

# GTK RESEARCH LABORATORY SERVICES SUPPORTING MINERAL EXPLORATION



*TUKES-GTK Exploration info 3.-4.5.2023*  
*AVI Lapland, Rovaniemi*



# GTK RESEARCH LAB: AREAS OF EXPERTISE

- Focus on applied mineralogy and isotope geochemistry
- Tailored research services for companies in all stages of mineral exploration, assessment of mineralizations, and mining operations
- Versatile and modern state-of-the-art technologies
- High expertise in the characterization of geological samples
- Research-based approach



# GEOMATERIALS RESEARCH

## RESEARCH TOPICS

- Ore and bedrock geology
- Mineralogy
- Hydrogeology
- Geochronology (U-Pb)
- Mineral exploration
- Mineral processing and geometallurgy
- Mining
- Environment
- Infrastructure

Primary to Secondary  
Geomaterials

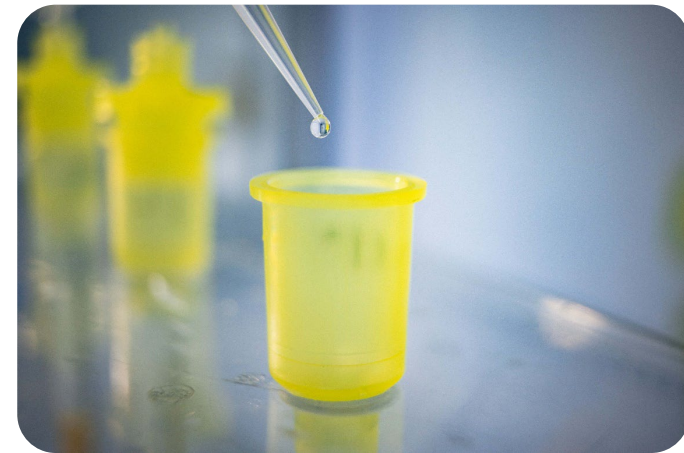
## RESEARCH MATERIALS

- Rocks, minerals, ores
- Soils and sediments
- Water
- Concentrates, tailings, and by-products
- Slags, ashes, and dusts
- E-waste
- Construction materials



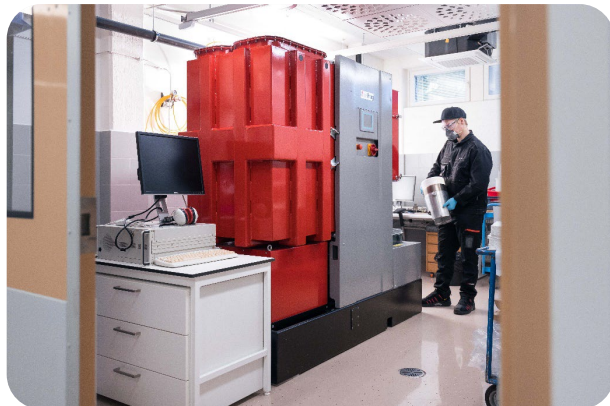
5.5.2023

Circular Economy  
Battery Minerals  
Water Management  
Changing Environment  
Critical Minerals  
Low-carbon energy solutions





# SAMPLE PREPARATION FACILITIES



Heavy liquid and magnetic separations



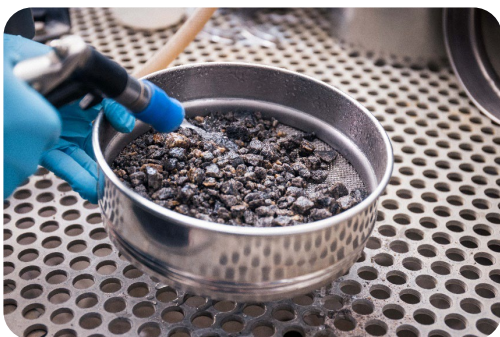
Microscopy:  
Optical, polarized & reflected



