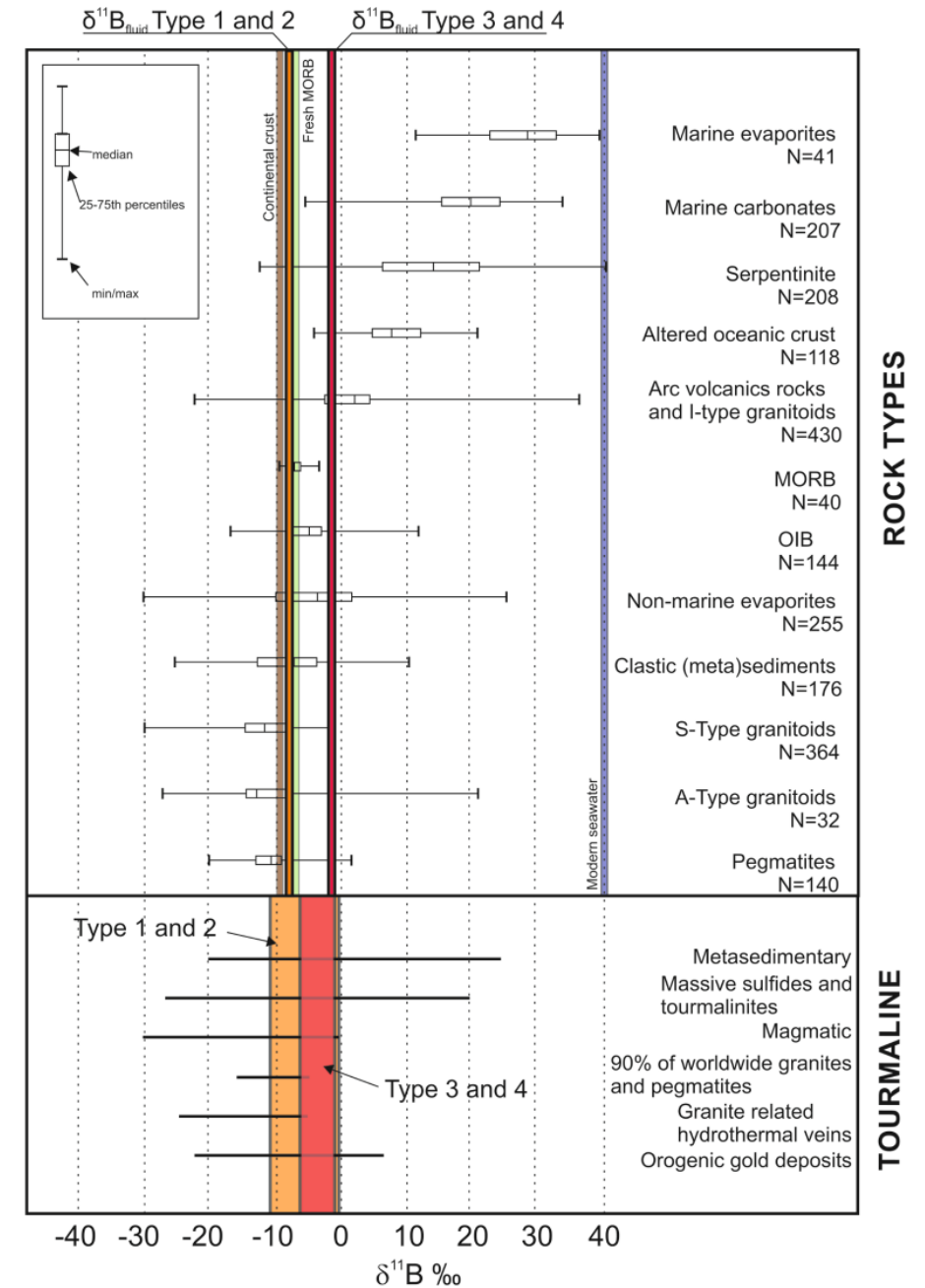


Case Rajapalot Au-Co deposit

- More extensive study of tourmaline from the area revealed wide range of boron isotope values from 4 different textural types of tourmaline
- Fractionation modelling indicates two fluids sources with distinct initial $\delta^{11}\text{B}$ values



