Mineralogical study of the heavy mineral concentrate from the Karkonosze-Izera Massif, SW Poland

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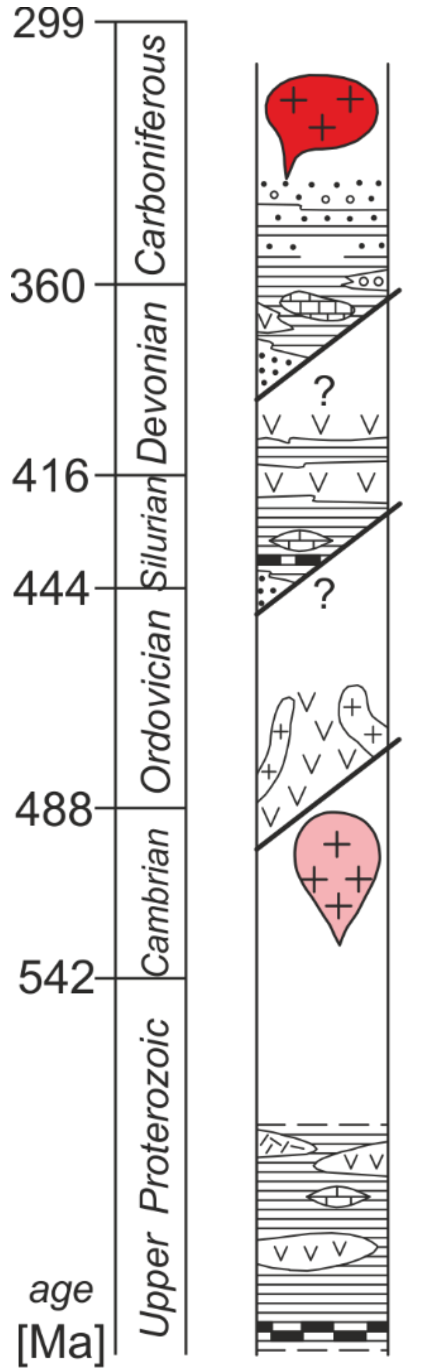
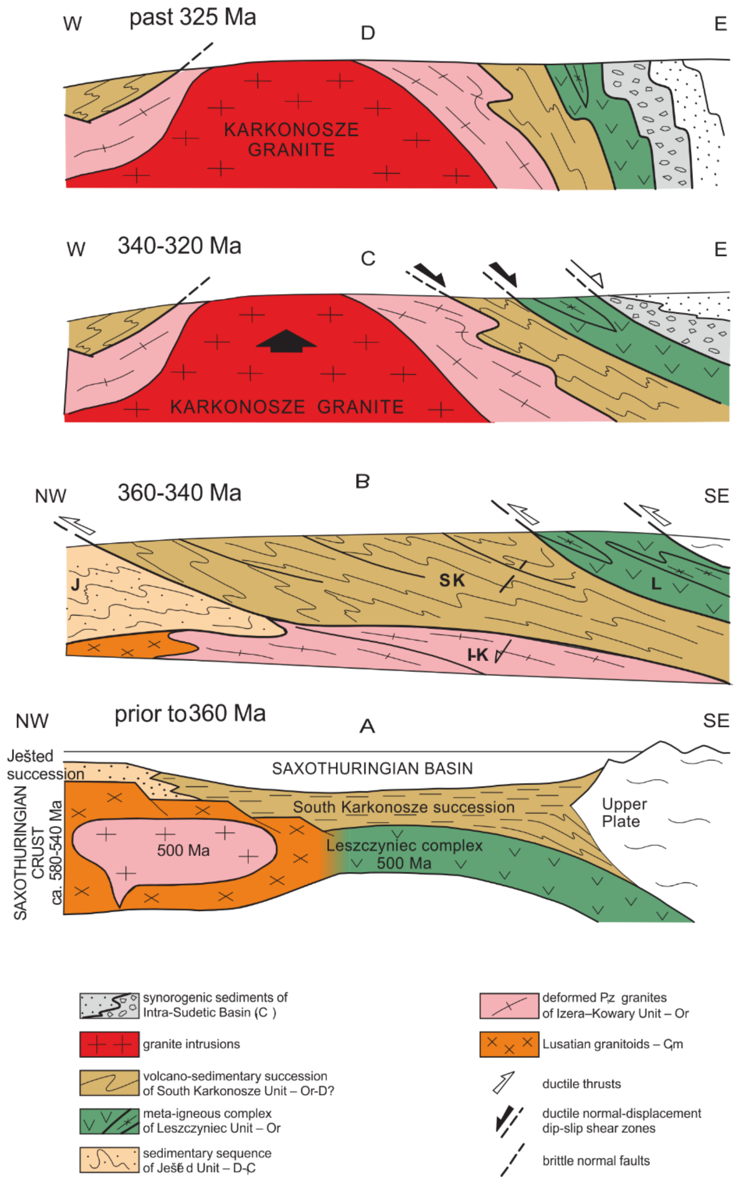
Heavy mineral concentration and analytical techniques in mineral exploration - from research to business