Technical facilities for sample preparation



Clean chemistry laboratories



Crushing, grinding, selective fragmentation & other pretreatment

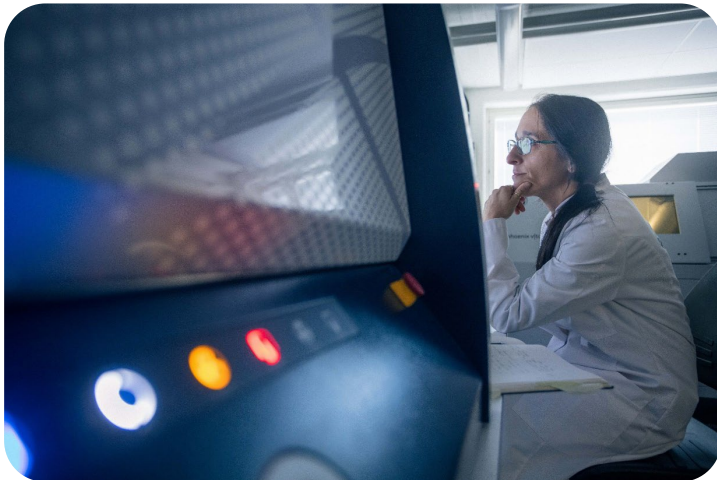


# MINERALOGY: X-RAY DIFFRACTION AND MICRO-XRF



## X-Ray diffraction

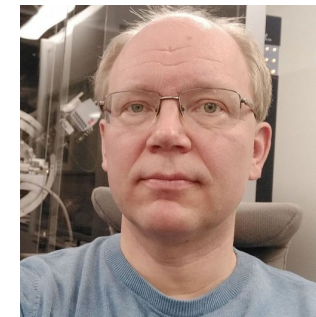
- Identification of minerals and other crystalline phases
- Qualitative and quantitative (Rietveld)
- Clay minerals
- Estimation of amorphous material
- Benchtop-XRF for support of data interpretation



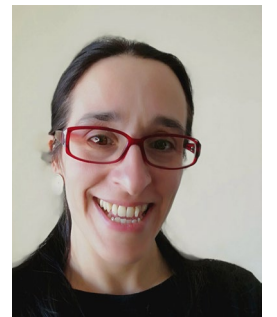
## Micro-XRF

- Elemental and phase mapping
- Modal mineralogy
- AMICS software
- Large sample chamber

## OUR EXPERTS AT YOUR SERVICE



Pasi Heikkilä, MSc  
Research Scientist (XRD, XRF)



Ester Jolis, PhD  
Research Scientist (Micro-XRF)



# MINERALOGY: ELECTRON OPTICS



## LV-SEM and FE-SEM

- High-resolution imaging
- Elemental and phase mapping
- Modal mineralogy
- Grain size distribution and associations of minerals
- Liberation of mineral grains



## EPMA and FEG-EPMA

- Quantitative compositions of minerals down to ppm level
- Quantitative mapping

## OUR EXPERTS AT YOUR SERVICE



Sari Lukkari, PhD  
Senior Scientist (SEM-EDS)



Paavo Nikkola, PhD  
Research Scientist (SEM-EDS)



Radoslaw Michallik, PhD  
Research Scientist (Microanalysis)



Mia Tiljander, PhD  
Senior Scientist (Microanalysis)



# MINERALOGY: X-RAY TOMOGRAPHY 3D-CHARACTERIZATION



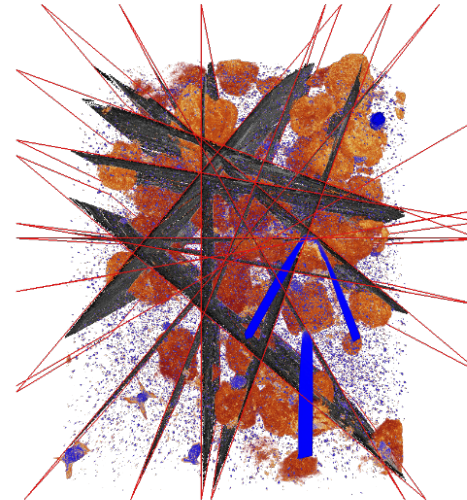
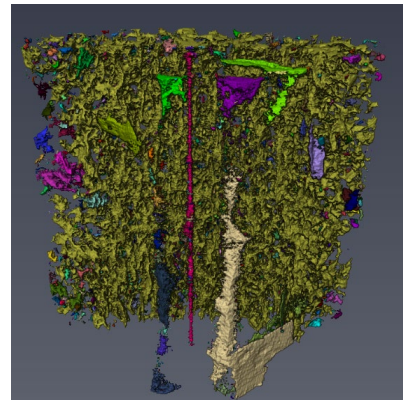
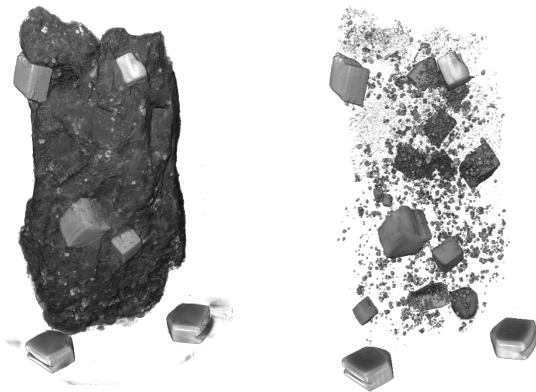
## XCT