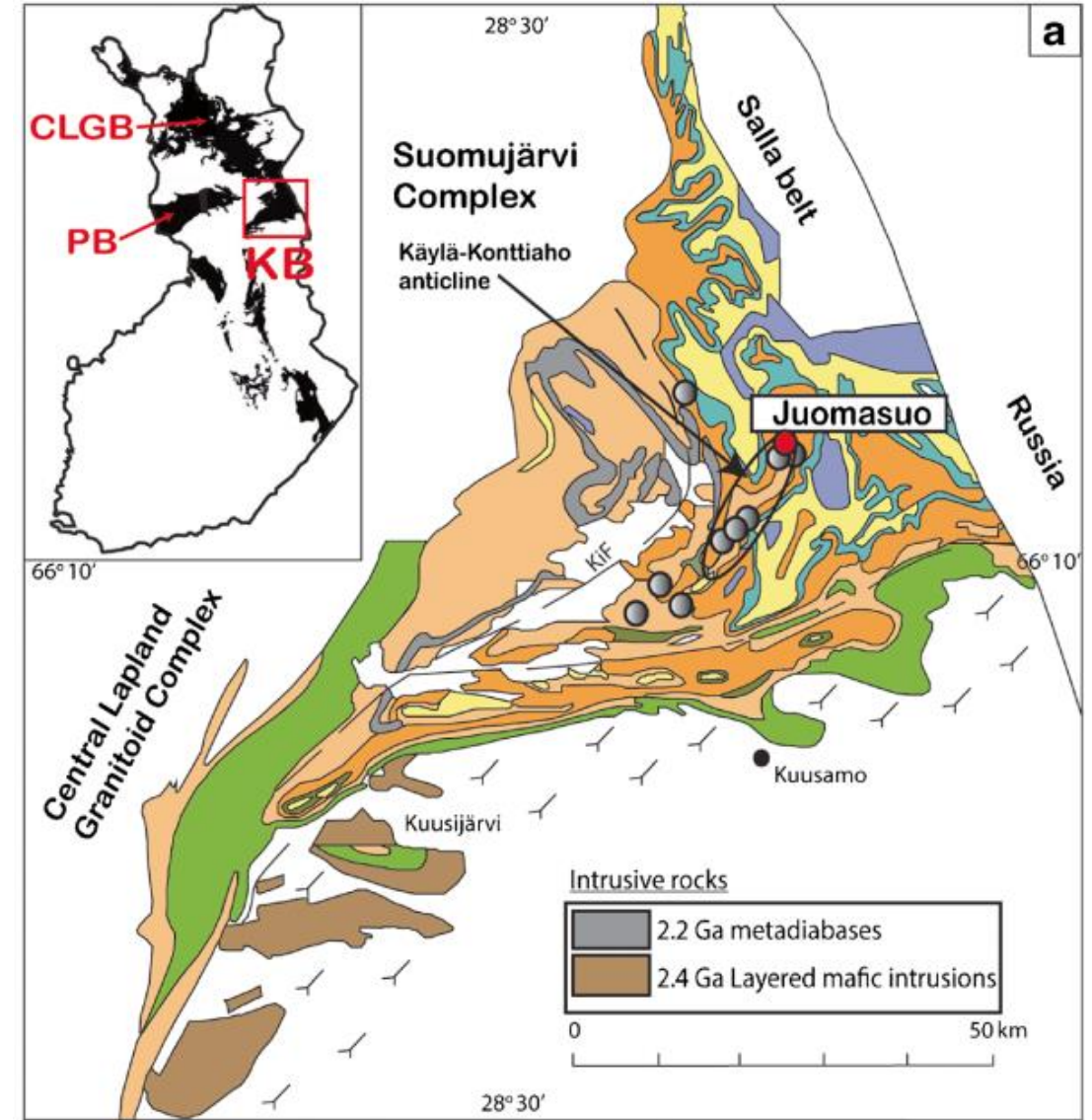
Tapio et al., 2021





Case Juomasuo Au-Co deposit

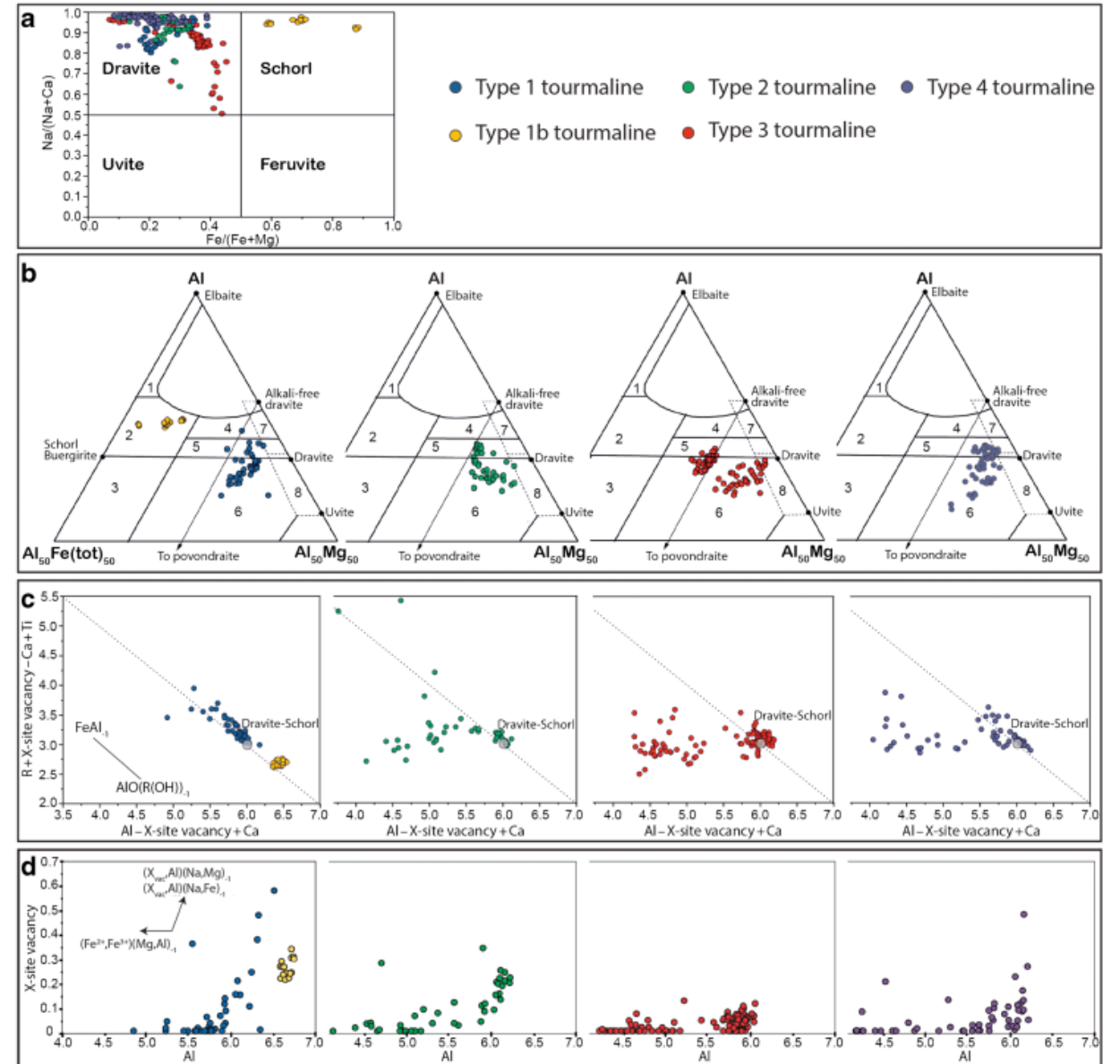
- Initially found from 1950's
- Several Au-Co rich occurrences within the Paleoproterozoic supracrustal Kuusamo belt
- Tourmaline is common mineral associated with the mineralized intervals