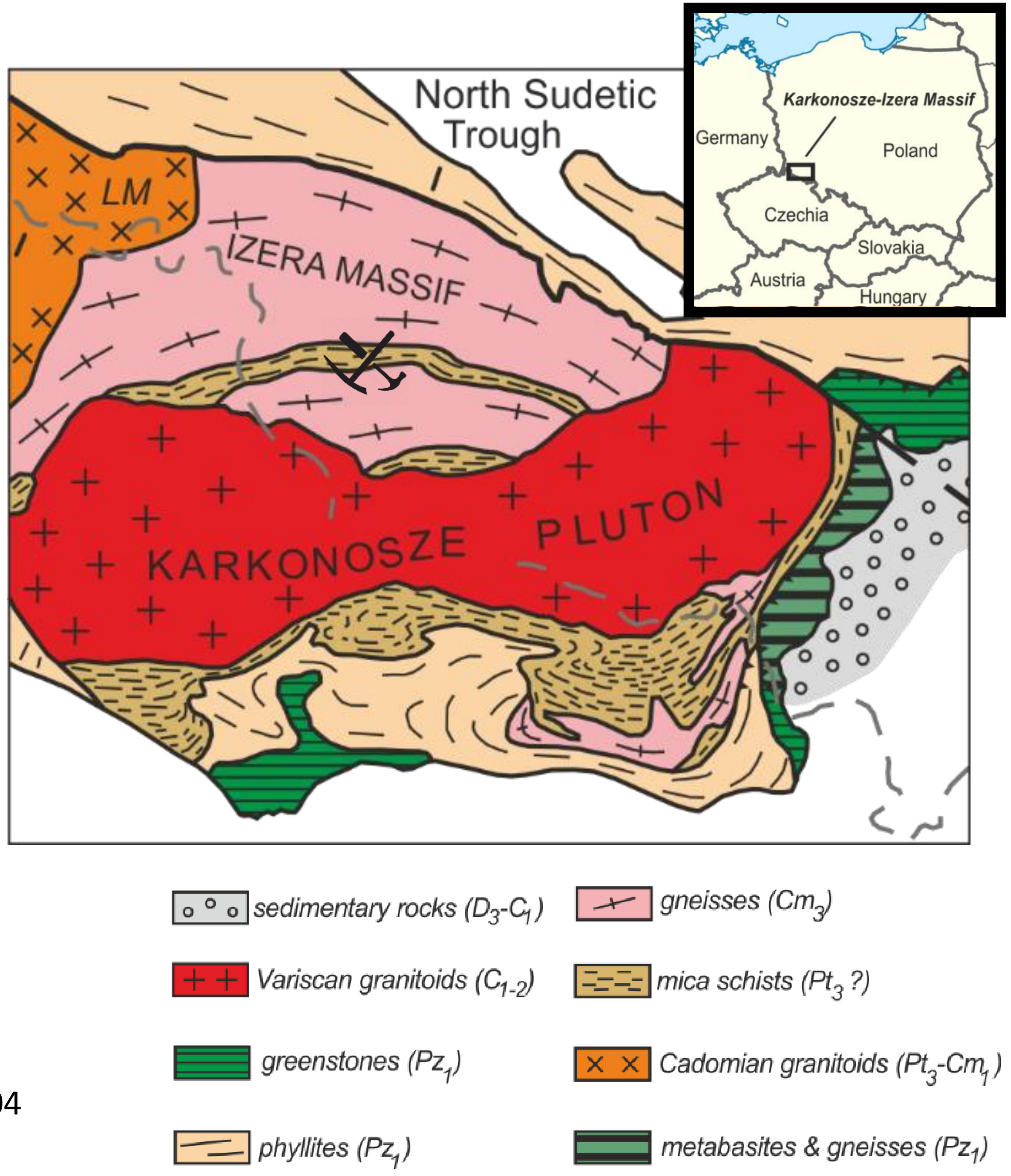
Workshop, 14th December 2021

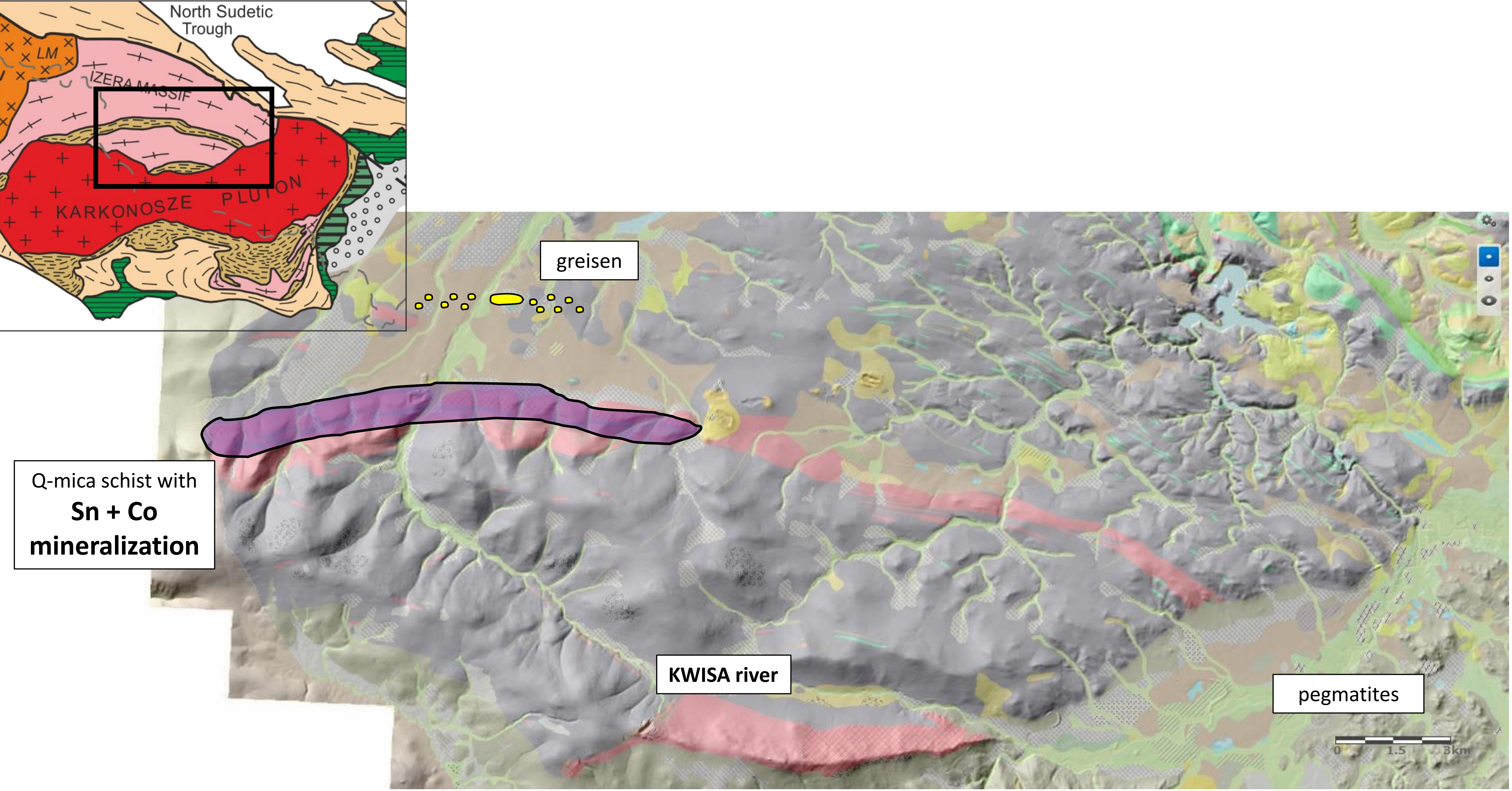


Mazur et al. 2010



Kryza et al. 2004





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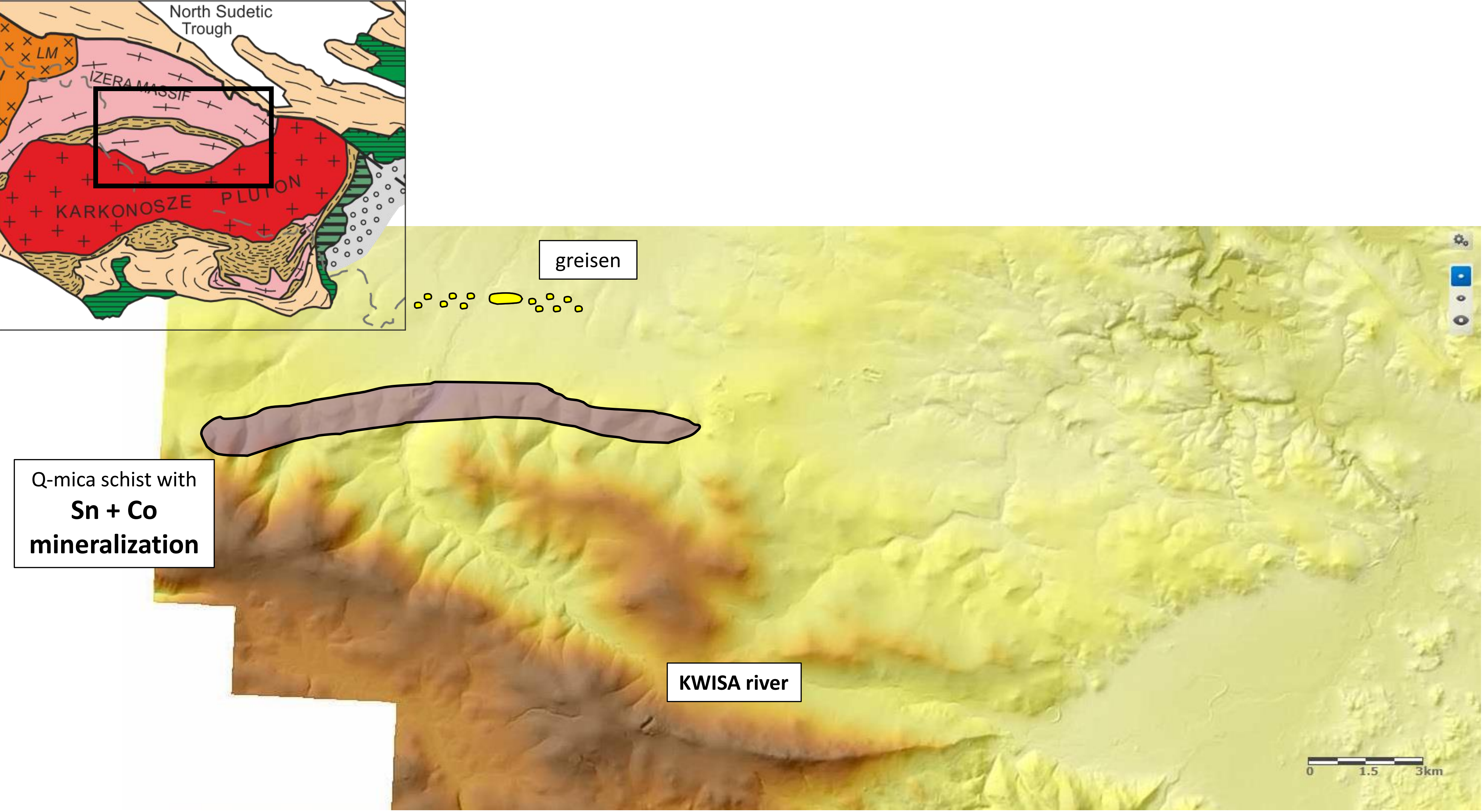

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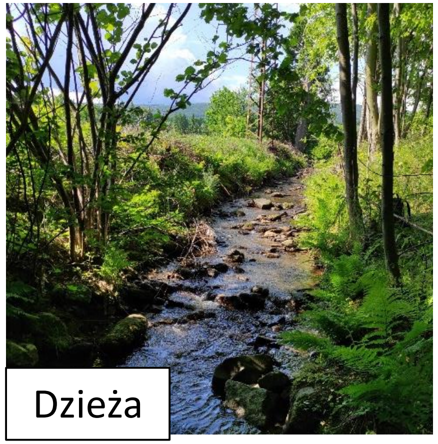
Alluvial sample collection (10 l)



Heavy minerals separation

Sieving <2mm (in the field)

Drying & sieving (in the laboratory)

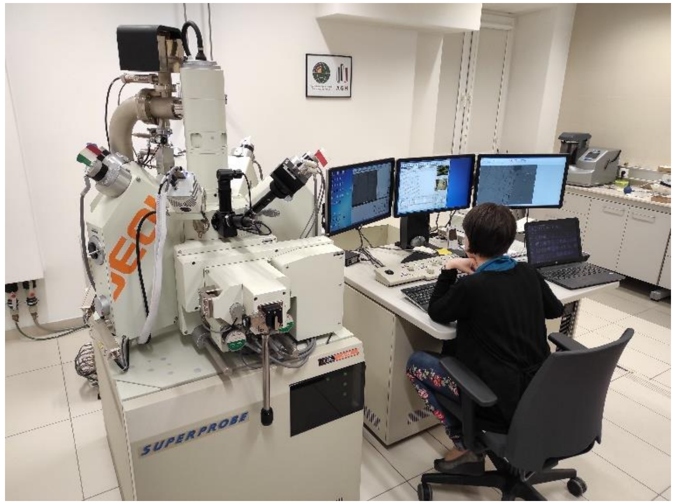
0-0.63 mm | 0.63-1 mm

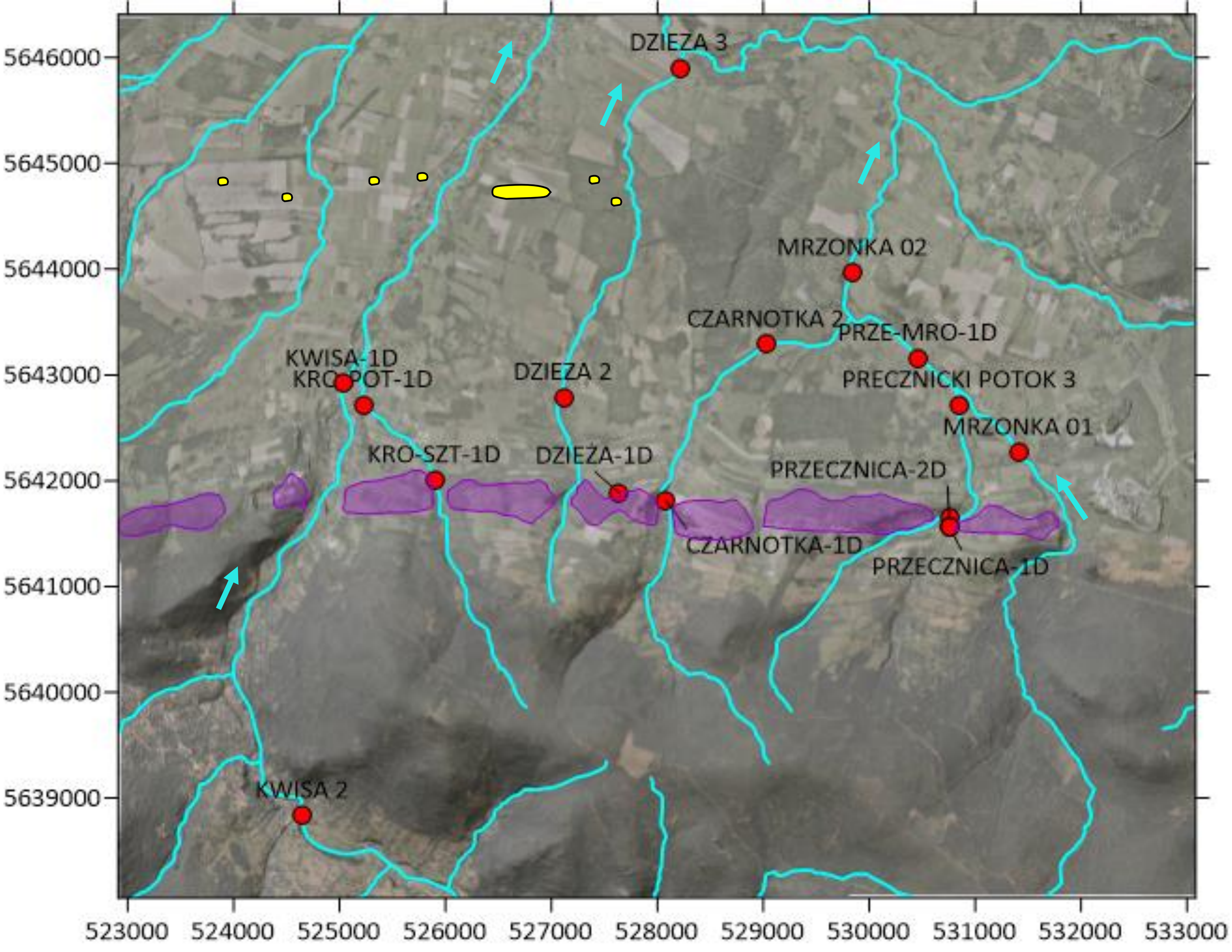
waste 0-0.63 mm | **HMC 0-0.63 mm** | waste 0.63-1 mm | HMC 0.63-1 mm

HMC 0-0.63 mm | HMC 0.63-1 mm

Epoxy mounts (one inch) | XRF (major oxides)

- ✓ Reflected light microscopy (AGH)
- ✓ TIMA (TESCAN)
- ✓ EPMA (AGH)
- ❑ Trace elements, dating, isotopes (GTK, GEUS, others)





DZIEZA 3
MRZONKA 02
CZARNOTKA 2
PRZE-MRO-1D
KWISA-1D
KRO-POT-1D
DZIEZA 2
PRECZNICKI POTOK 3
MRZONKA 01
KRO-SZT-1D
DZIEZA-1D
PRZECZNICA-2D
CZARNOTKA-1D
PRZECZNICA-1D
KWISA 2
5646000
5645000
5644000
5643000
5642000
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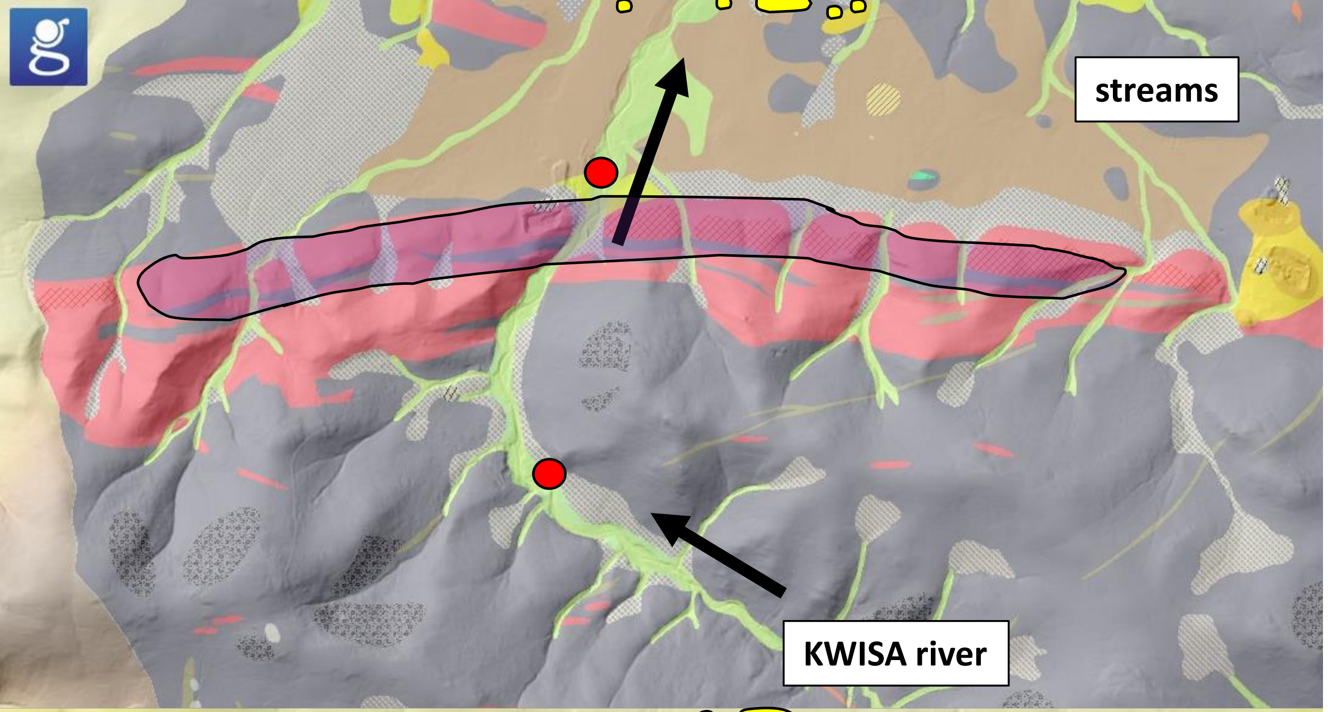

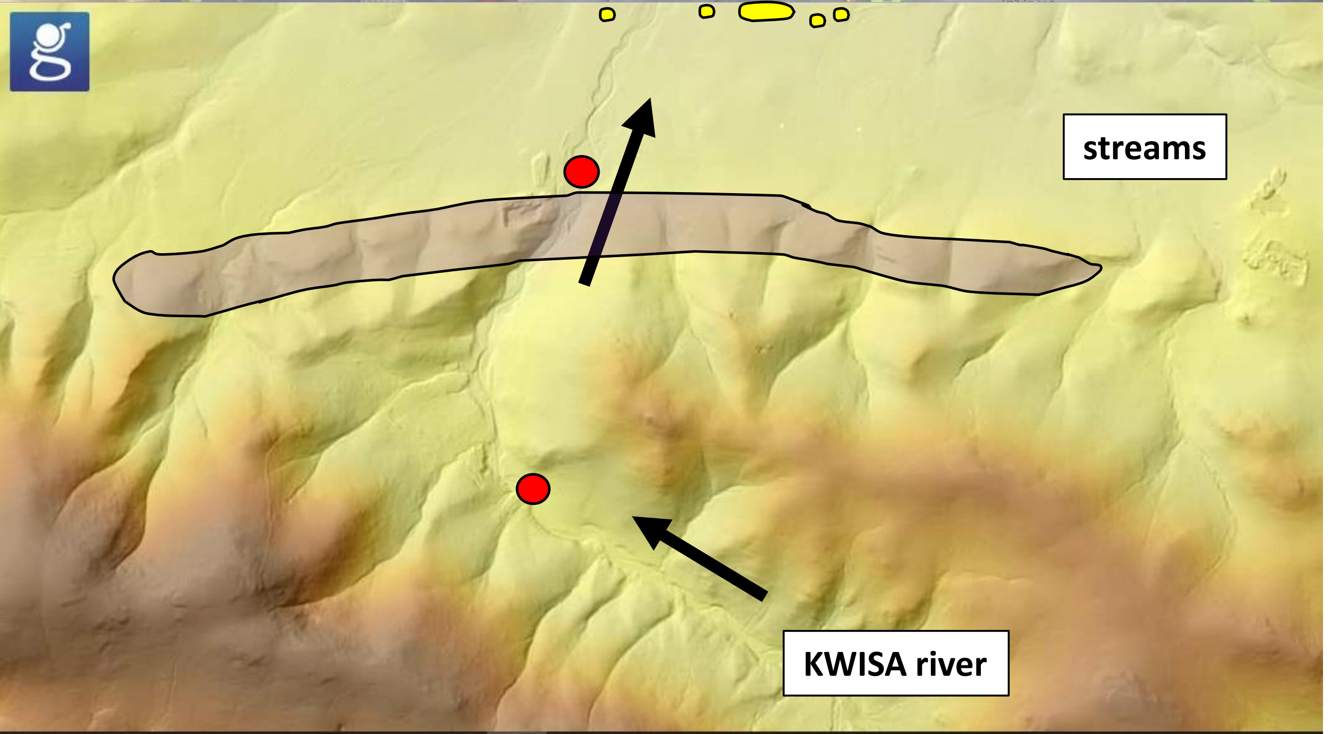

Heavy minerals → mineralization

Known mineralization → heavy minerals

E.g.