- Volume fraction/porosity
- Pore formation/filling
- Grayscale values (mineralogy)
- Orientation, grain shapes
- Grain size distribution
- 4D imaging
- 3D context to other measurements

OUR EXPERT AT YOUR SERVICE



Jukka Kuva, PhD  
Senior Scientist (X-Ray Tomography)





# ISOTOPE GEOCHEMISTRY ANALYTICAL TECHNIQUES

## Single Collector HR ICP-MS



**Trace element geochemistry:** Liquid (ppq limit of detection) / Solid (any material)

**U-Pb geochronology (in-situ/single grains):** zircon, monazite, baddeleyite, titanite, apatite, xenotime, uraninite, garnet...

## Multiple Collector HR ICP-MS



**Solution analysis (water or dissolved materials) high precision isotope ratios:**

Li, Mg, S, Cu, Fe, Zn, Rb, Sr, Sm, Nd, Hf, Th, Pb, U

**Minerals in-situ isotope measurements:** Sulfides (S, Fe, Cu, Zn), tourmaline (B), Plagioclase-carbonate (Sr), monazite (Nd), zircon (Hf), Pb (Pb-rich phases, K-fsp), spodumene (Li)...

## OUR EXPERTS AT YOUR SERVICE



Matti Kurhila, PhD  
Senior Scientist (Geochronology)



Yann Lahaye, PhD  
Senior Scientist (Isotope Geochemistry)



Xuan Liu, PhD  
Senior Scientist (Isotope Geochemistry)



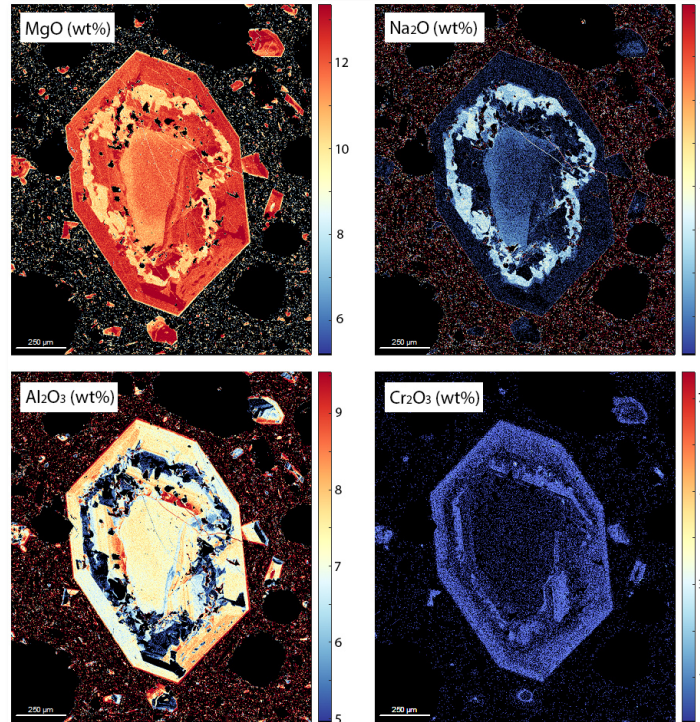
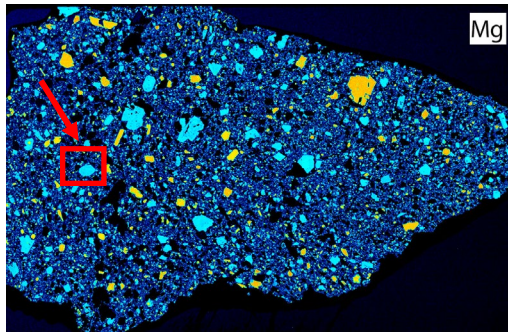
Minna Myllyperkiö, MSc  
Research Scientist (Analytical Chemistry)