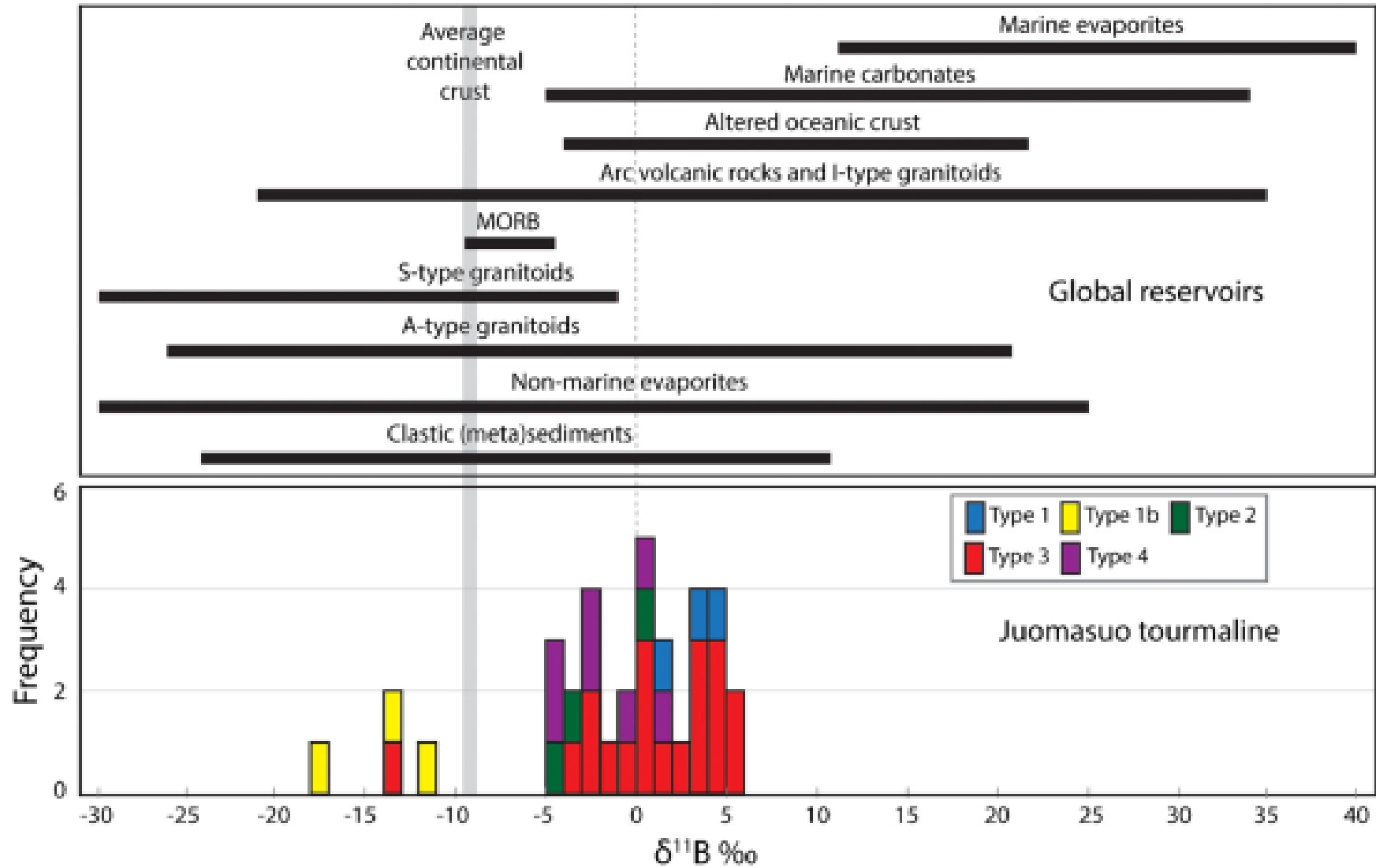
Case Juomasuo Au-Co deposit

- Several textural types of tourmaline were identified
- Elemental substitutions indicate FeAl_{-1} substitution implying oxidizing environment for some of the tourmaline types (Type 1 and Type 4)
- Na values are relatively high, indicating saline fluids