- Presence of specific mineral phases
- Chemical composition of minerals
- Abundance and shape of grains

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TESCAN Integrated Mineral Analyzer **(TIMA)**

TESCAN TIMA FOR EARTH SCIENCES

The combined Automated Petrography and Microanalysis solution for Geoscientists

TESCAN TIMA FOR MINERAL PROCESSING

The Automated Mineralogy solution for particle-by-particle measurement of mineralogy, grind size, liberation, and separation

TESCAN
PERFORMANCE IN NANOSPACE

TESCAN
PERFORMANCE IN NANOSPACE

Cassiterite

EPMA results

DZIEŻA n=65	Min	Max	Mean >DL	% above DL
WO3	<0.19	0.26	0.26	2%
Nb2O5	<0.07	0.07	0.07	2%
Ta2O5		<0.2		0%
SnO2	98.23	100.99	100.35	100%
SiO2		<0.05		0%
MnO		<0.05		0%
FeO	<0.06	0.70	0.28	32%
CaO	<0.02	0.03	0.03	3%
In2O3		<0.04		0%
TiO2	<0.03	0.26	0.14	55%

Primary mineralization → heavy minerals

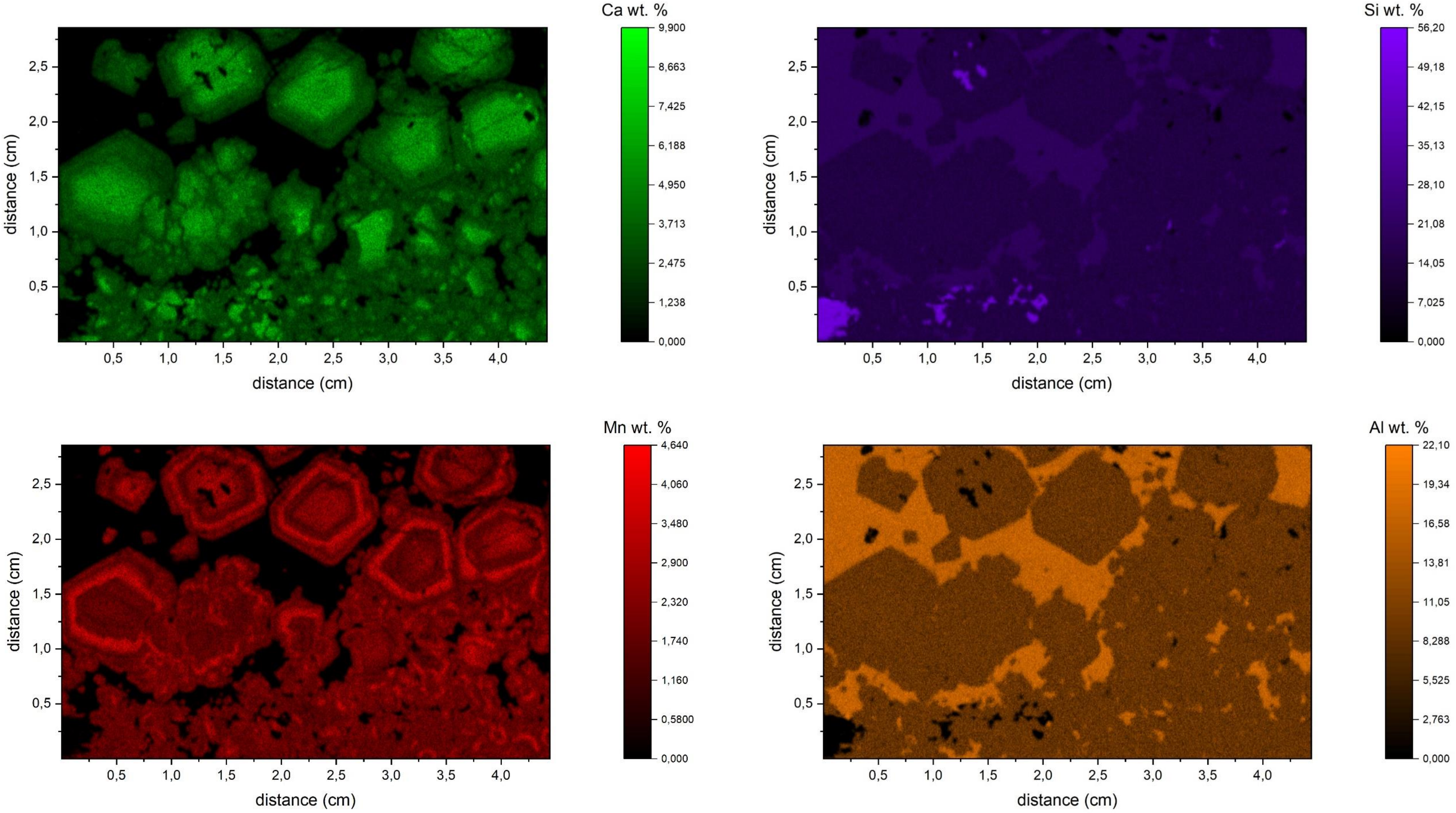
Specific vs. Ubiquitous

Abundant vs. Rare

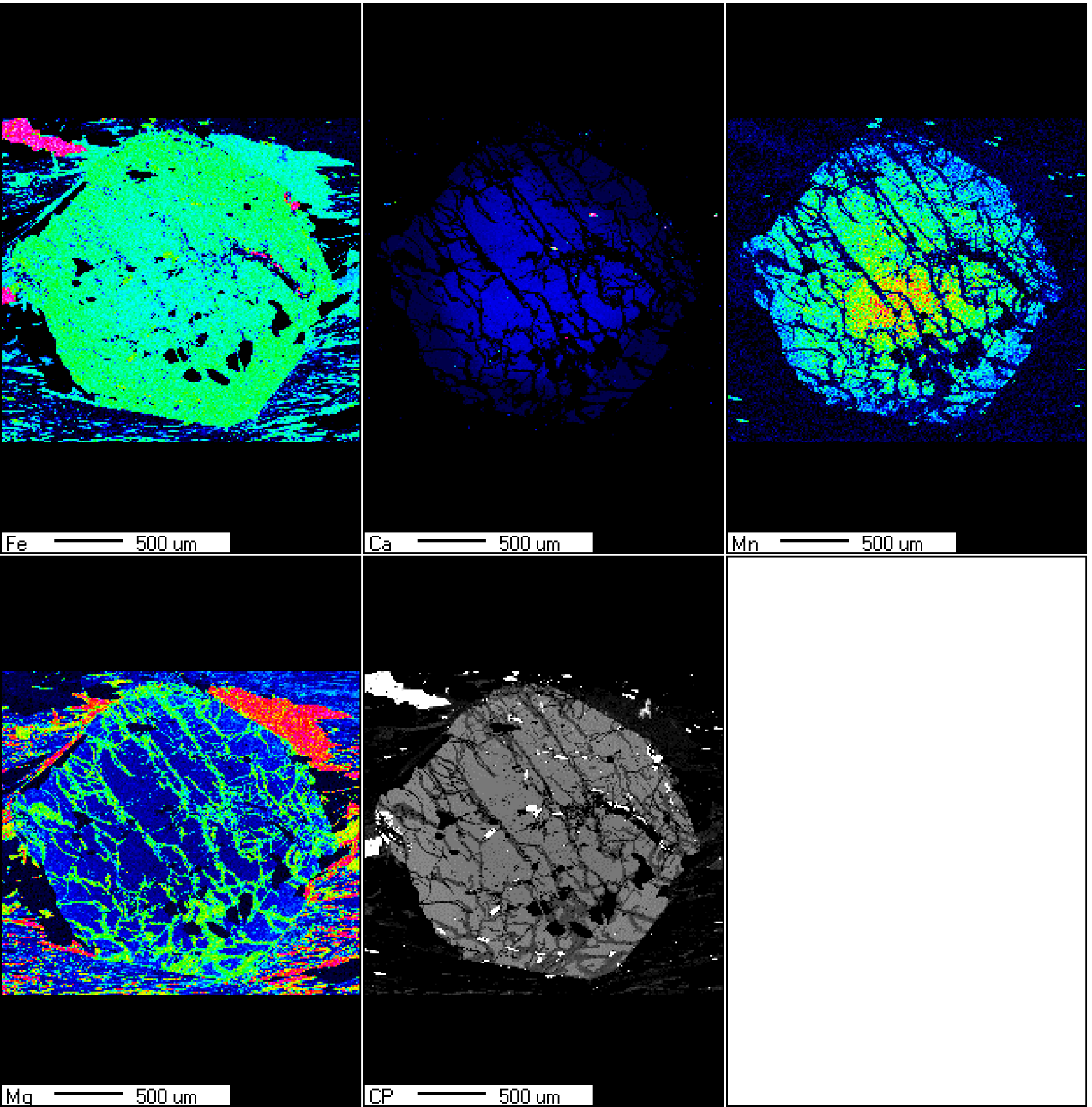
- presence or lack;
- chemical composition;
- other parameters: shape, roundness etc

Issues to keep in mind: nonhomogenous composition, solid solutions, fields & big grains

Oscillatory zoned garnets – primary rock (µXRF maps)

