Back to the Roots – Part IV: An Introduction to micro-XRF on SEM

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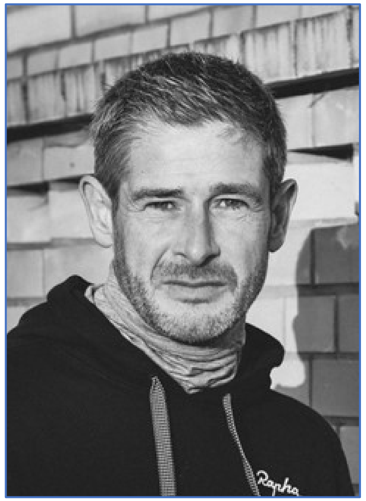

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SEM-XRF (XTrace): Introduction

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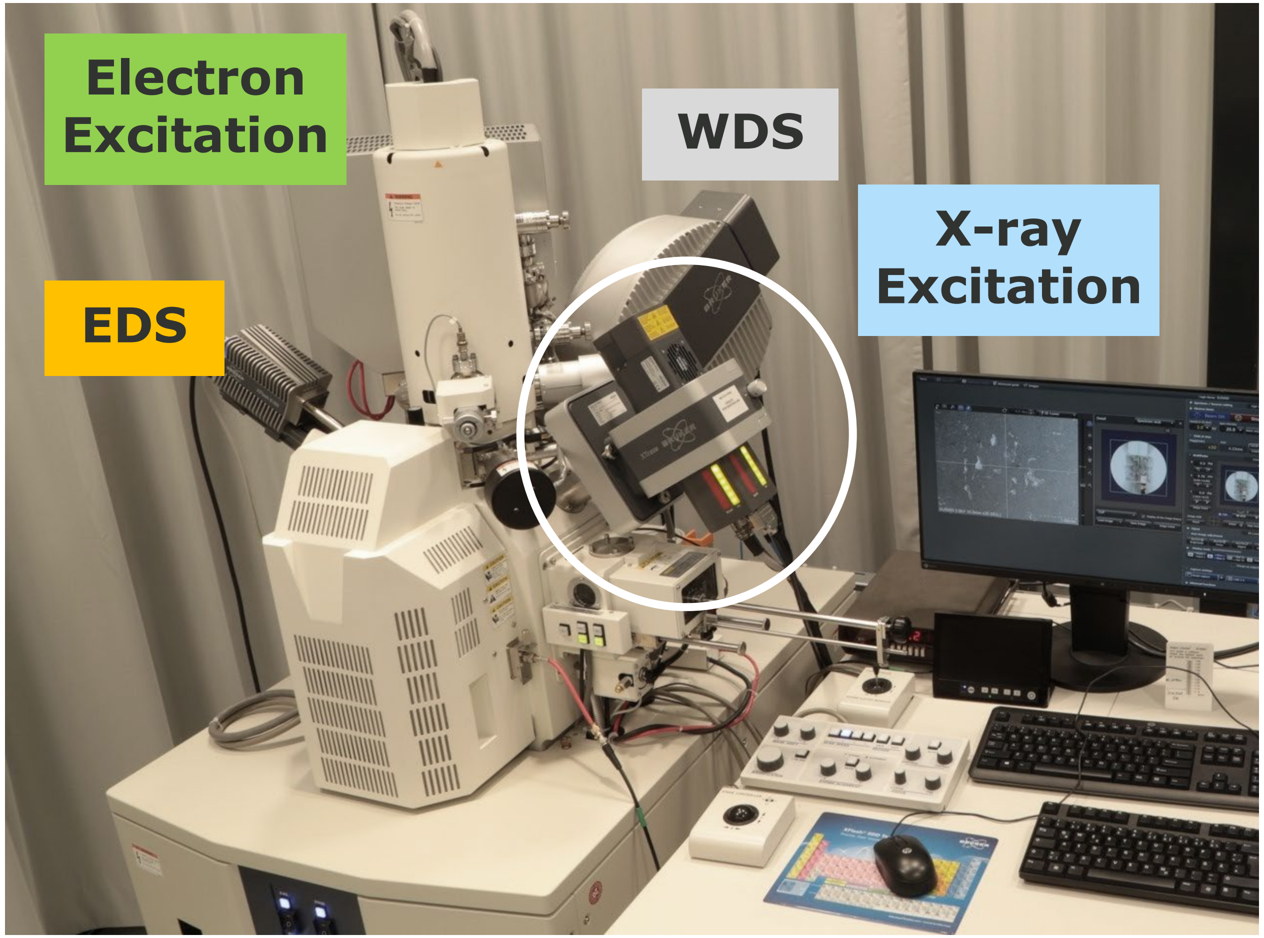
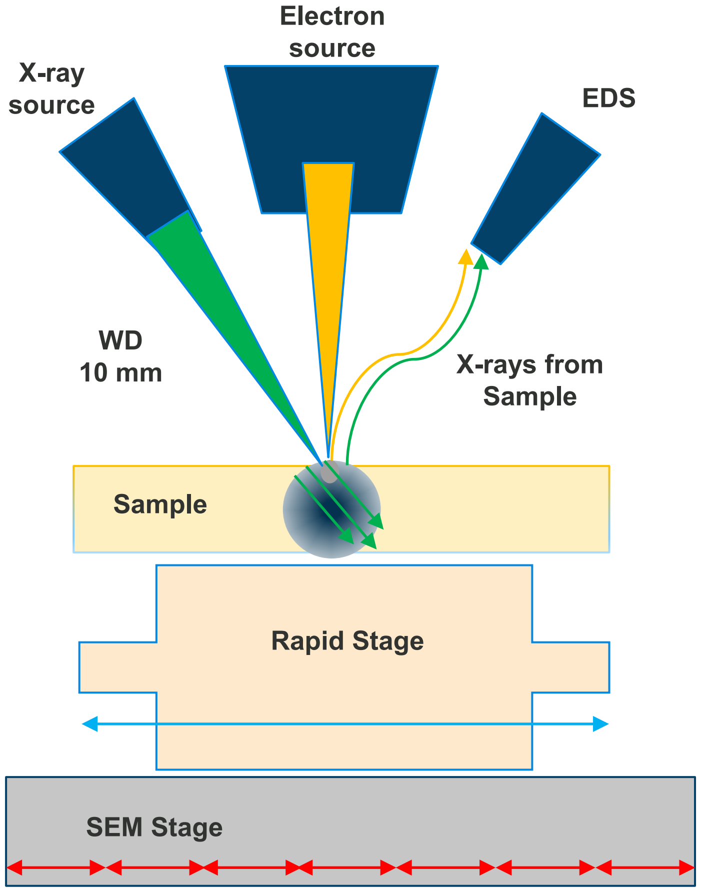
SEM and Analytical Options:
Electron and Photon Excitation for micro-XRF and EDS/WDS