Hugh O'Brien, PhD  
Senior Scientist (Isotope Geochemistry)

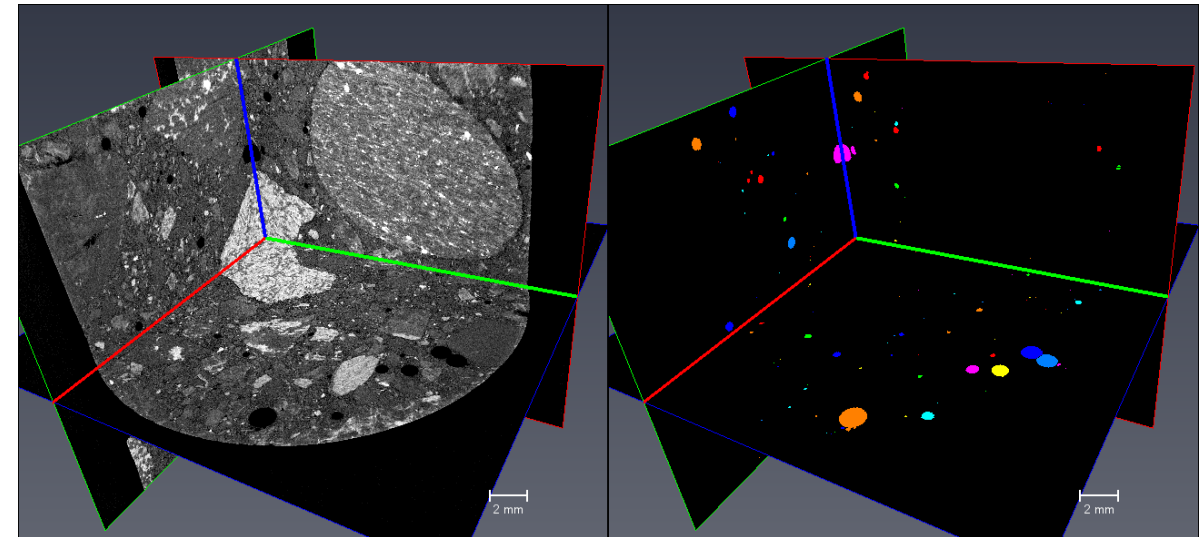


# EXPLORATION SERVICES: CHARACTERIZATION (2D-3D)



Micro-XRF  
40 x 26 mm field of view  
Semiq. elemental mapping  
by Ester Jolis

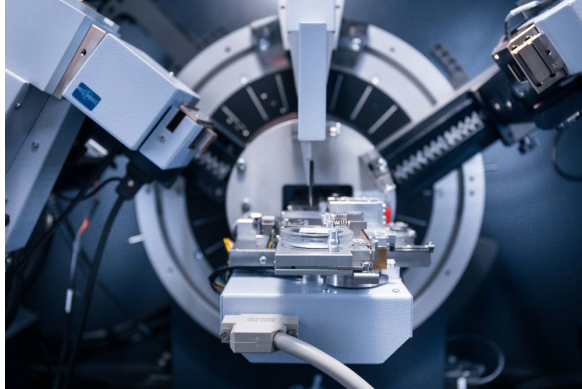
EPMA  
1.5 x 1.8 mm field of view  
Quantitative elemental mapping  
by Radoslaw Michallik



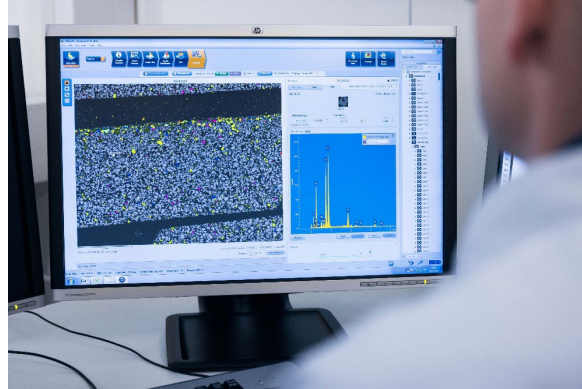
XCT  
Drill core intersections: 3D Porosity mapping by Jukka Kuva