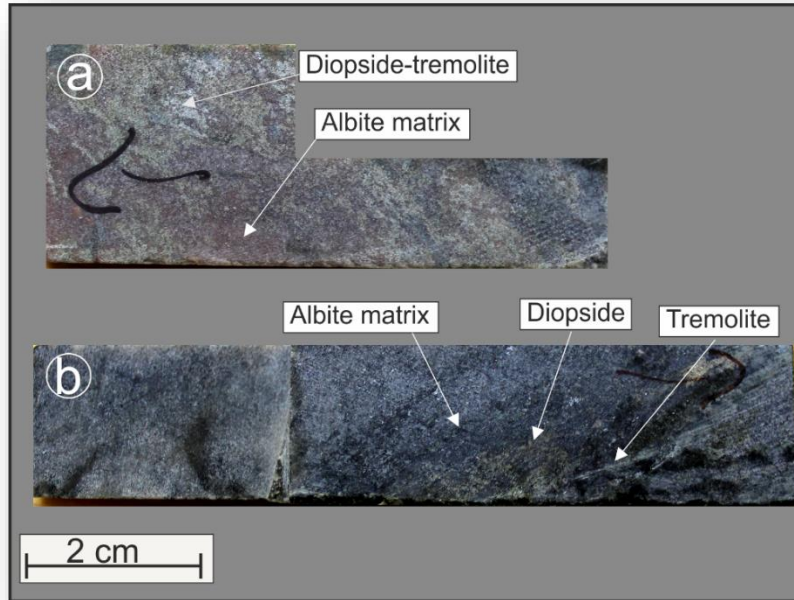
Case Juomasuo Au-Co deposit





Putting it all together

Palokas Au-Co



Ranta et al. (2018)

Kuusamo Au-Co-Cu-(REE)-U

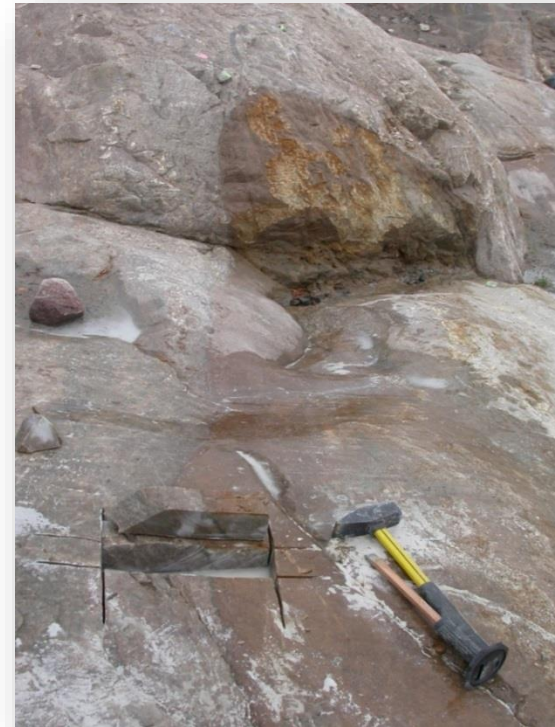
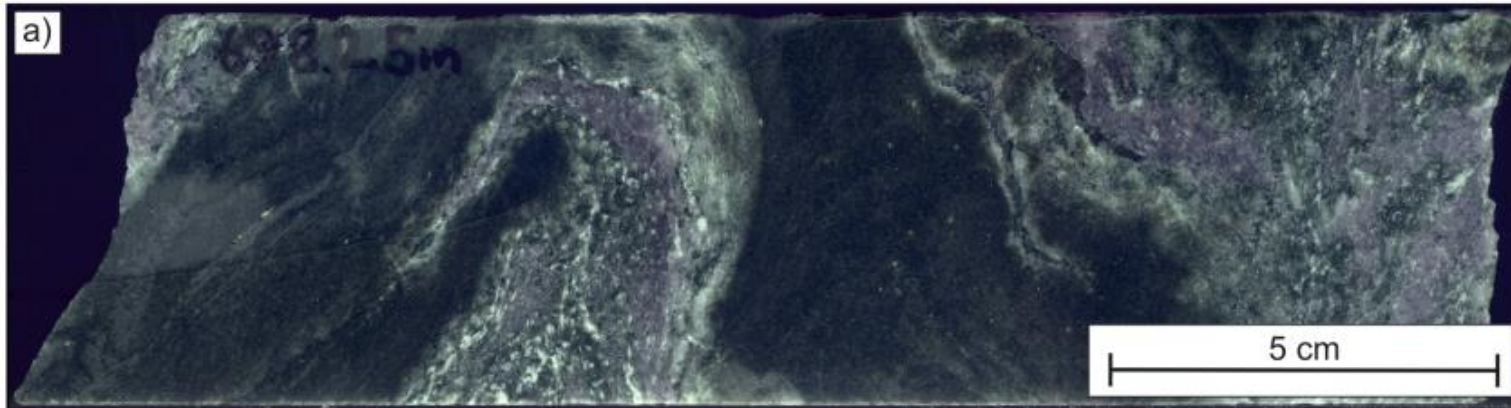