2 Excitation Sources:

Electron Beam (e-beam)

Micro-XRF (X-ray beam)

1 Detector:

Energy Dispersive Spectrometer (EDS)

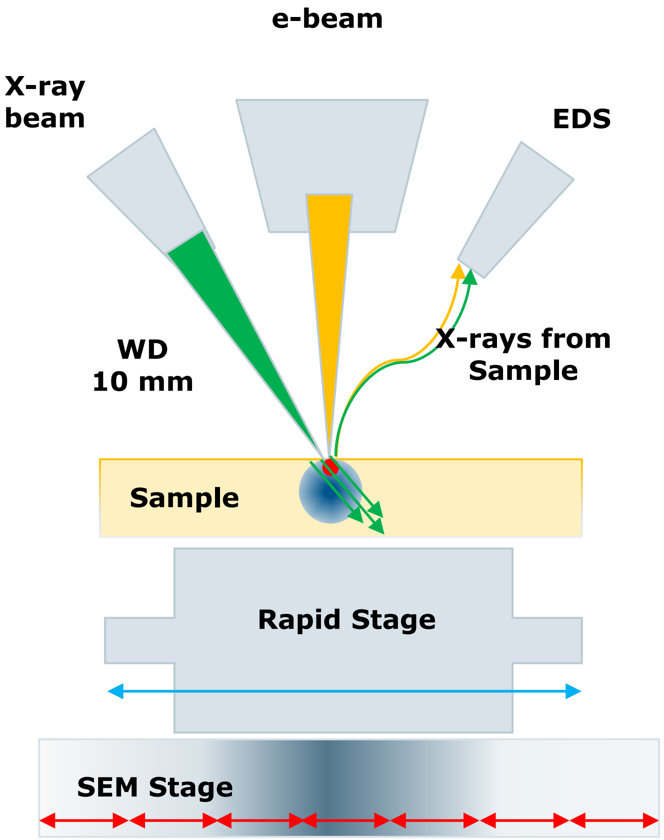
2 Stages:

SEM Stage

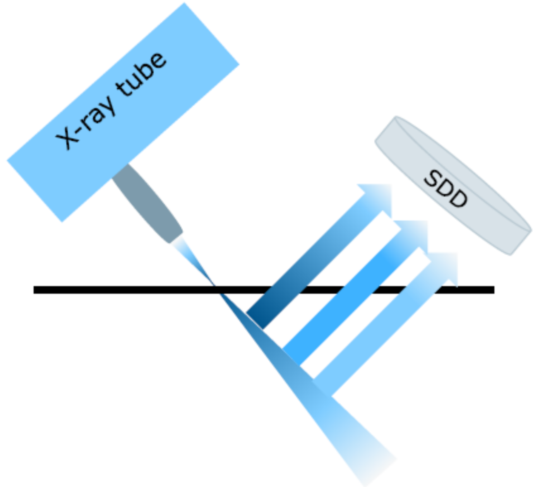
Rapid Stage

Analytical Parameters and Conditions
SEM-EDS vs SEM-XRF

Parameter	E-beam (SEM-EDS)	Micro-XRF (SEM-XRF-EDS)
Spatial Resolution & Analyzed Volume	Ø: few µm Information depth: µm; (depending primarily on electron energy)	Ø: 15-30 µm Information depth: µm to mm; (depending on analysed element and matrix)
Detectable Elements	Atomic number Z ≥ 4 (beryllium)	Atomic number Z ≥ 6 (carbon)
Energy range	K- L –M – Lines (up to 20 keV)	K- L –M – Lines (up to 40 keV)
Concentration Range	Down to 1000 ppm	Down to 5 ppm
Quantification	Standard less and Standard based	Standard less and standard based
Data collection	Simultaneously	Simultaneously
Sample Preparation	Sample needs to be electrically conductive (commonly carbon-coated), polishing required	Electrical Conductivity not required, samples doesn´t need to be polished
Sample stress	Heated due to absorbed electrons	minimal
Spectroscopic resolution	Down to 121 eV for Mn Ka	Down to 121 eV for Mn Ka
Distribution Measurements	By rastering e-beam	By continuously (Rapid) Stage movement since the X-ray optic is fixed in space



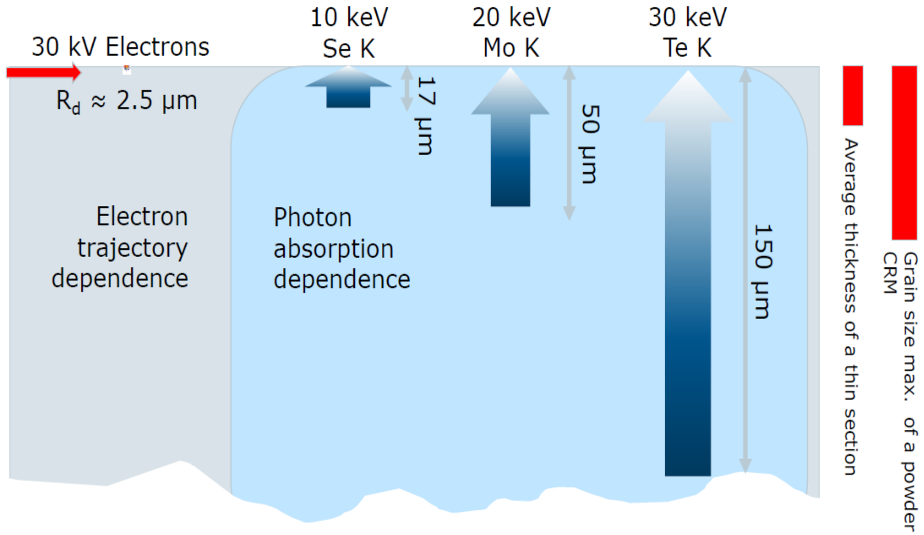
Spatial Resolution and Analyzed Volume: Transmission and Attenuation