# EXPLORATION SERVICES: ELEMENTAL DEPARTMENT



XRD for phase identification



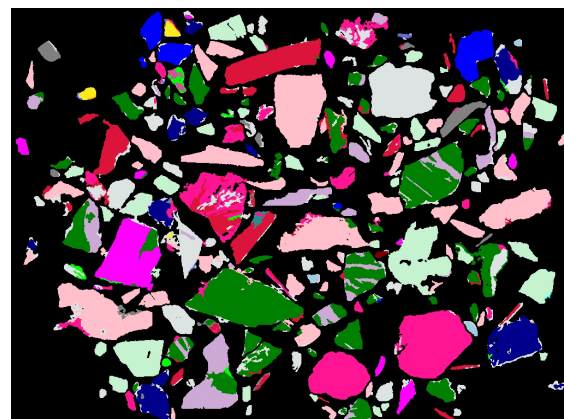
SEM-EDS for modal mineralogy



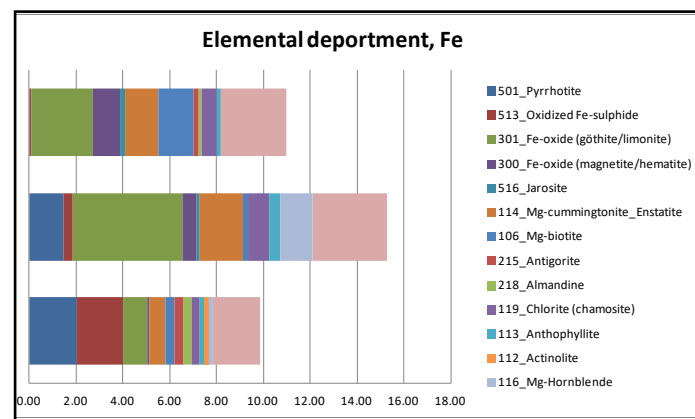
EPMA for quantitative compositions



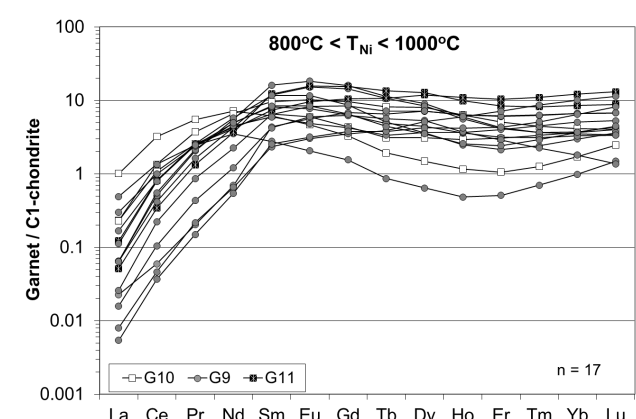
LA-SC-ICPMS for trace elements



100\_Quartz  
103\_K-feldspar  
Unclassified  
201\_Calcite  
106\_Mg-biotite  
118\_Chlorite (clinocllore)  
101\_Albite  
102\_Plagoclase  
200\_Apatite  
108\_Phlogopite  
Undersized  
204\_Bartite  
110\_Augite  
116\_Mg-Hornblende  
401\_Monazite  
500\_Pyrite  
107\_Muscovite  
119\_Chlorite (chamosite)  
513\_Oxidized Fe-sulphide  
206\_Epidote  
117\_Tremolite  
112\_Actinolite