Photo by Mikael Vasilopoulos

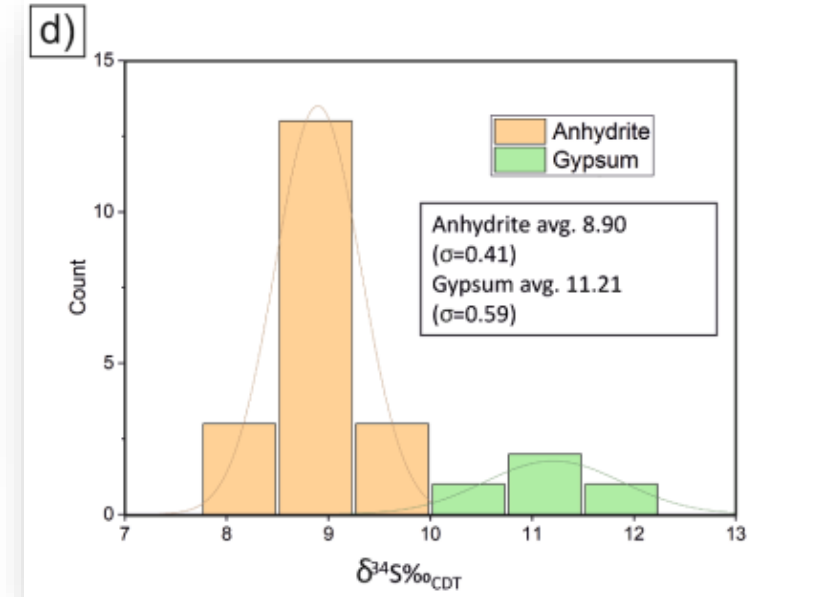
Extensive regional albitization that predates the Au mineralization