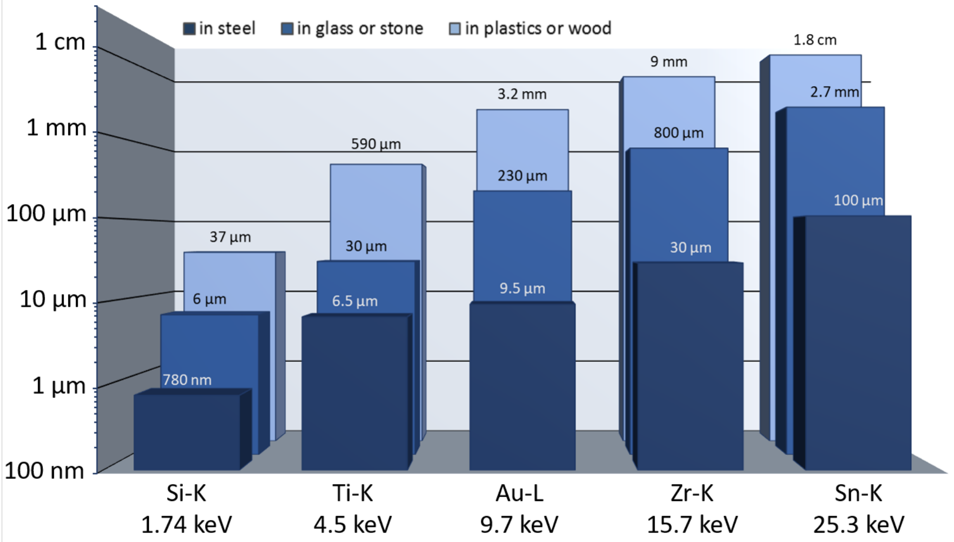
The transmission of X-rays is important for excitation of samples as well as for the fluorescence radiation.

Penetration depth: the depth that can still be excited

Information depth: the depth from which fluoresced X-rays can still reach the detector