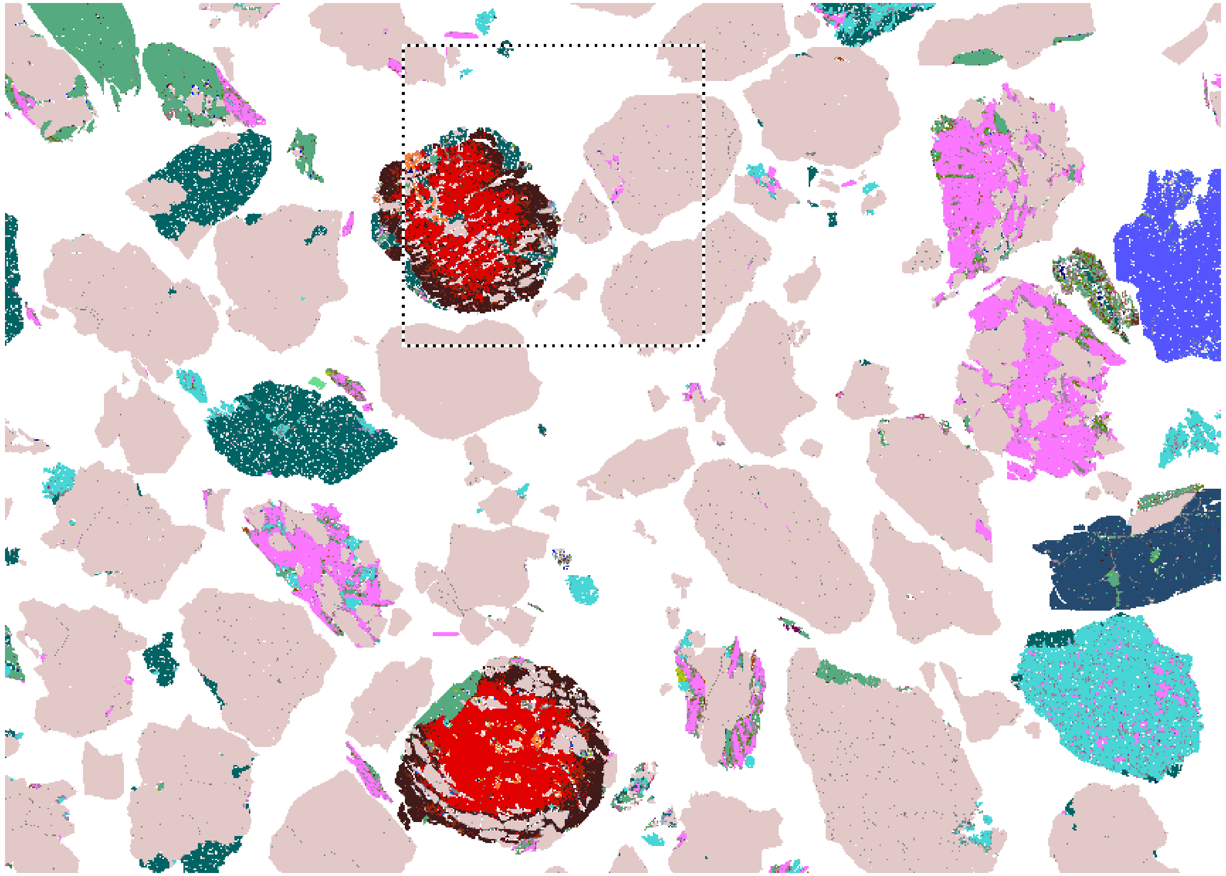


Source rock – EMPA WDS



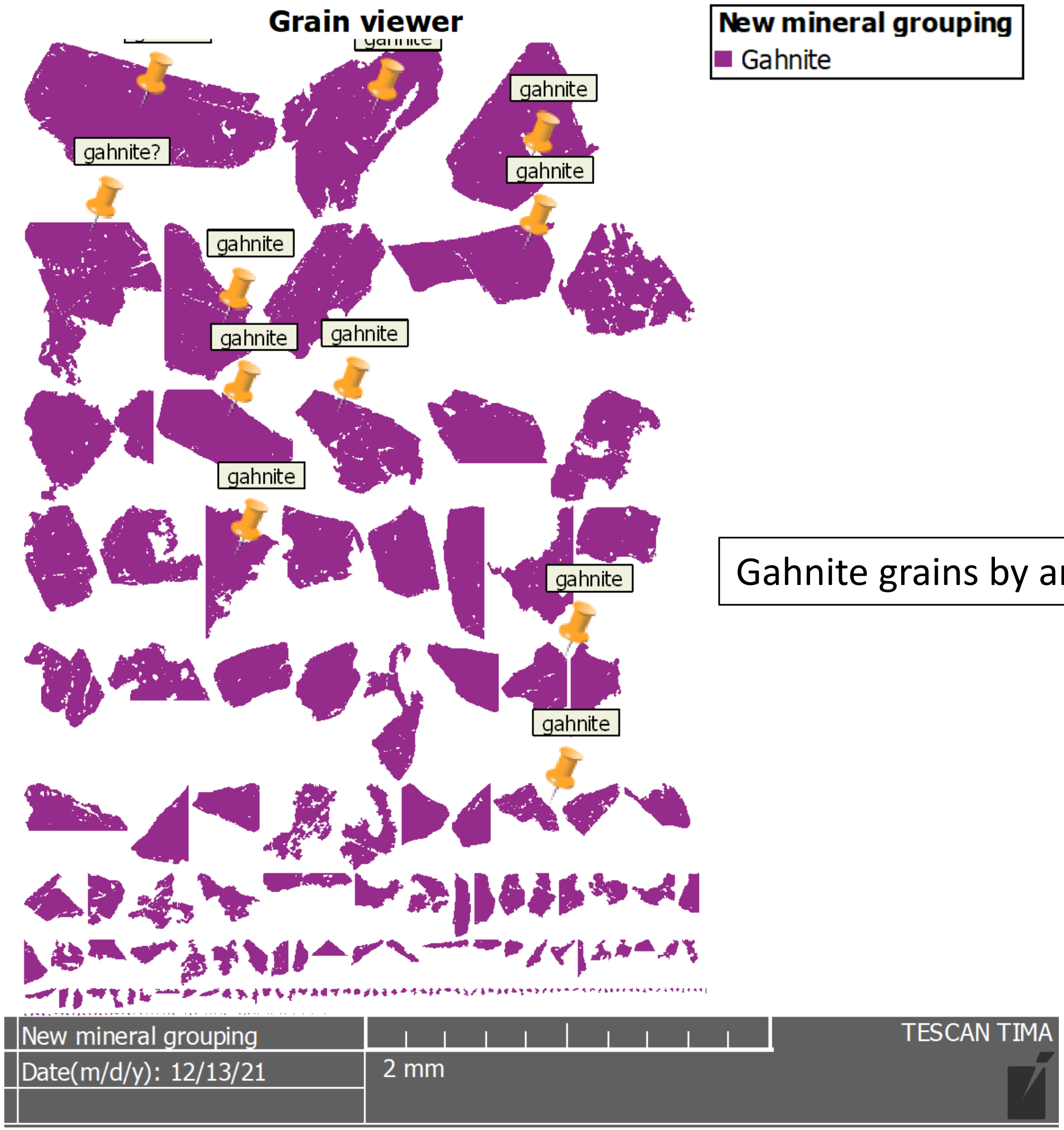
Heavy mineral concentrate - **TIMA**

Przecz 2G - Primary phases



Primary phases	Przecz 2G
Quartz	64.97
Muscovite	9.32
Orthoclase	5.67
Chlorite - Chamosite1	3.57
Albite	2.87
glass? + Fe	1.28
Garnet Fe + Ca low Mn	1.17
Biotite/Chlorite	0.86
Biotite	0.69
Augite	0.67
Garnet Fe + Ca Mn	0.64
glass?	0.60
Garnet Fe - Ca low Mn	0.55
Ilmenite	0.53
[Unclassified]	1.62
The rest	**4.99**
Total	**100.00**

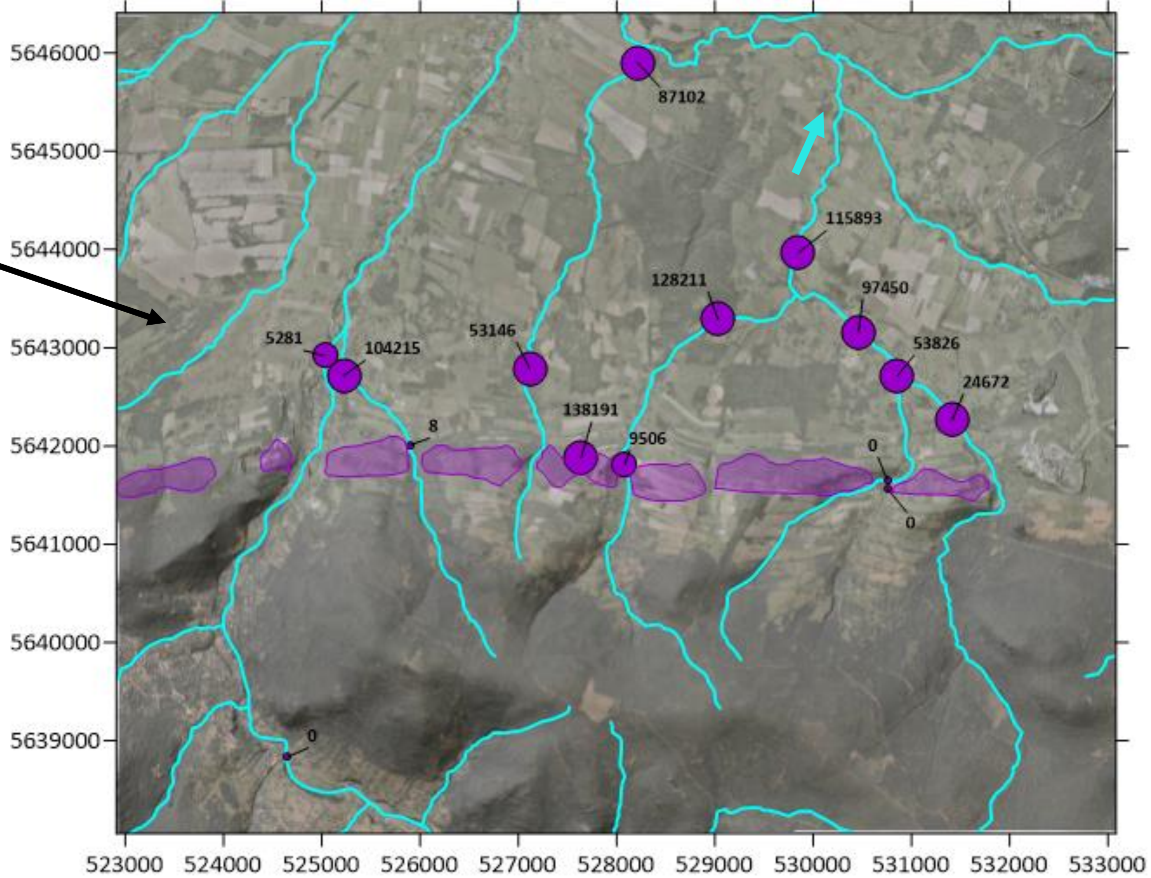
Gahnite $ZnAl_2O_4$

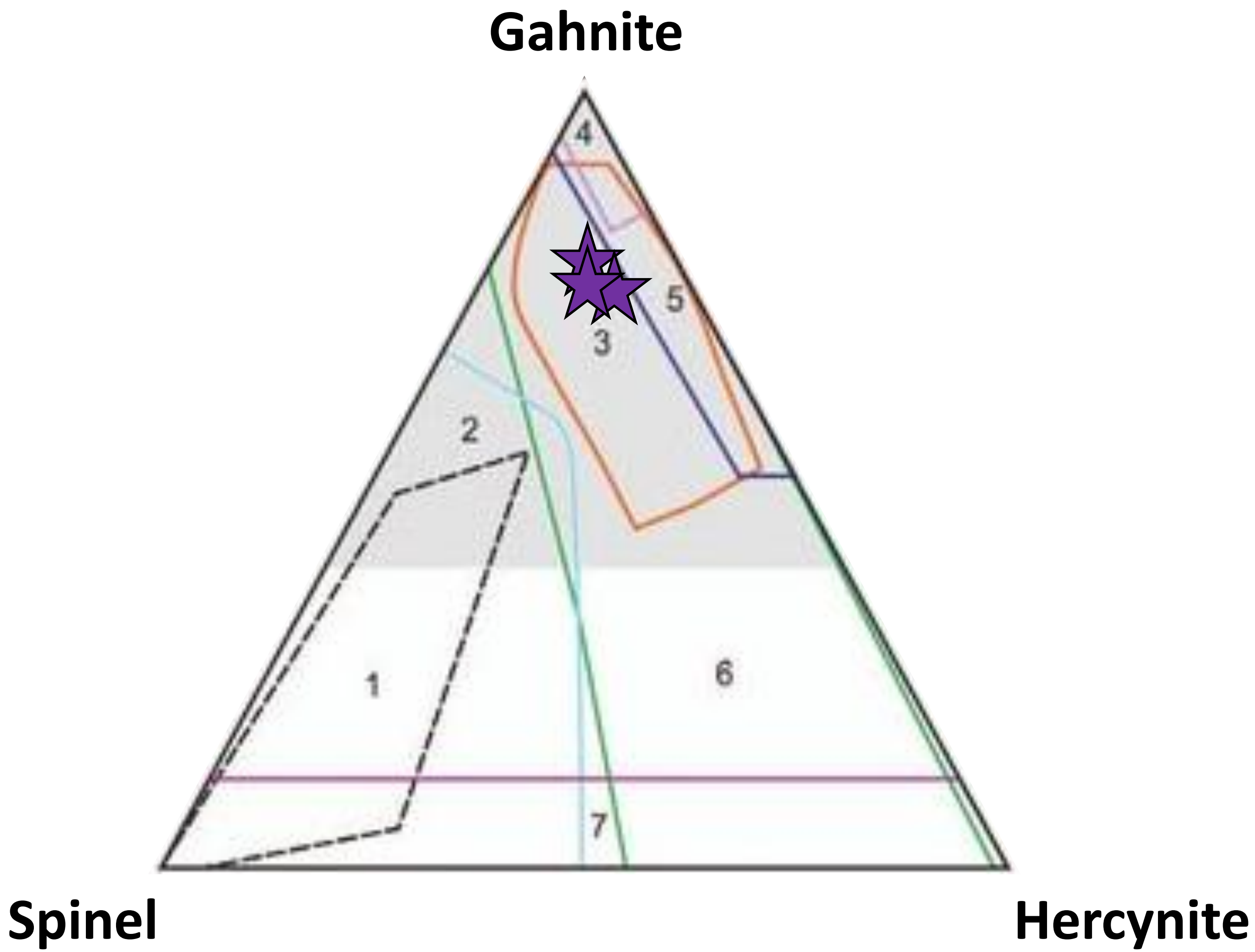


Showing 100 out of 216 total particles

	A	B	C	D	E	F	G	H
1								
2	**Grain**	**Area[px]**	**Surface[px]**	**Size[µm]**	**X[µm]**	**Y[µm]**	**Dataset**	**Field**
3	Grain 3363	31813.0	1808.0	402.5	-4986.0	-5682.0	6 / KRO-POT 1D	N05
4	Grain 5308	22608.0	1384.0	339.3	-7196.0	-5090.0	15 / DZIEZA 1D	M03
5	Grain 2887	21307.0	939.0	329.4	-2644.0	-5608.0	15 / DZIEZA 1D	N07
6	Grain 2407	17420.0	1537.0	297.9	-2750.0	-800.0	5 / PRZE-MRO 1D	J07