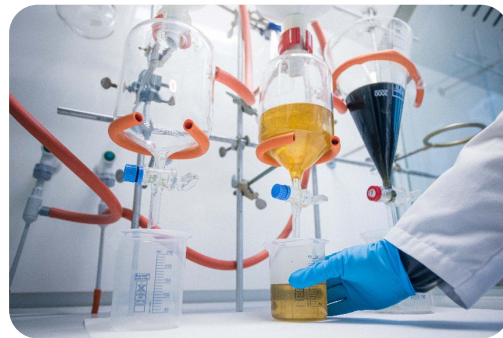
	J	K	L	M	N	
wt%	K(wt%)	Ca(wt%)	P(wt%)	Ti(wt%)	Cr(wt%)	Na
0.10	0.00	16.24	0.01	1.37	0.00	
0.12	0.00	16.14	0.01	1.37	0.02	
0.09	0.00	16.14	0.01	1.30	0.00	
0.12	0.01	16.07	0.01	1.40	0.00	
0.13	0.00	16.18	0.01	1.58	0.01	
0.15	0.00	16.17	0.00	1.51	0.03	
0.16	0.01	16.12	0.00	1.66	0.01	
0.14	0.00	16.18	0.01	1.57	0.04	
0.13	0.00	16.18	0.00	1.60	0.02	
0.11	0.00	16.00	0.00	1.72	0.01	
0.14	0.00	16.10	0.00	1.40	0.00	
0.13	0.01	15.92	0.01	1.32	0.04	
0.08	0.00	15.91	0.01	2.12	0.08	
0.10	0.00	15.90	0.01	2.09	0.12	
0.00	0.37	8.45	0.02	0.15	0.02	
0.02	0.32	8.83	0.01	0.15	0.03	
0.00	0.29	9.03	0.01	0.17	0.01	
0.00	0.28	9.16	0.02	0.12	0.00	
0.00	0.46	7.71	0.03	0.19	0.00	



The deportment of elements of interest (carrier mineral phases) can be solved down to the ppm level.



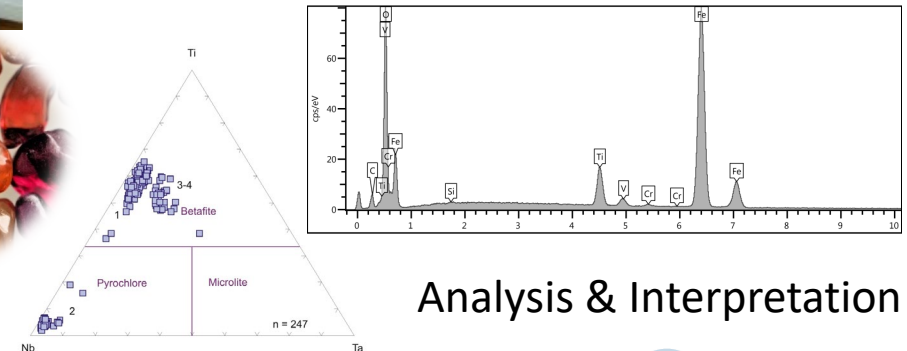
# EXPLORATION SERVICES: INDICATOR MINERAL WORK FLOW



Sampling

Concentration

Microscopy



Analysis & Interpretation



# The MinExTarget service concept



**Sampling**



**Heavy mineral  
separation**



**Mineral trace  
element analysis**

**Advanced data  
analysis**

Interpretation of the genetic origin of the sediment hosted heavy minerals. Do they originate from a mineralized bedrock source?



By courtesy of Paavo Nikkola



# EXPLORATION SERVICES: GEOCHRONOLOGY AND ISOTOPE GEOCHEMISTRY DATA FOR THE BEDROCK OF FINLAND

- ~2600 samples for U-Pb
- ~1000 samples for Sm-Nd
- numerous other isotope analyses
  - Rb-Sr, Pb-Pb
  - also stable isotopes (S, Fe, Zn, Cu ...)