Putting it all together



Tapio et al., 2021

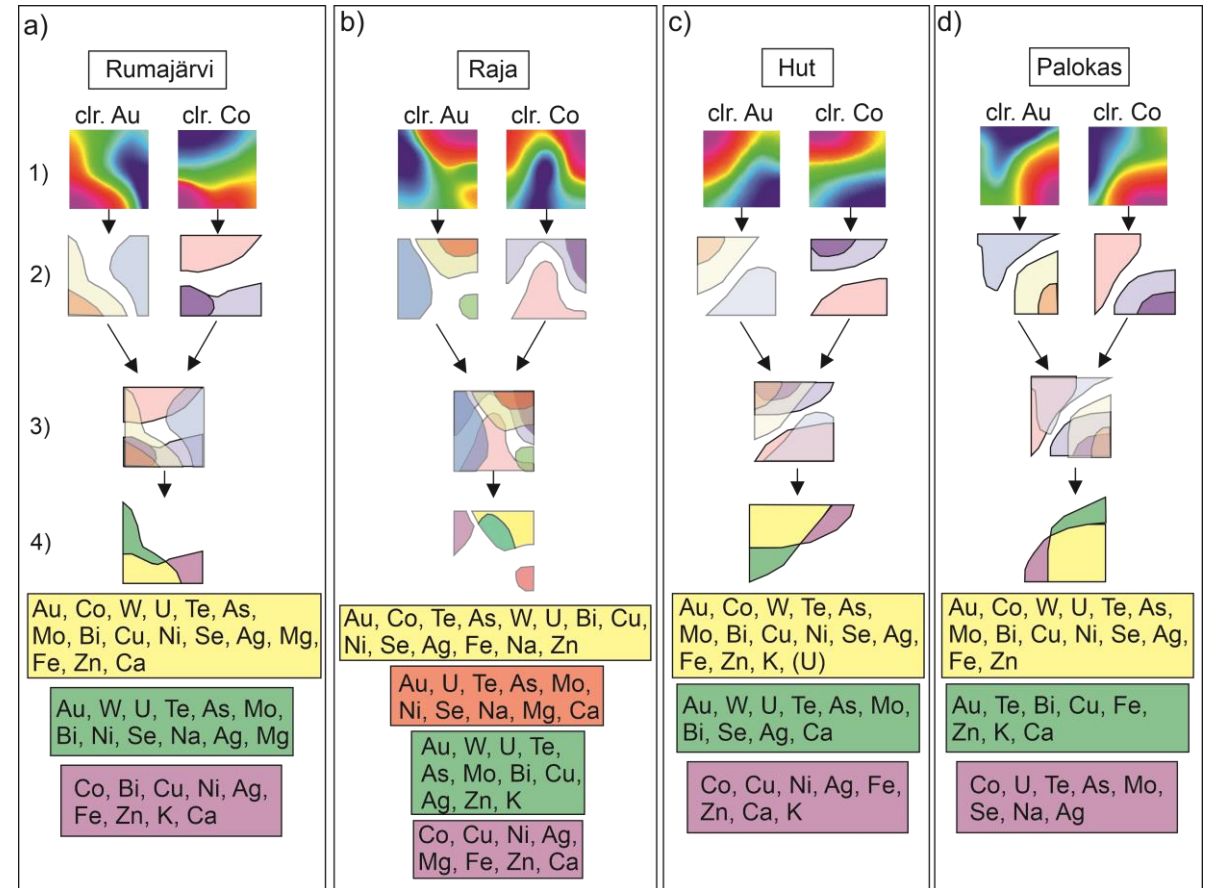
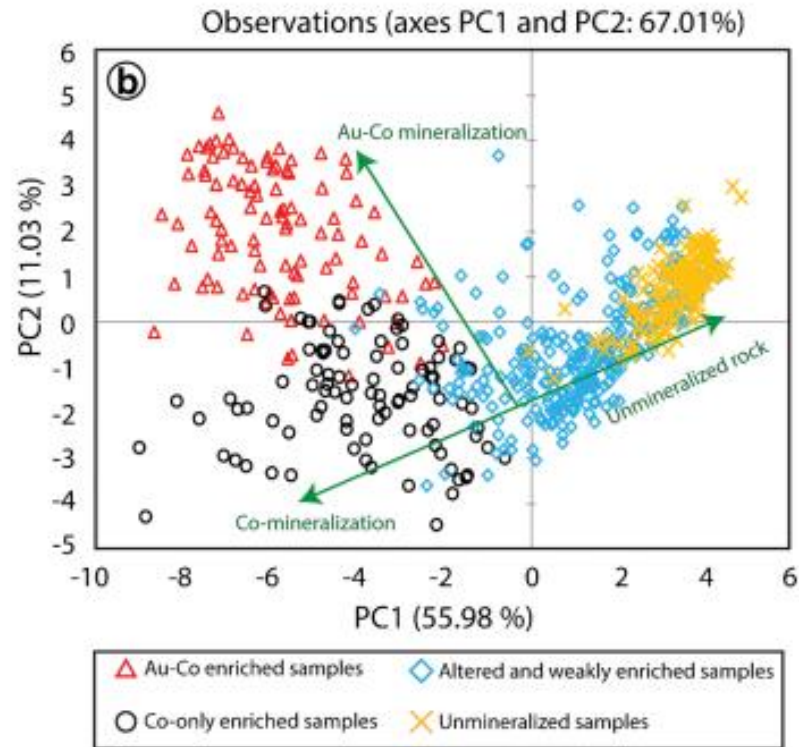