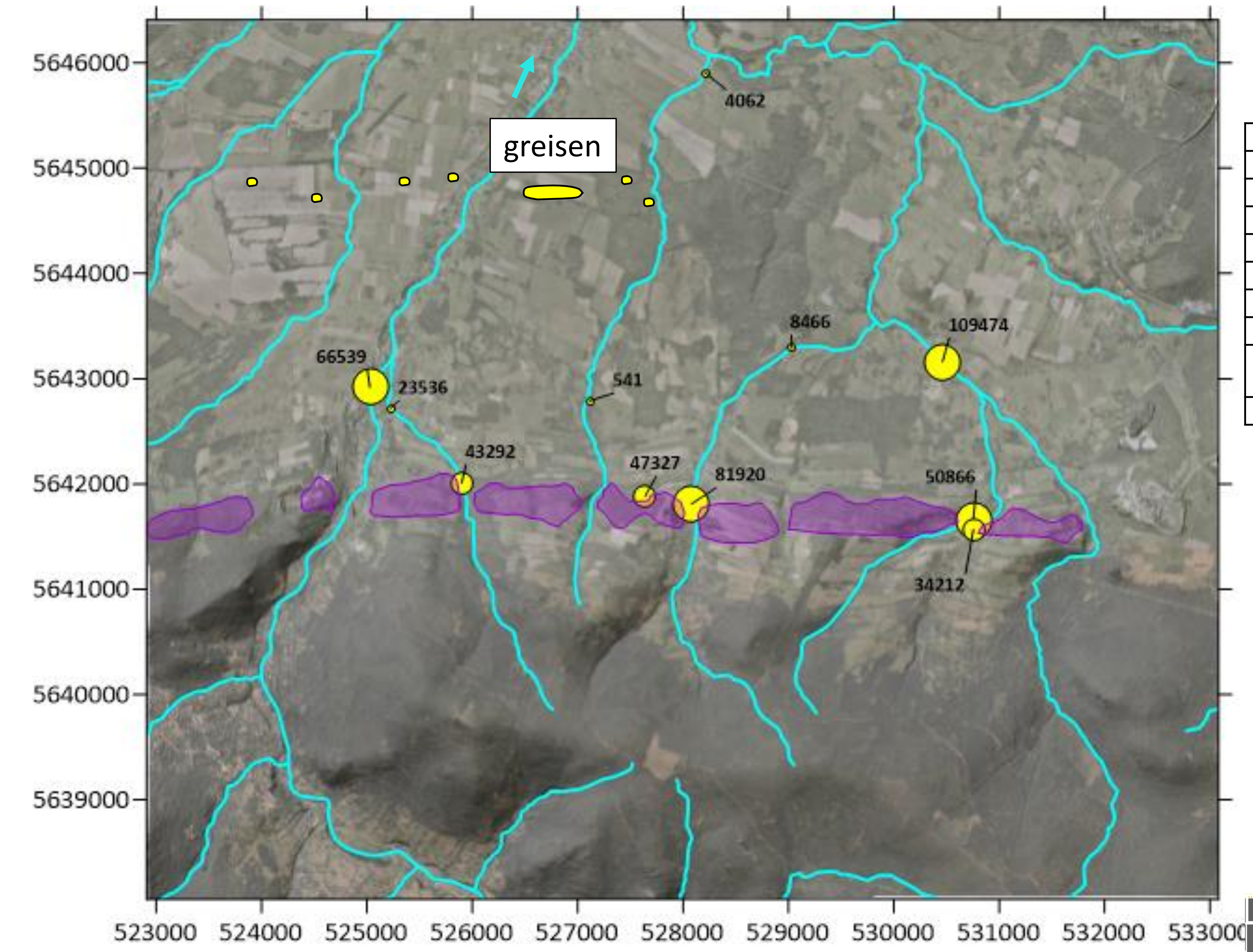
Gahnite grains by area





1. Marbles
2. **Metamorphosed massive sulfide deposits and S-poor rocks in Mg-Ca-Al alteration zones**
3. **Metamorphosed massive sulfide deposits in Fe-Al metasedimentary and metavolcanic rocks**
4. Metabauxites
5. Pegmatites
6. Unaltered and hydrothermally altered Fe-Al-rich metasedimentary and metavolcanic rocks
7. Al-rich granulites

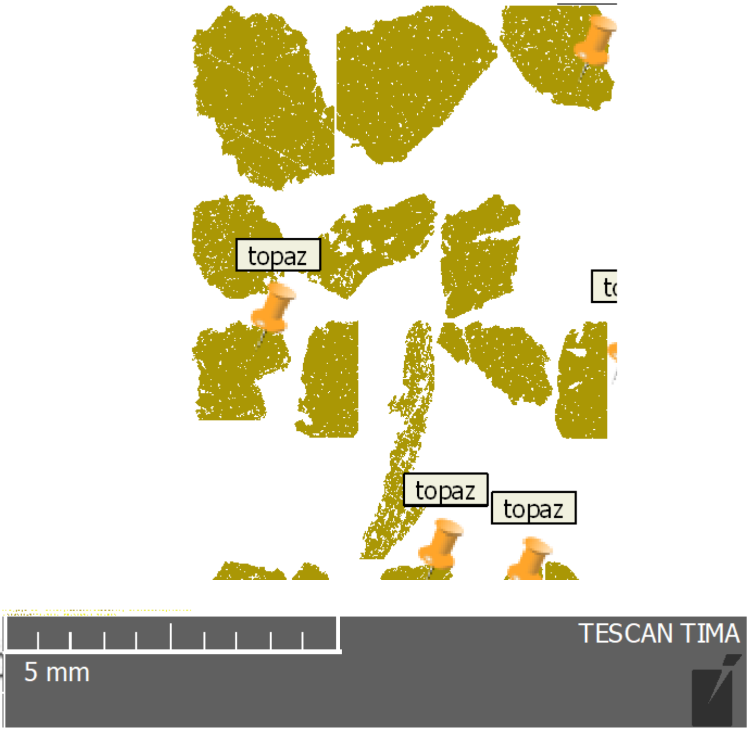
O’Brien et al. 2015
Faulstich et al. 2016

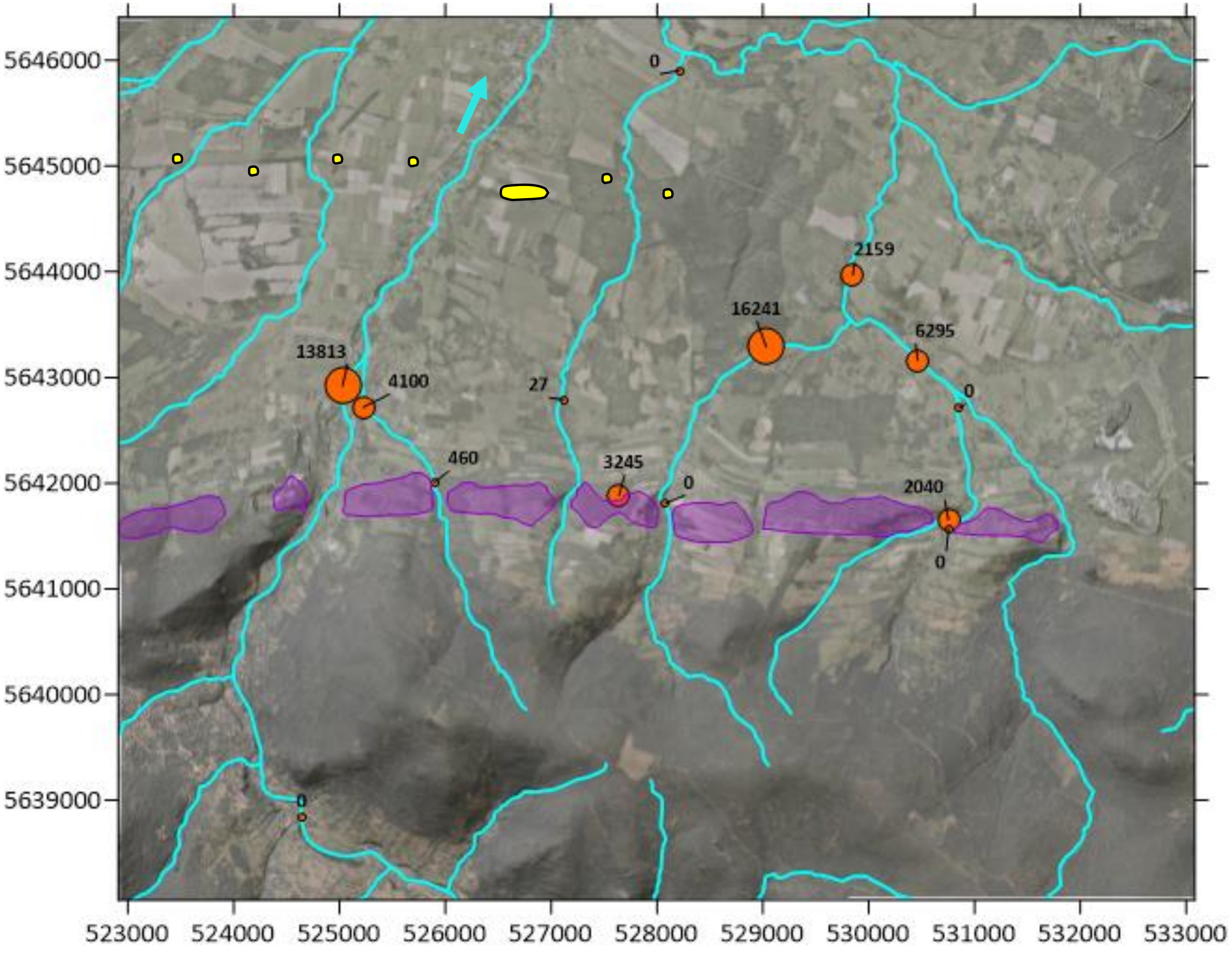


Topaz

SiO_2	31.77	31.19	31.20	30.65
Al_2O_3	54.62	55.03	55.12	55.06
Nb_2O_5	bdl	bdl	bdl	bdl
FeO	bdl	bdl	bdl	bdl
Ta_2O_5	bdl	bdl	bdl	bdl
WO_3	1.49	1.42	1.47	1.87
SnO_2	bdl	bdl	bdl	bdl
F	16.53	16.30	16.18	16.31
Total – F=O	97.58	97.15	97.26	97.27
	MRO_D	DZIEZA_1D	KWISA_1D	Pr_MRO_D

Grain viewer





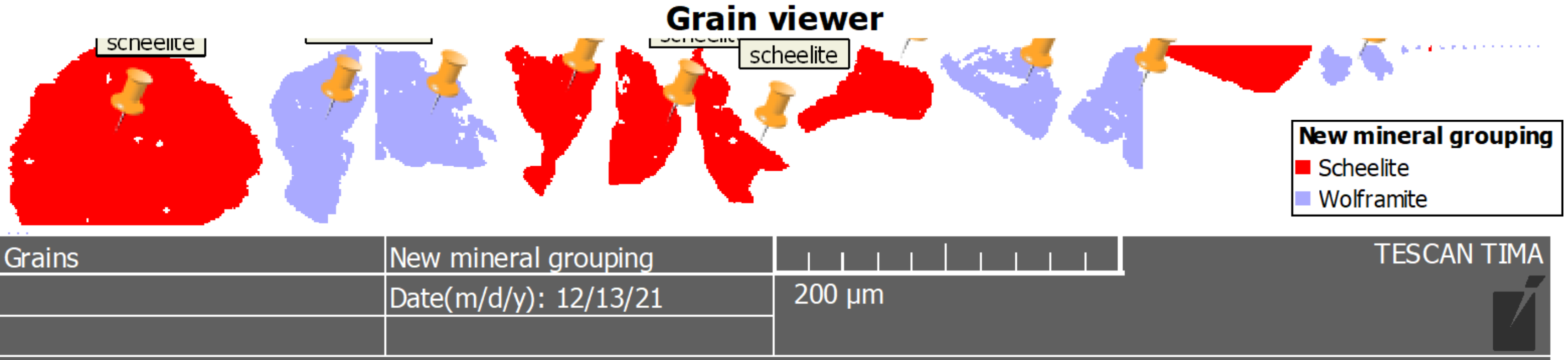
Scheelite and wolframite

Rare phases

Nugget effect???

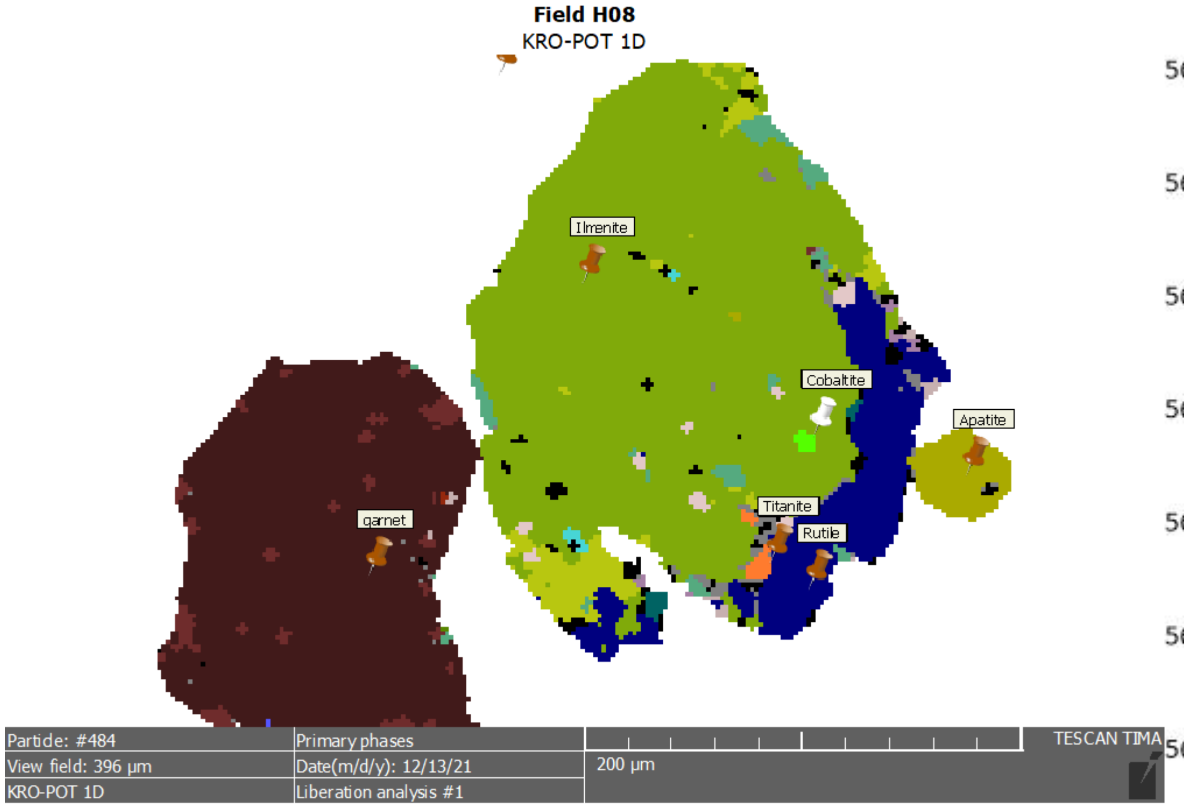
Sulphides rare in the analyzed samples – similar problem