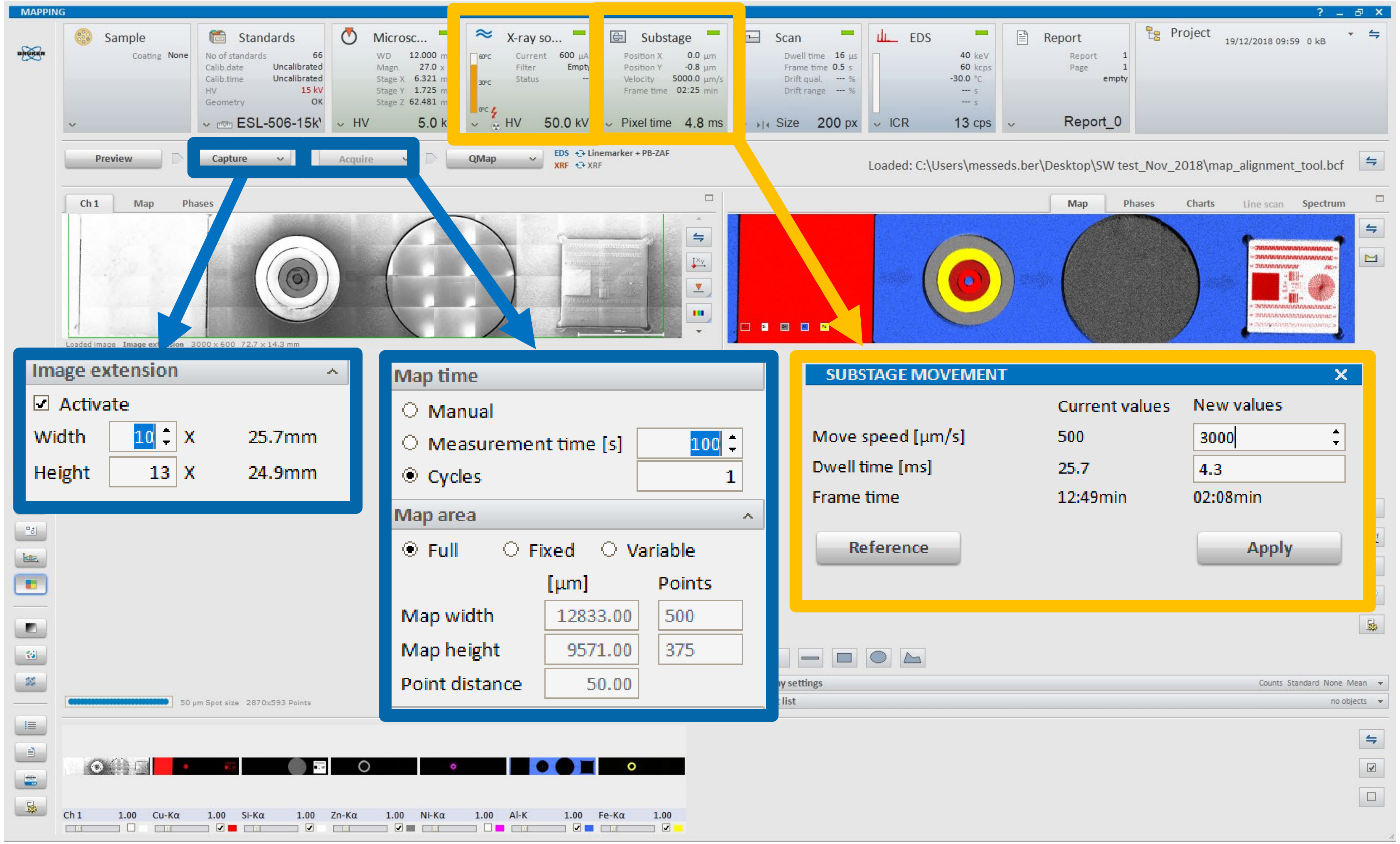


Information depths of selected element fluorescence lines in different matrices

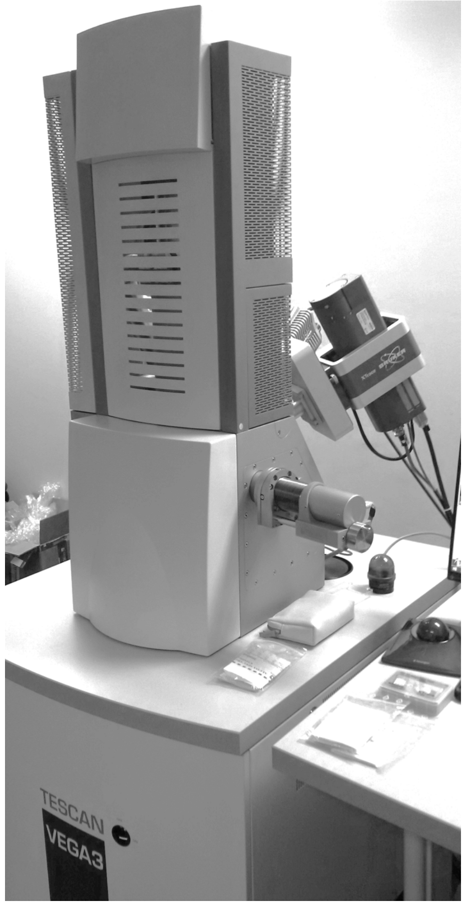


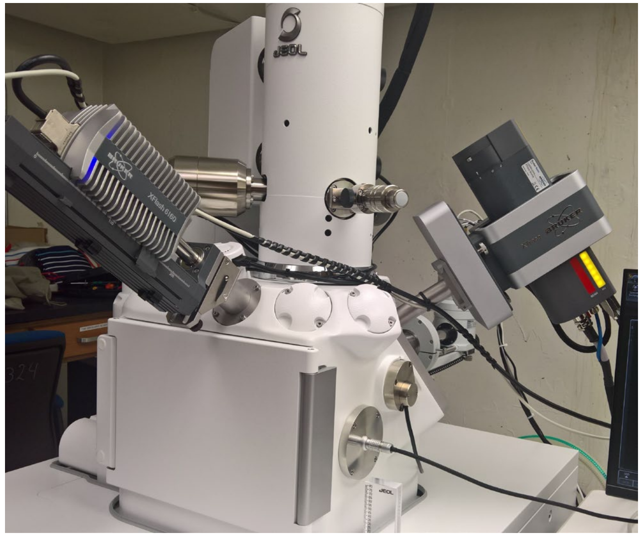
WEBINAR: SEM-XRF (XTRACE)

SEM-XRF and Rapid Stage
Integration in ESPRIT Software



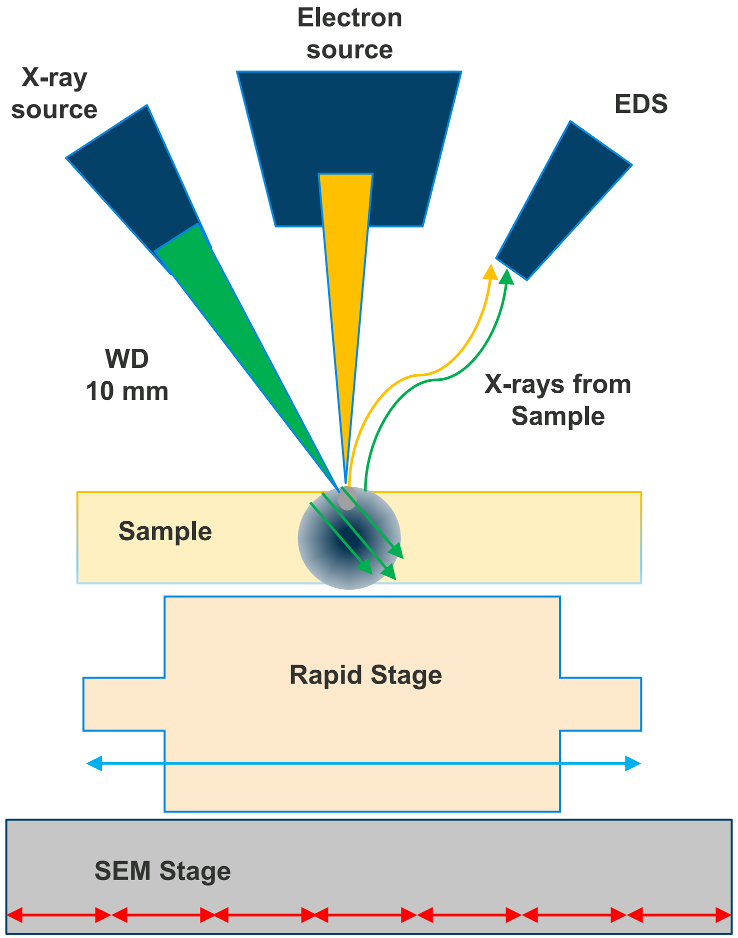
Micro-XRF Installations:
Adaptable to Various SEM models





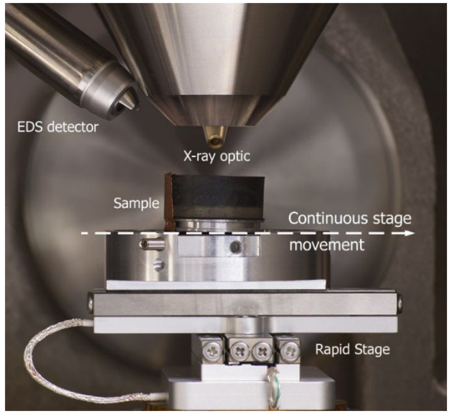
Introduction to Micro-XRF and Rapid Stage
Differences to Electron Beam Excitation

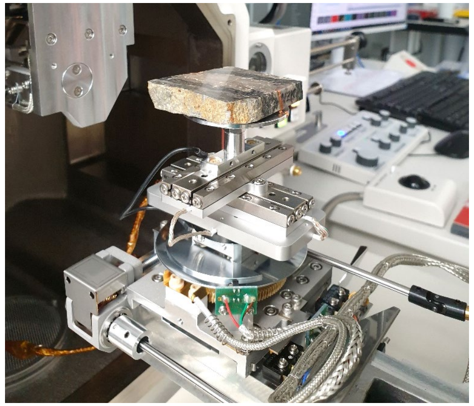
Enhanced SEM



Micro-XRF Benefits:

- Non-destructive analytical technique
- No charging effects
- Minimal Sample Preparation Required
- Lower detection limits (down to 5 ppm)
- Wide elemental range (from Z = 6 to 92)
- High Energy Lines Detection (Full Spectrum Range up to 40 keV)
- Ideal for Low kV or Beam sensitive samples
- Fast Large Area Mapping
- Micrometer scale measurement over cm
- Versatility in Application





SEM-XRF :
Application Fields

The following Application fields will have benefits from the enhanced functionality on the SEM:

- **Materials Science**
- **Archaeology and Art Conservation**
- **Environmental Science**
- **Geology and Mineralogy**
- **Forensics**
- **Electronics and Semiconductor Industry**