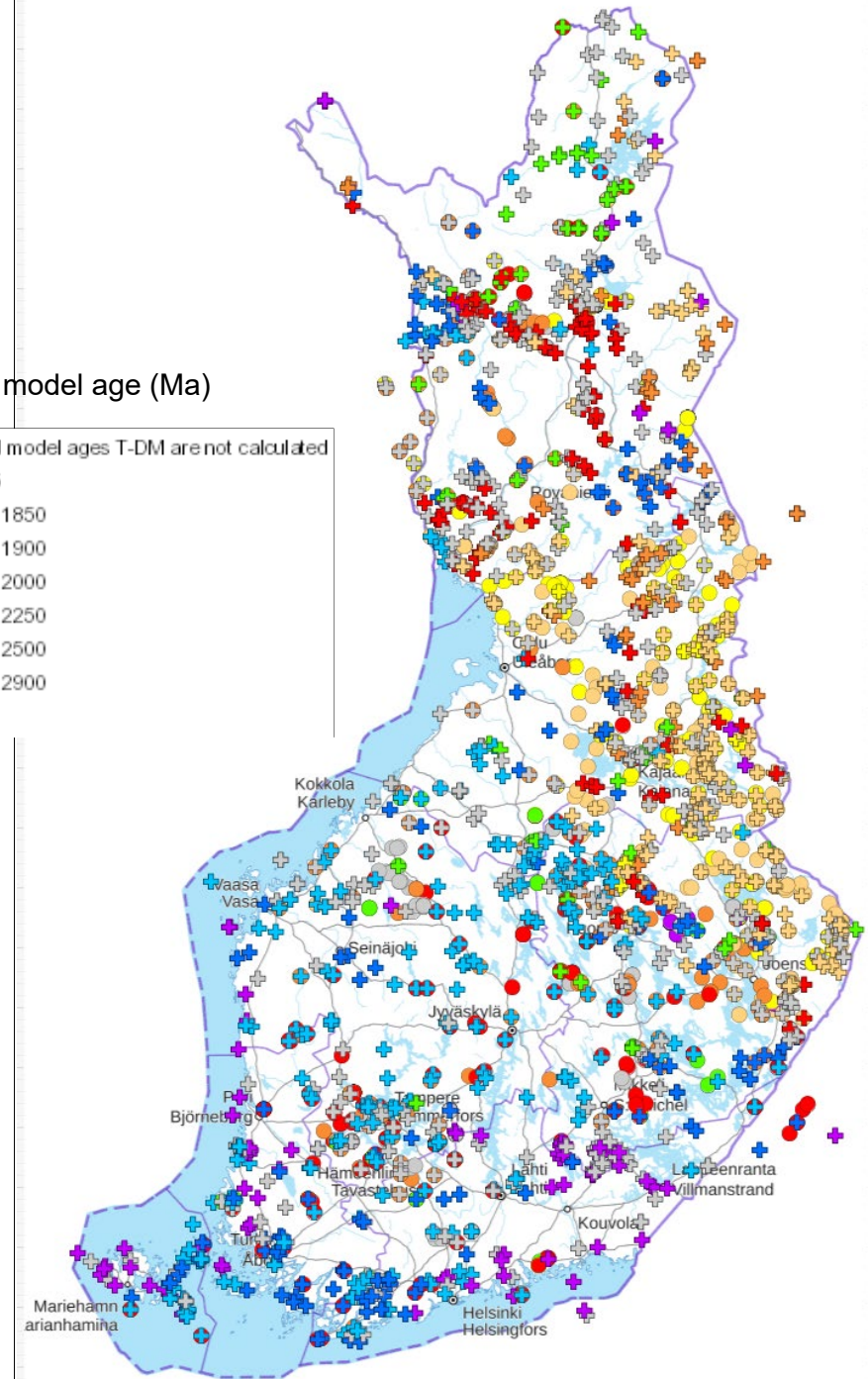
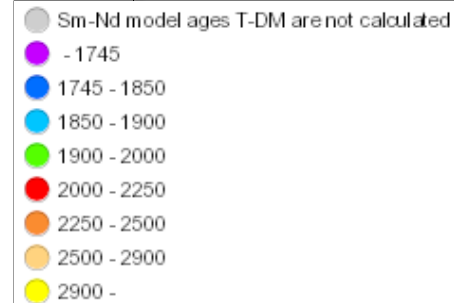
*By courtesy of Matti Kurhila*

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U-Pb age (Ma)



Sm-Nd model age (Ma)