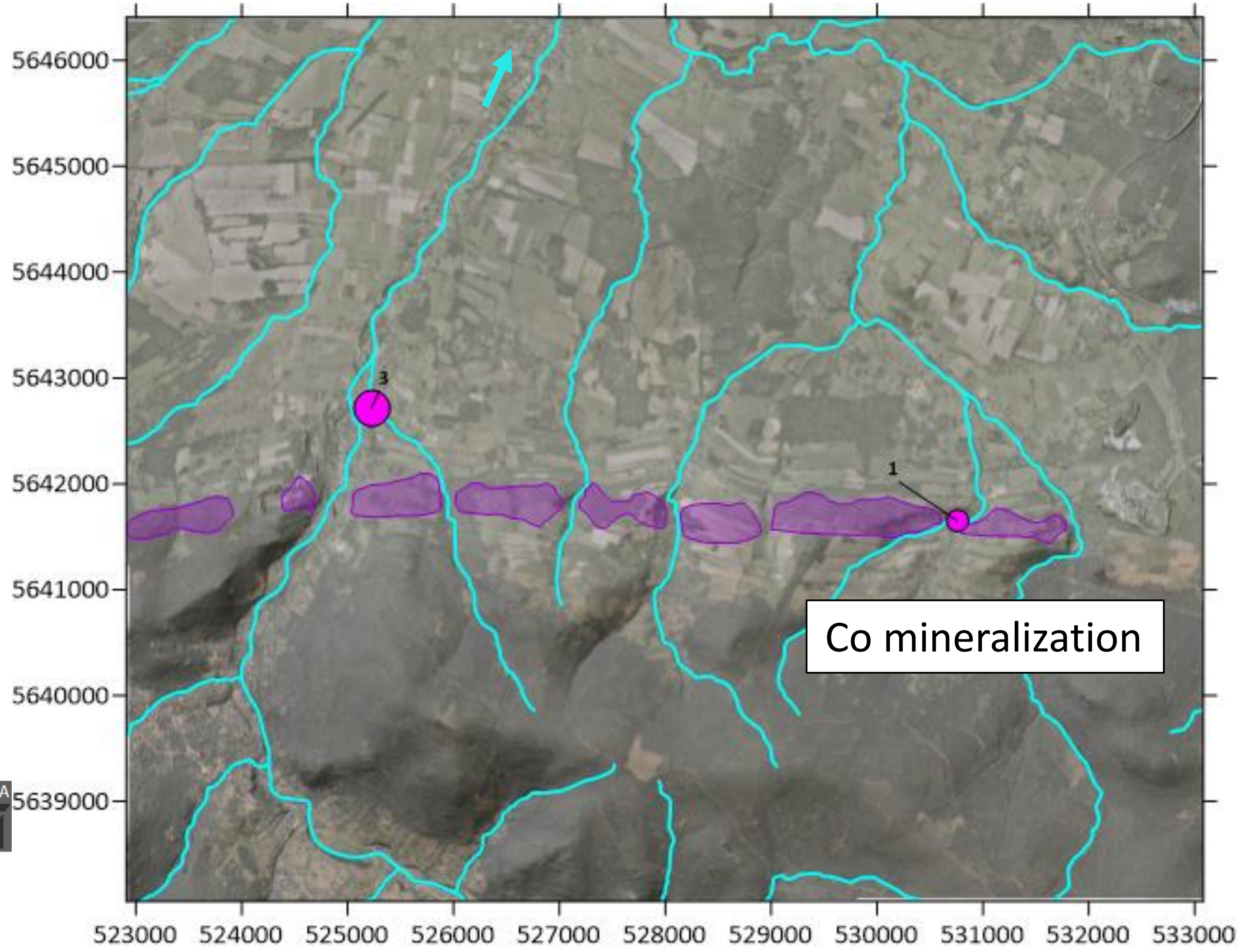
Although 2 types of sphalerite has been identified
< 1% Fe
5-10 % Fe



Known sulphide deposit – 5-10% Fe

Cobaltite – only as inclusions in ilmenite

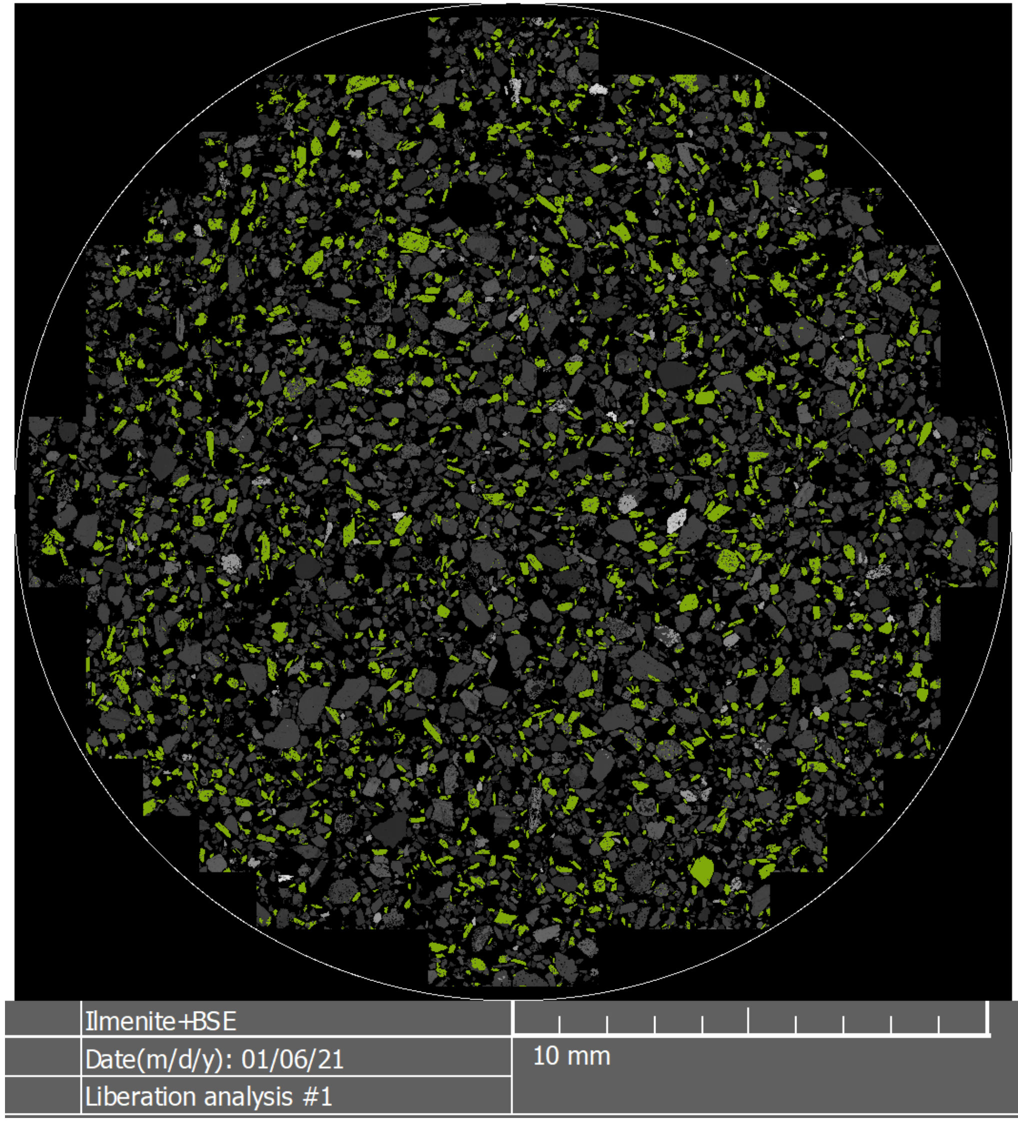




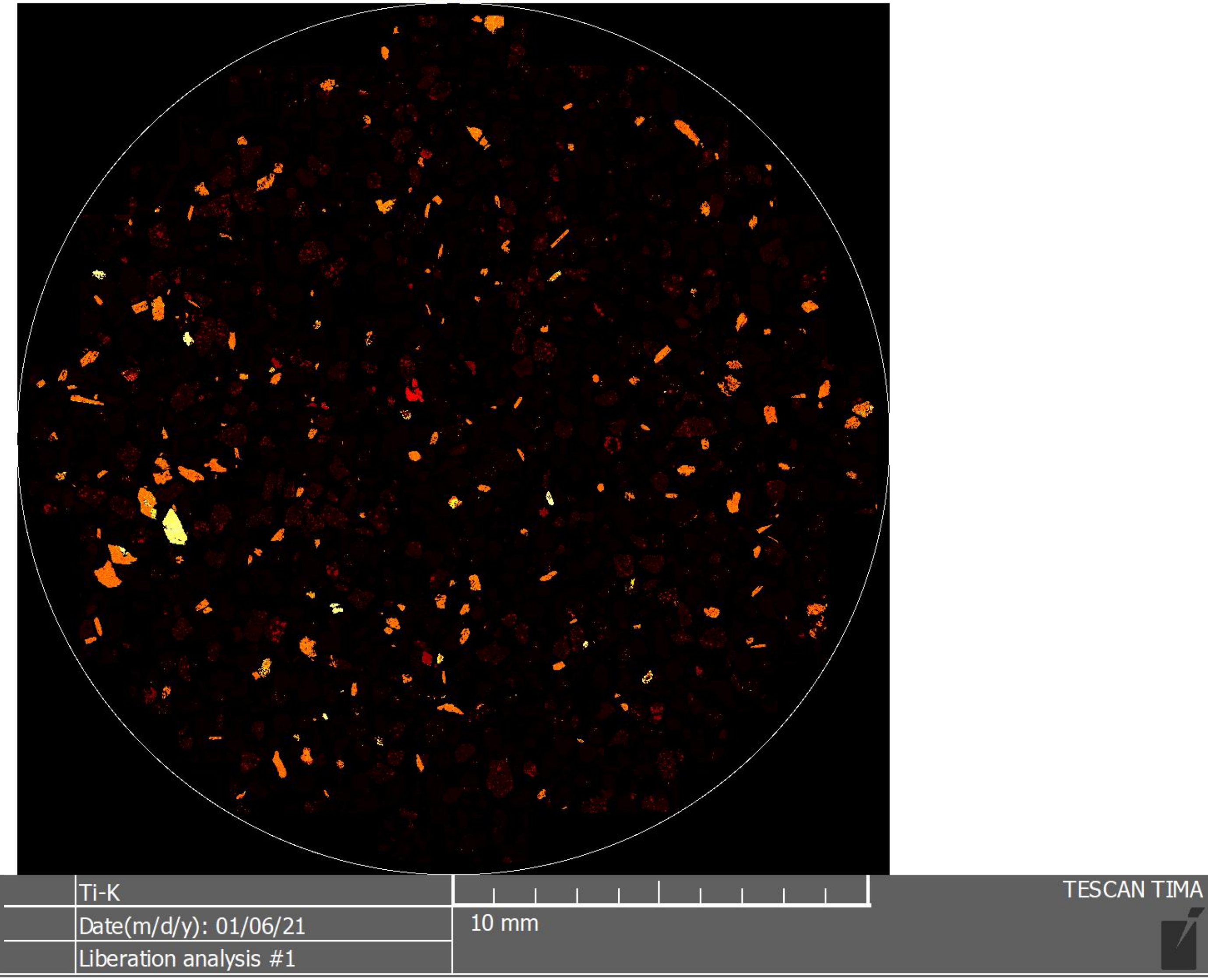
Co exploatation in the past – Przecznica area (E part of the belt)

Ti oxides

Panorama - Ilmenite+BSE
DZIEZA 1D

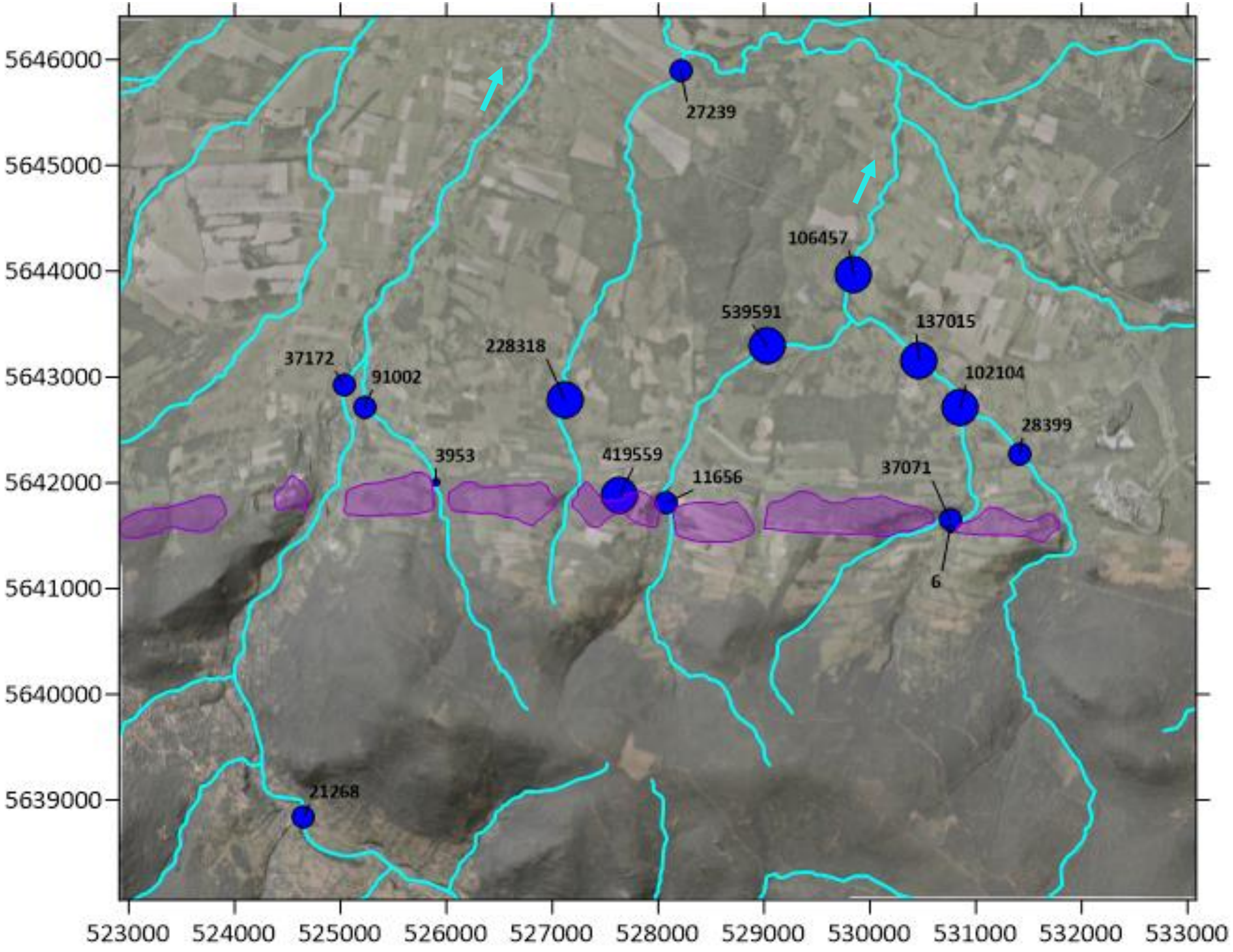


Panorama - Ti-K
CZARN 1D



Wt%	V2O3	Nb2O5	TiO2	FeO	Ta2O5	MnO	MgO	ZnO
max	0.29	0.32	56.70	46.33	0.18	6.51	2.08	0.39
min	<0.04	<0.04	48.64	37.56	<0.13	0.36	0.03	0.07