SEM-XRF (XTrace): Materials Science

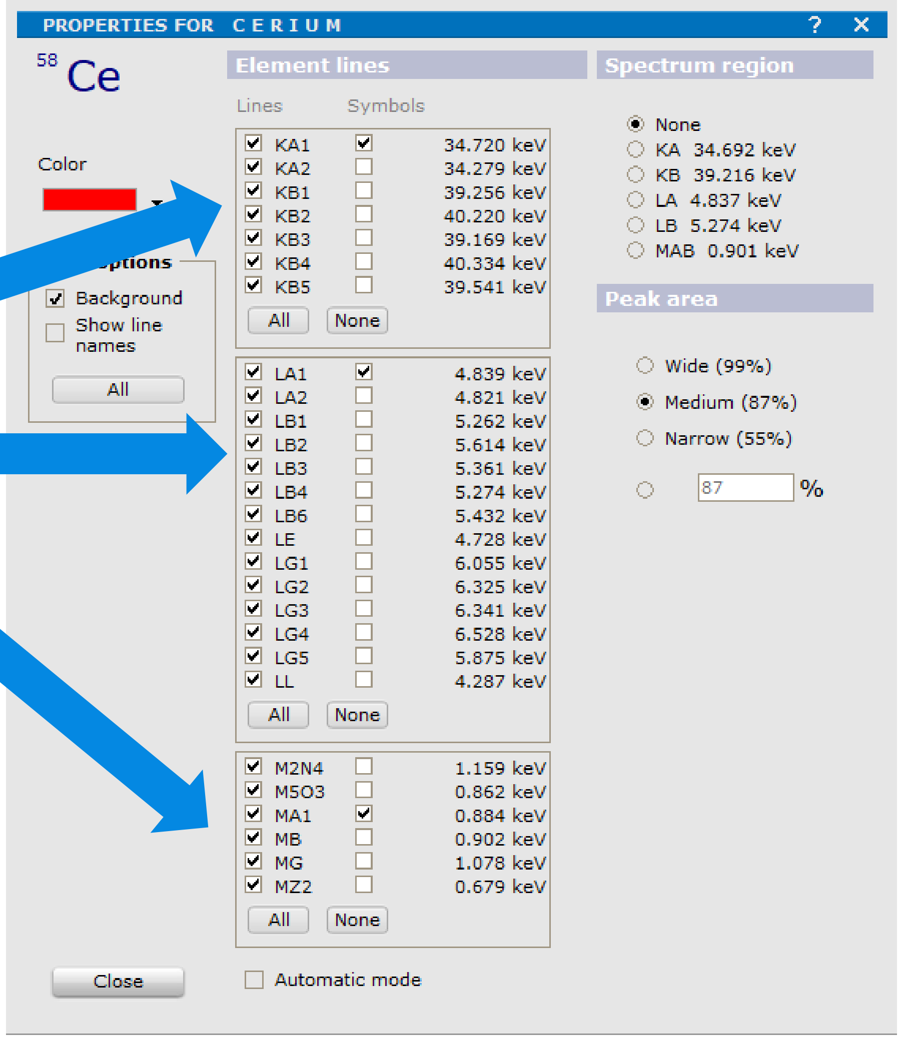
Rare Earth Elements: X-ray Energies

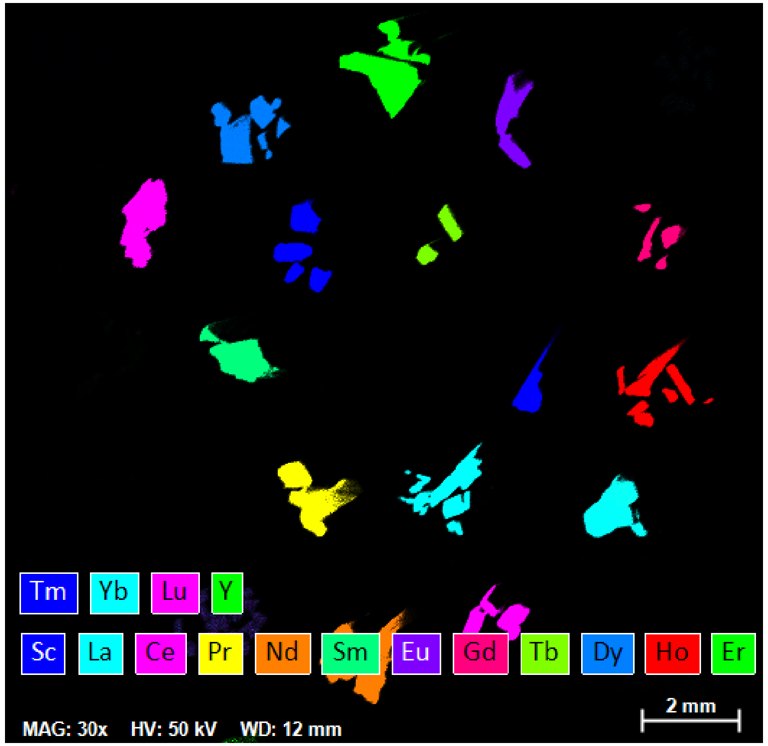
Rare Earth Elements have a range of X-ray energies that are detectable by EDS:

K-Series:	34 to 55 keV
L-Series:	4 to 10 keV
M-Series:	0.5 to 1.5 keV

L-Series detectable with both electron and x-ray excitation source.

K-Series detectable with x-ray excitation source only.