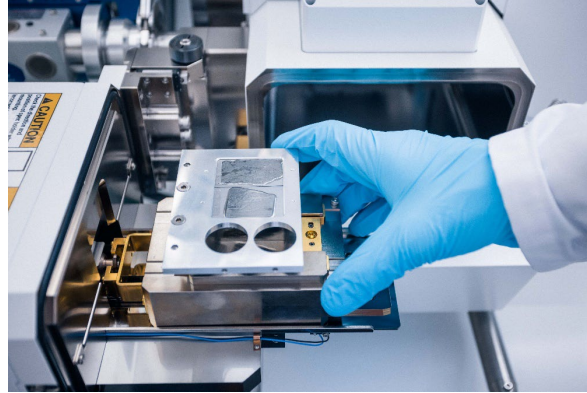




# EXPLORATION SERVICES: GEOCHEMICAL FINGERPRINTING



SEM-EDS for modal mineralogy



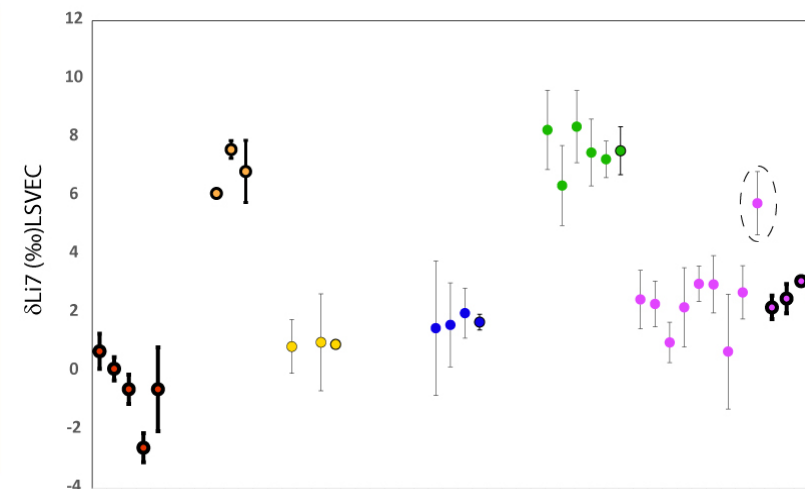
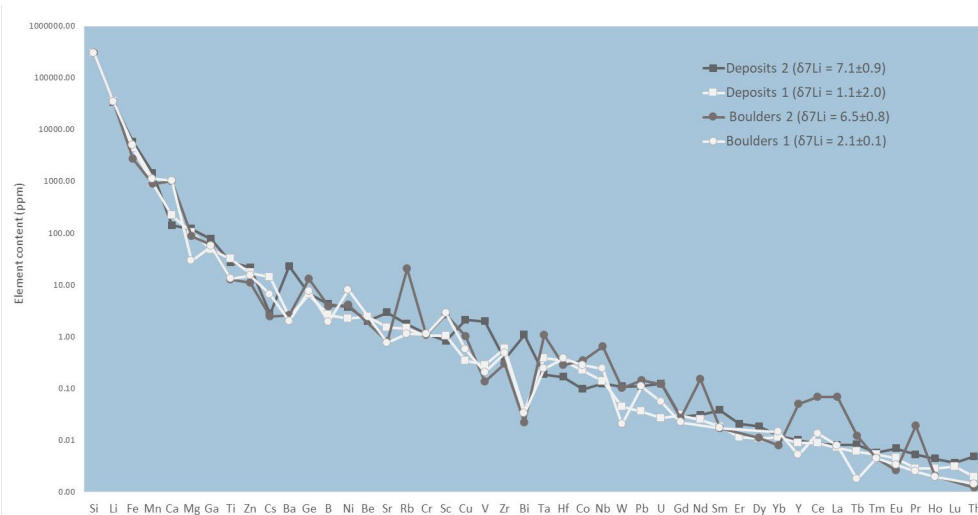
EPMA for quantitative compositions



LA-SC-ICPMS for trace elements



MC-SC-ICPMS for isotopic ratios



Li trace elements and isotopes in spodumene from pegmatites from different localities in Finland by *Lukkari et al (2021)*

- *Pegmatite population could be identified based on Li isotopic compositions*
- *Li isotopes from spodumene boulders can identify new populations of pegmatites*
- *TE composition of spodumene can be used to estimate the differentiation stage and Li content of the deposit*



# MINERAL PROCESSING SERVICES – GTK MINTEC



Mineralogical research and geometallurgy • Bench-scale testing for beneficiation • Continuous minipilot- and pilot-scale test runs • Unit operation testing in the pilot plant • Full process testing in the pilot plant • Evaluation of the commercial potential of a mineral deposit based on test results • Environment and recycling studies

[www.gtk.fi/en/research-infrastructure/outokumpu-mineral-processing-pilot-plant-and-laboratories/](http://www.gtk.fi/en/research-infrastructure/outokumpu-mineral-processing-pilot-plant-and-laboratories/)





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**GTK**

**Kiitos!**