Cassiterite

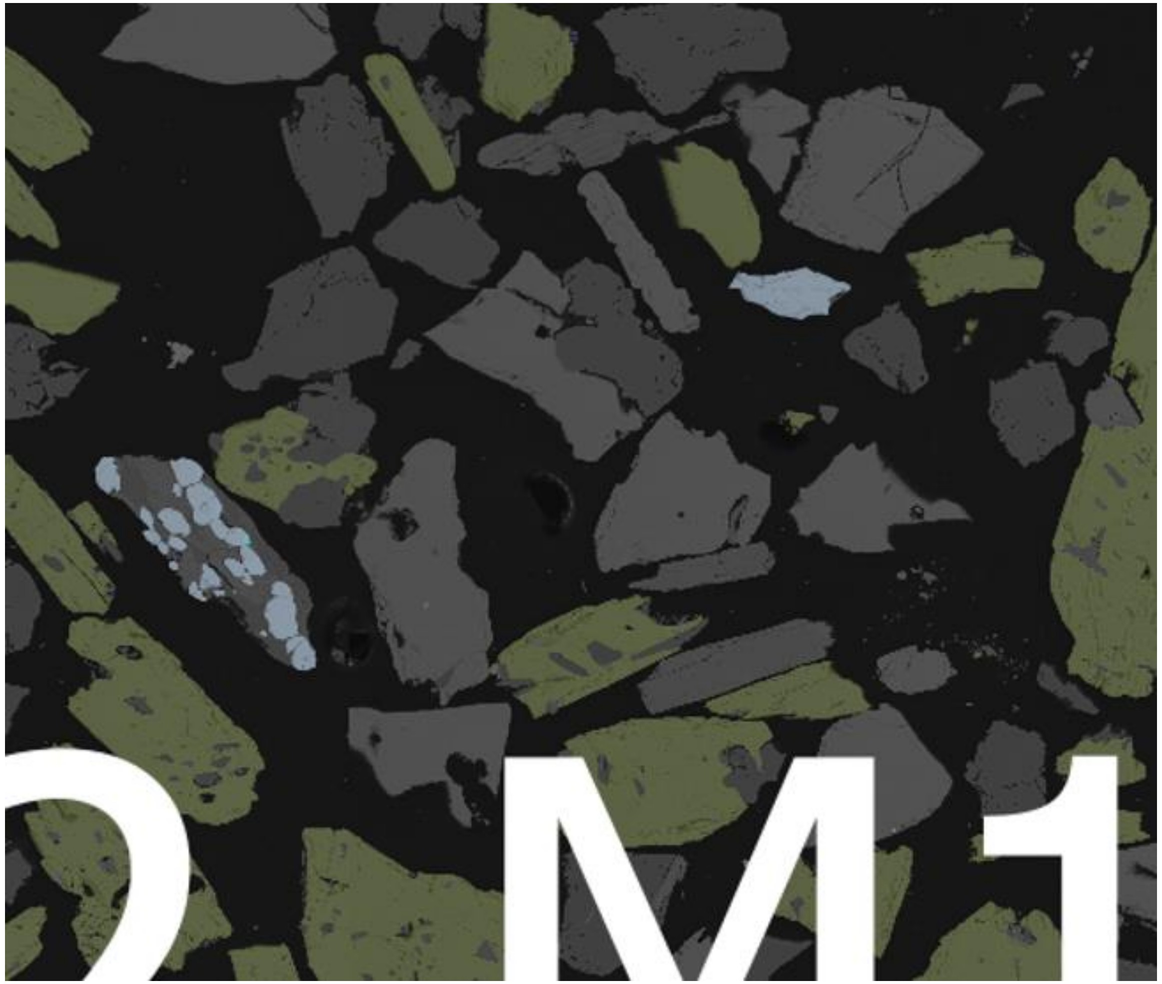


Not everything can be automated

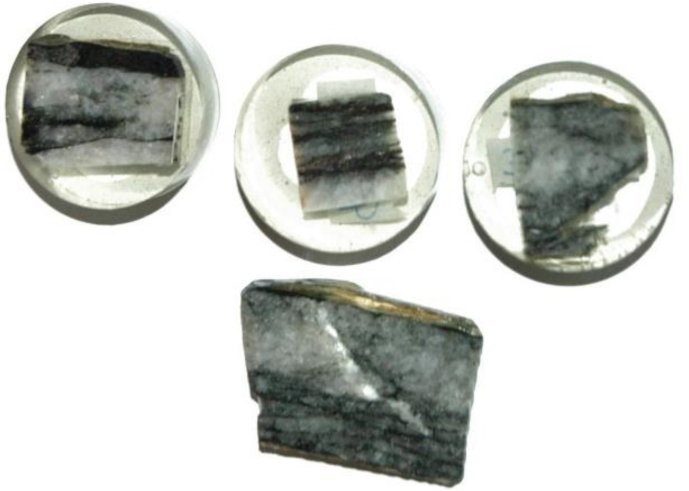
KWI 2 (S from the SK Belt)

1 mm

DZIE 2 (N from the SK Belt)