SEM-XRF Analysis of Rare Earth Elements (REE´s):
Comparison with SEM-EDS

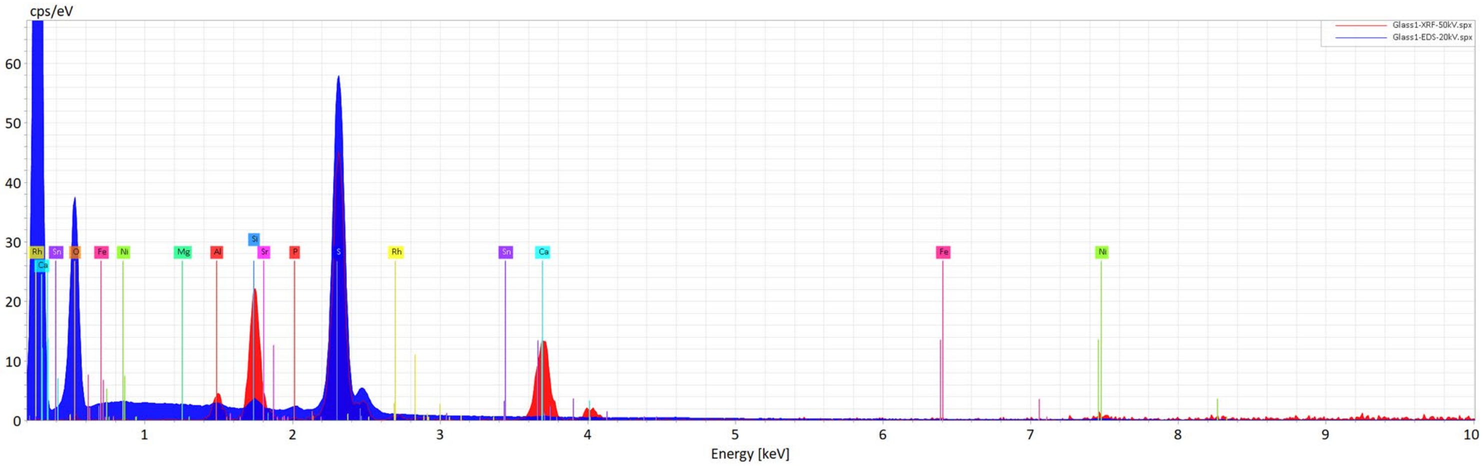
SEM-EDS is better for low energy lines

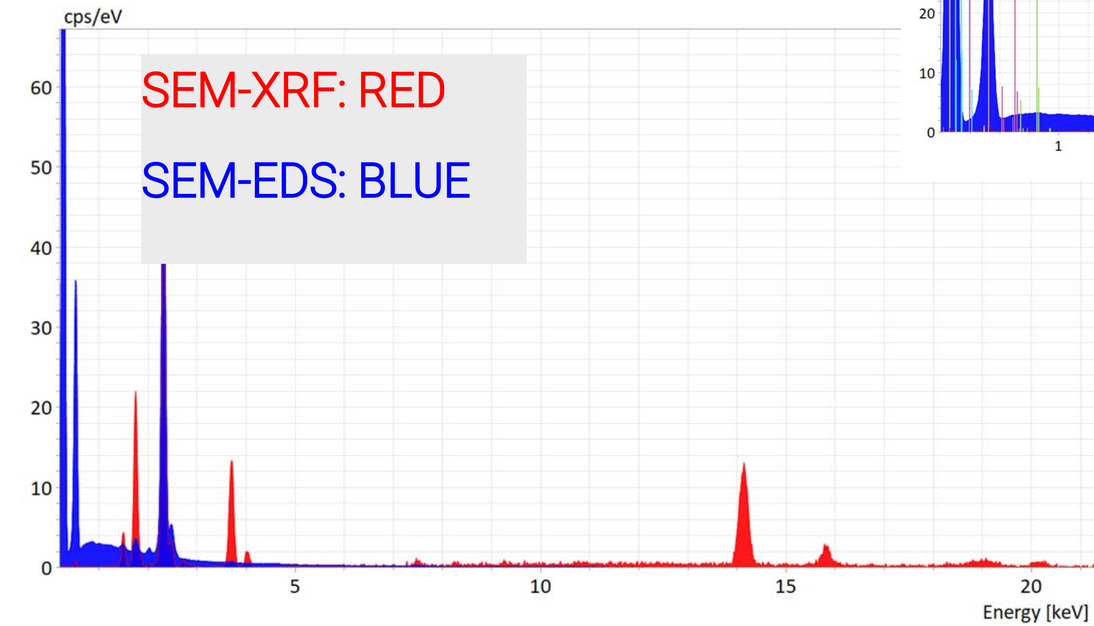
SEM-XRF is better for high energy lines

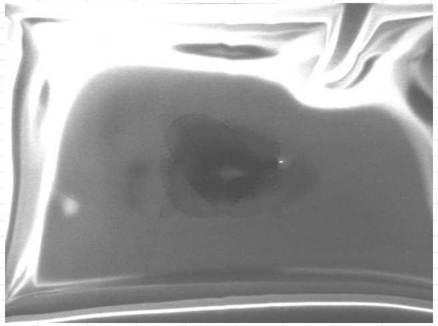
Glass Spectrum: SEM (20 kV), XRF (50 kV)

Bottom: 0 to 40 keV

Right: 0 to 10 keV







SEM Image showing charging under e-beam:

5 kV (left) and

20 kV (right)

SEM-XRF Analysis of Rare Earth Elements (REE´s): Applications – High Index Glass

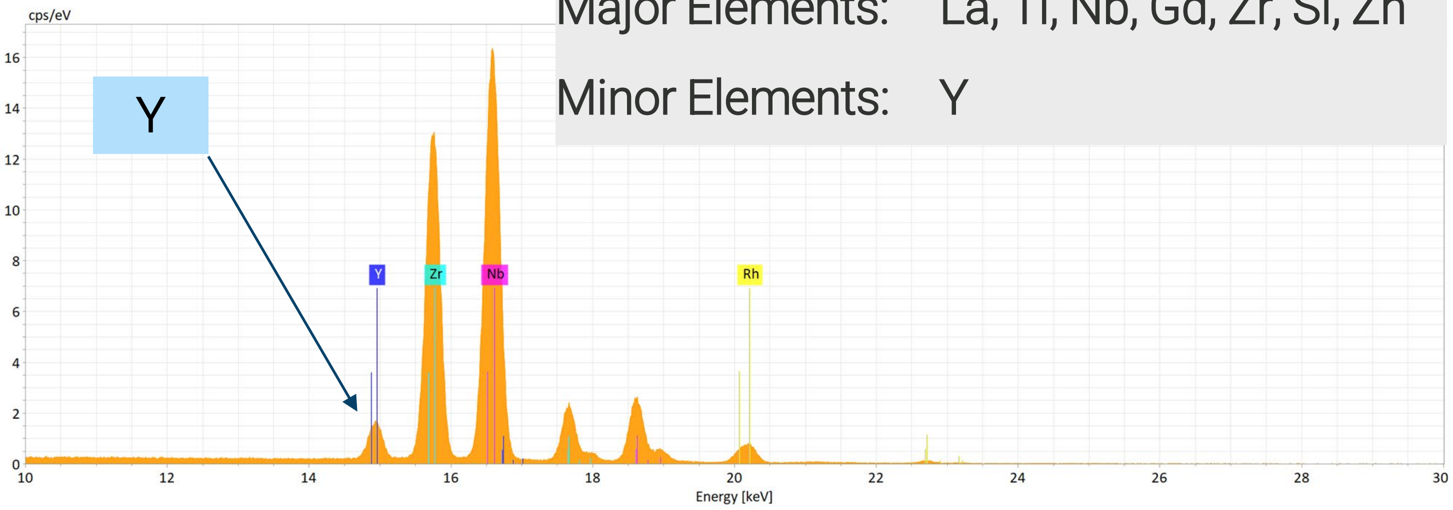
Major Elements: La, Ti, Nb, Gd, Zr, Si, Zn