Tapio et al., 2021

Indications of Paleoproterozoic evaporites



Putting it all together



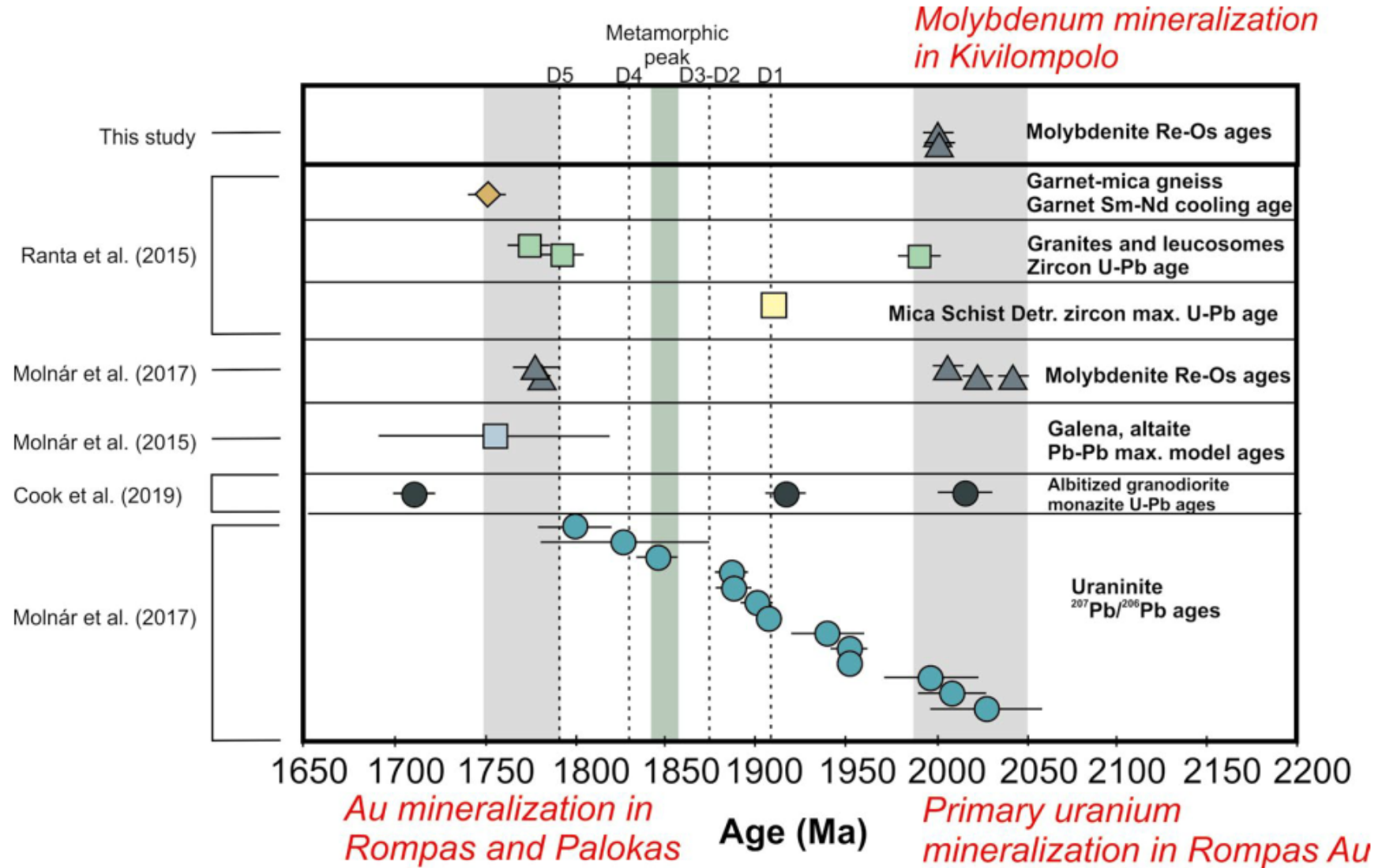
Vasilopoulos et al., 2020

Ranta et al., in press

Multi-mineralized evolution with Au-only, Au-Co, Co-only associations shown by the whole-rock and in-situ trace elements



Putting it all together



THANK
YOU!

Sometimes all that glitters is gold

13.11.2021

Oulu Mining School/ Jukka-Pekka Ranta



University of Oulu