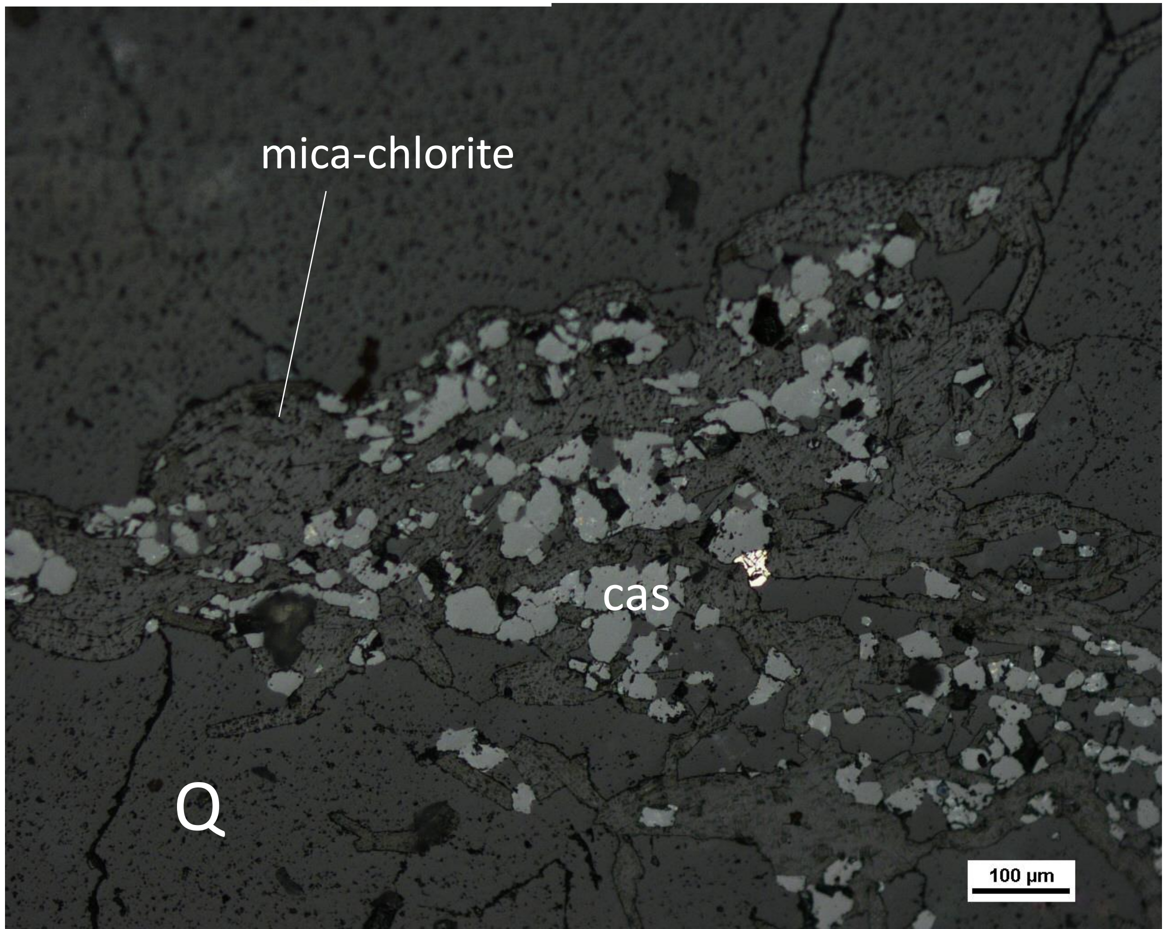


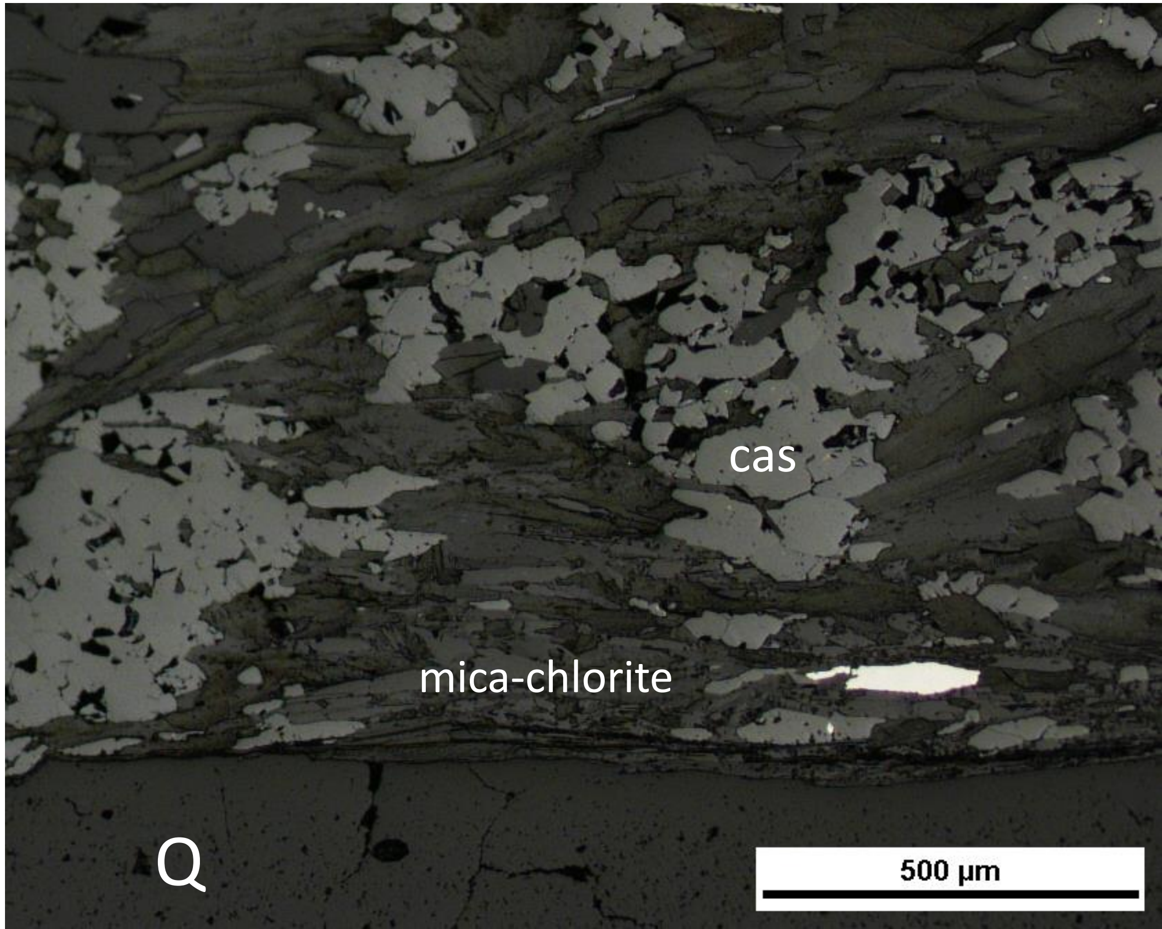
1 mm



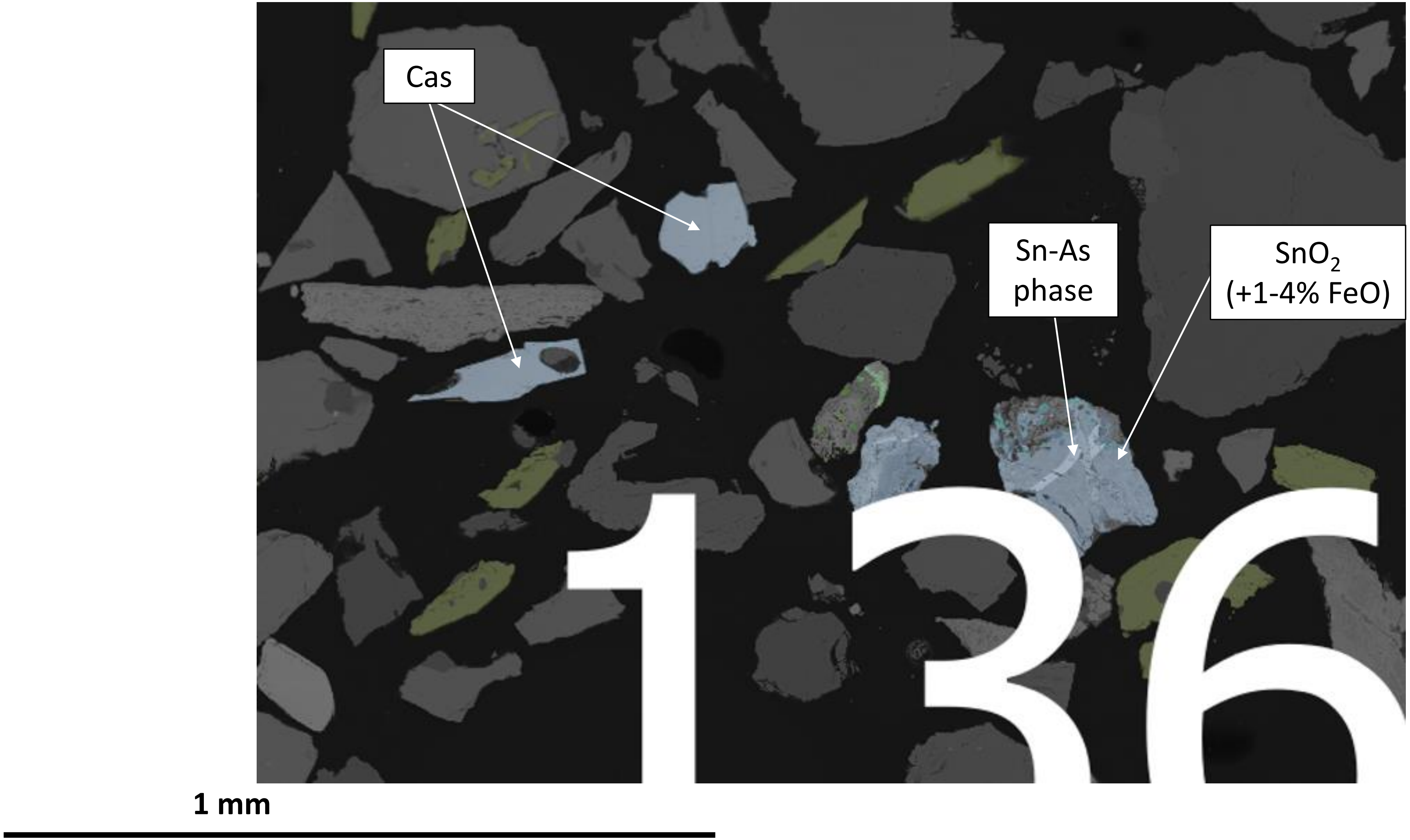
Typical example of tin ore in quartz-mica-chlorite schist

Cas II - „transparent” & grape-like shape





Anthropogenic materials



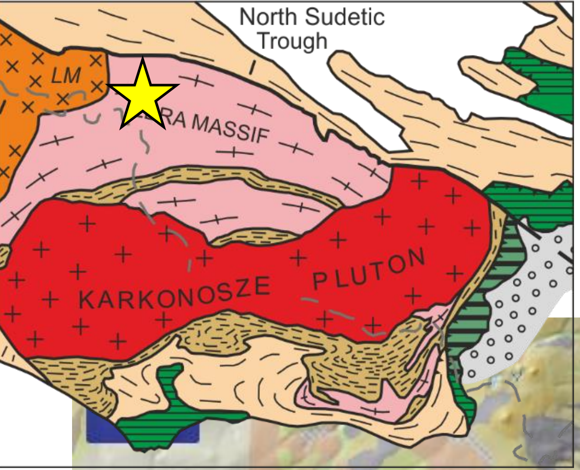
EPMA

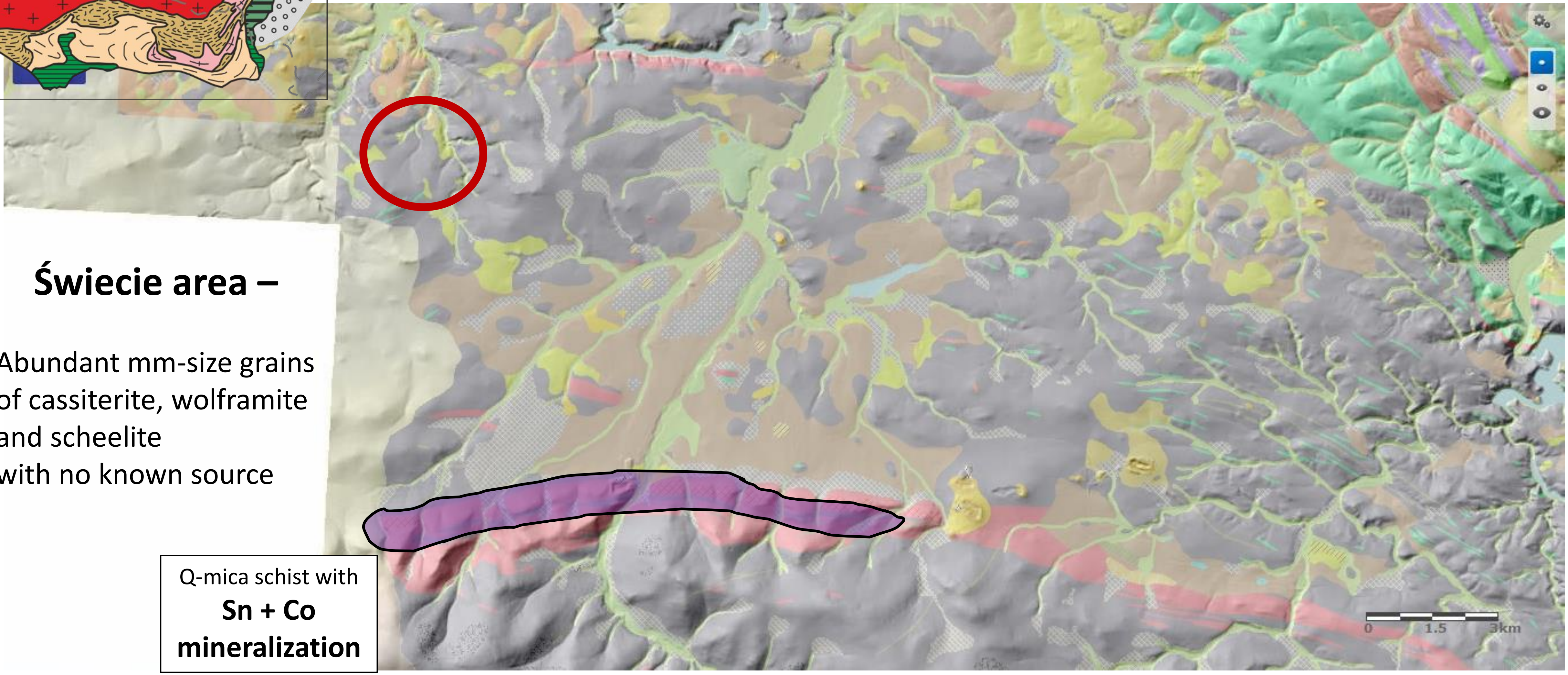
average
min-max

	Strzegom (n=29)	Piława (n=25)	Czarnów (n=19)	Jelenia Góra pegmatite (n=22)	Gierczyn-Przecznica (n=236)	Heavy minerals concentrates (n=93)
WO_3	**0.31** *<0.23-0.5*	**0.30** *<0.23-0.47*	**0.38** *<0.23-0.66*	*<0.23-0.23*	**0.27** *<0.23-2.18*	*<0.23-2.07*
Nb_2O_5	**1.18** *<0.15-1.97*	**0.65** *0.17-1.05*	<0.15	**0.32** *<0.15-0.86*	<0.15	<0.15
Ta_2O_5	**5.5** *0.63-11.7*	**0.65** *0.22-1.43*	*<0.2-0.28*	**0.40** *<0.2-0.93*	*<0.2*	*<0.2*
SnO_2	**91.12** *83.77-97.61*	**98.38** *88.91-99.77*	**99.91** *98.67-101.5*	**95.59** *93.34-98.8*	**99.67** *91.25-101.37*	**100.01** *88.33-100.99*
In_2O_3	<0.04	<0.04	**0.2** *<0.04-0.23*	<0.04	**0.24** <0.04-*0.73*	<0.04
	MnO (0.08-1.77)			ZrO_2 (0.2-2.24) HfO_2 (0.16-0.24)		

Average - only values above detection limits

Heavy minerals ⟶ Primary mineralization



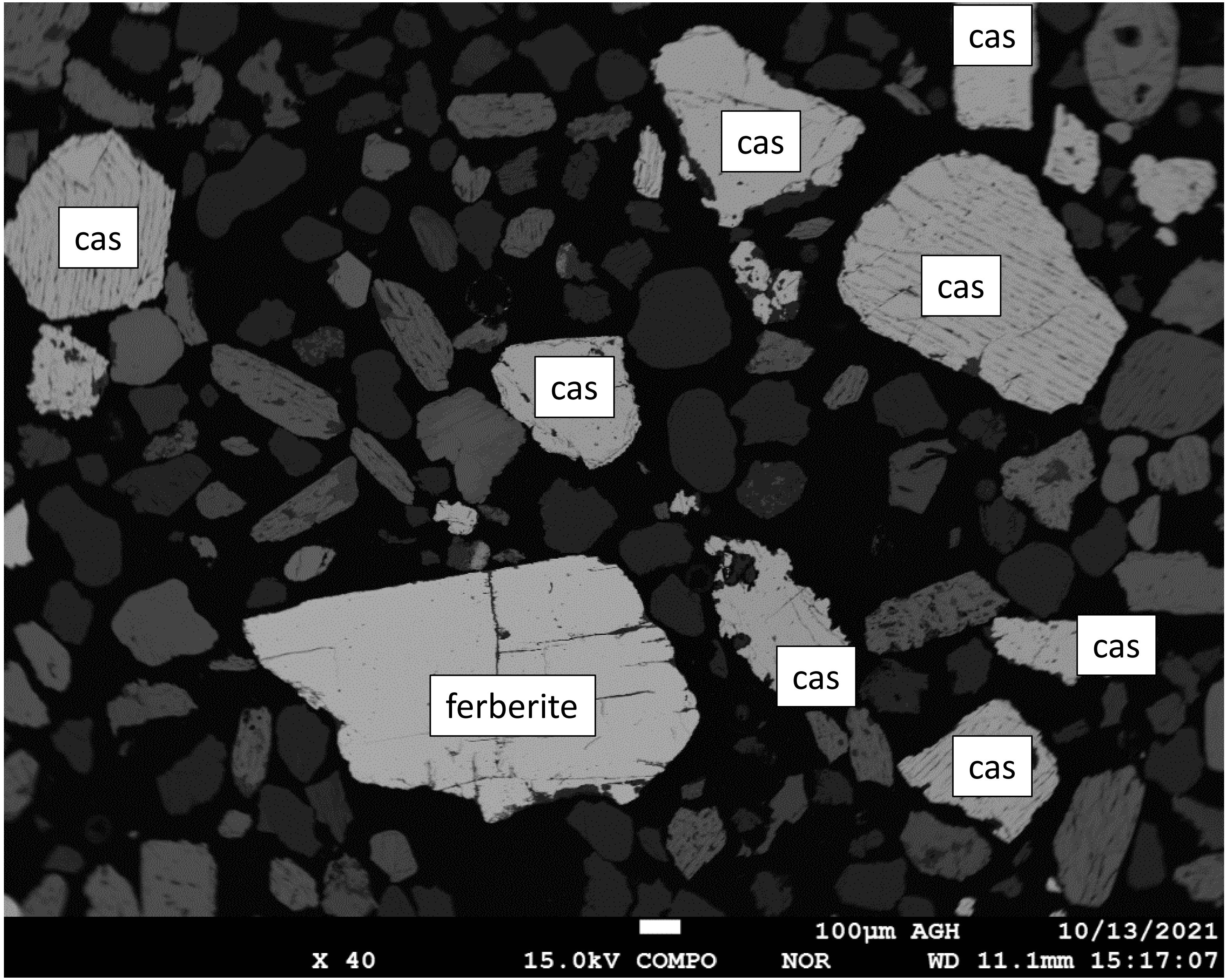


Świecie area –

Abundant mm-size grains of cassiterite, wolframite and scheelite with no known source

Q-mica schist with
Sn + Co mineralization

Unidentified source - quartz veins?



Chemical composition (EPMA) similar to Gierczyn-Przecznica cassiterites

Conclusions

- Geological and geographical features makes Karkonosze-Izera Massif a good area for test studies
- Automated measurement techniques based on SEM and EDS are a powerful tool for studying heavy minerals concentrates, especially paired with complementary methods
- Combining results from several minerals, not only from one phase
- Be vary of potential anthropogenic contamination in some areas