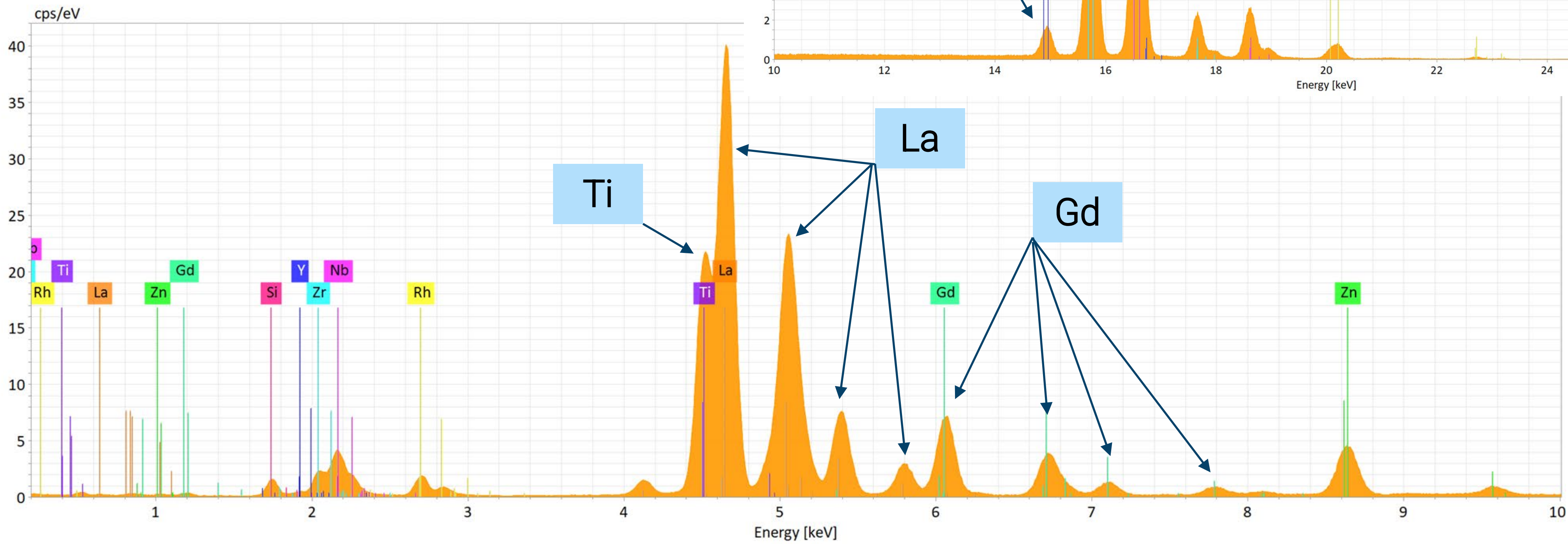
Minor Elements: Y

Spectrum X-axis Range:

Bottom: 0 to 10 keV

Right: 10 to 30 keV





SEM-XRF Analysis of Rare Earth Elements (REE´s): Applications – High Index Glass

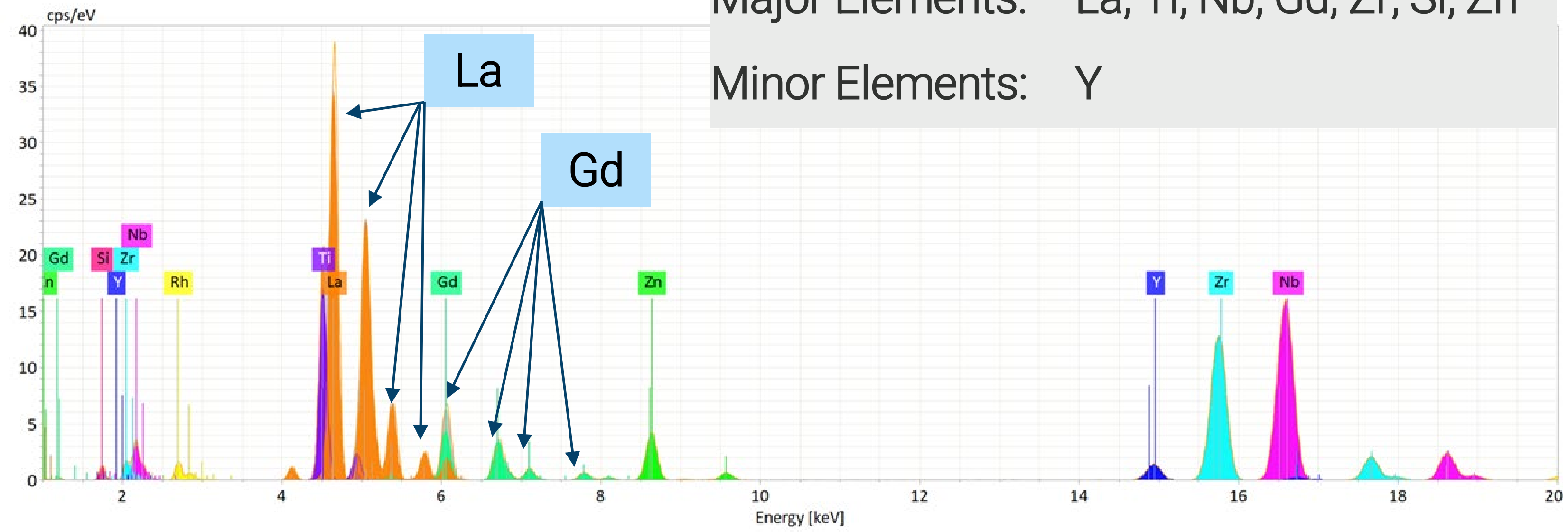
Major Elements: La, Ti, Nb, Gd, Zr, Si, Zn

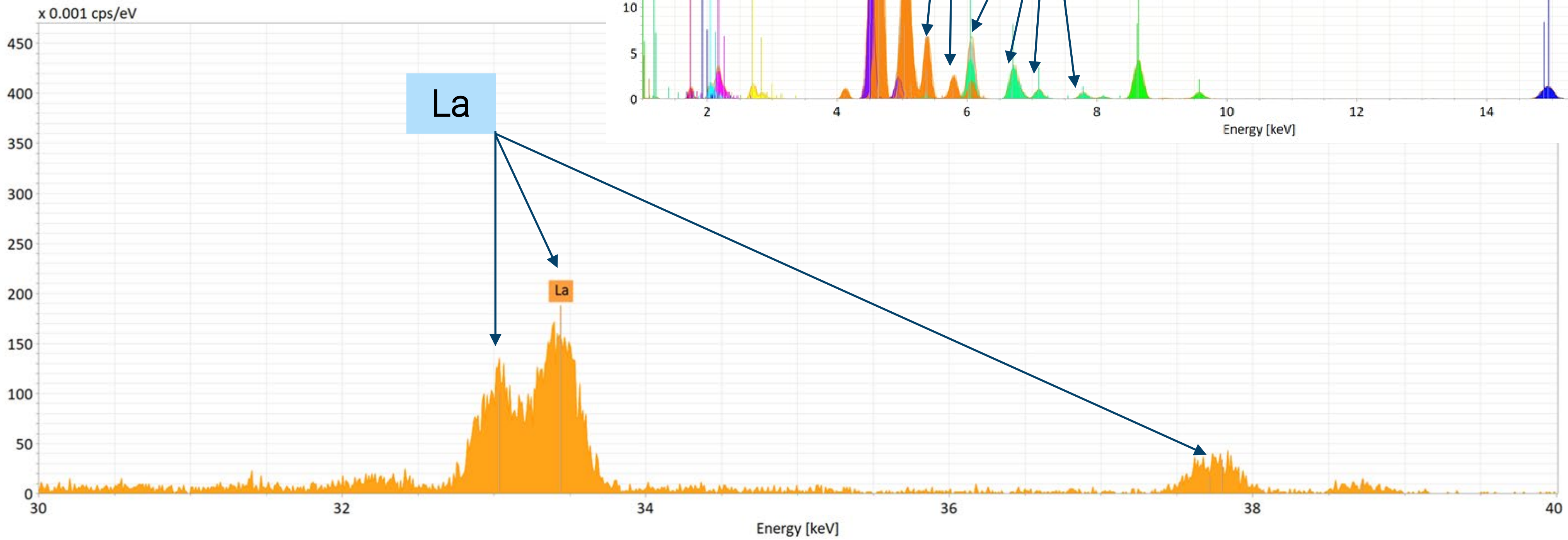
Minor Elements: Y

Spectrum X-axis Range:

Bottom: 30 to 40 keV

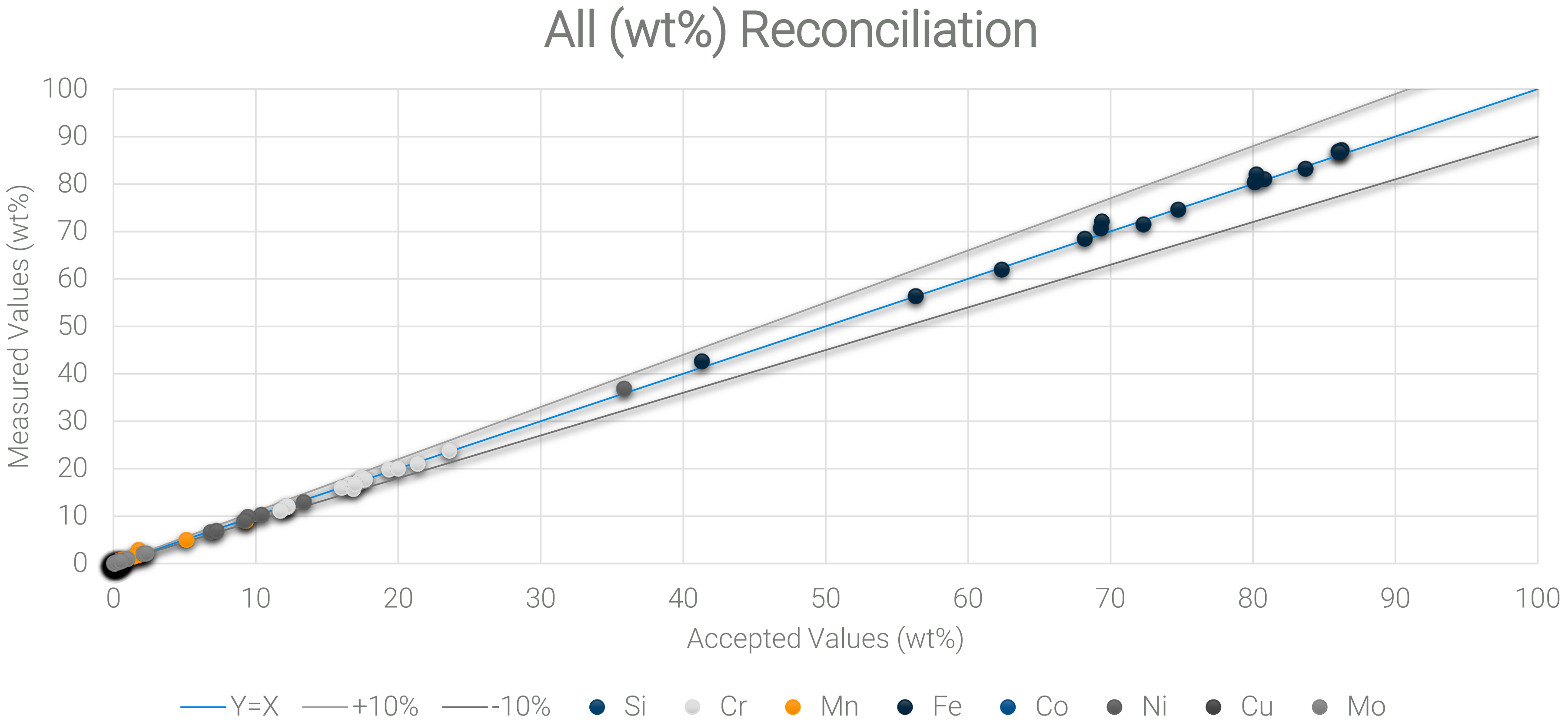
Right: 1 to 20 keV (Deconvolution)

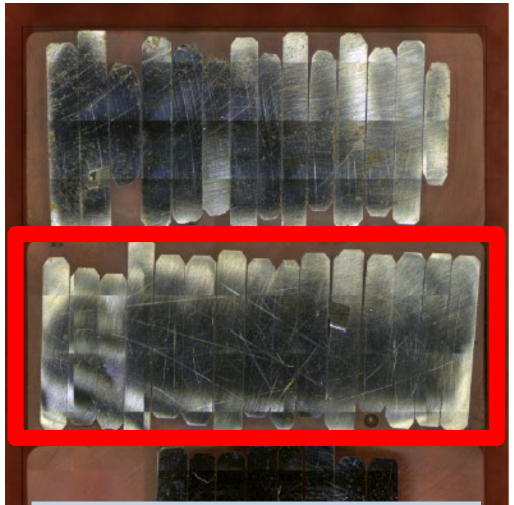




Analysis of Steels and Alloys
Excitation: Micro-XRF; Detector: EDS

Analytical Conditions Point Analysis: 50 kV, 600 uA, No Filter, 130 kcps, under vacuum, Working Distance 12 mm, 120 seconds





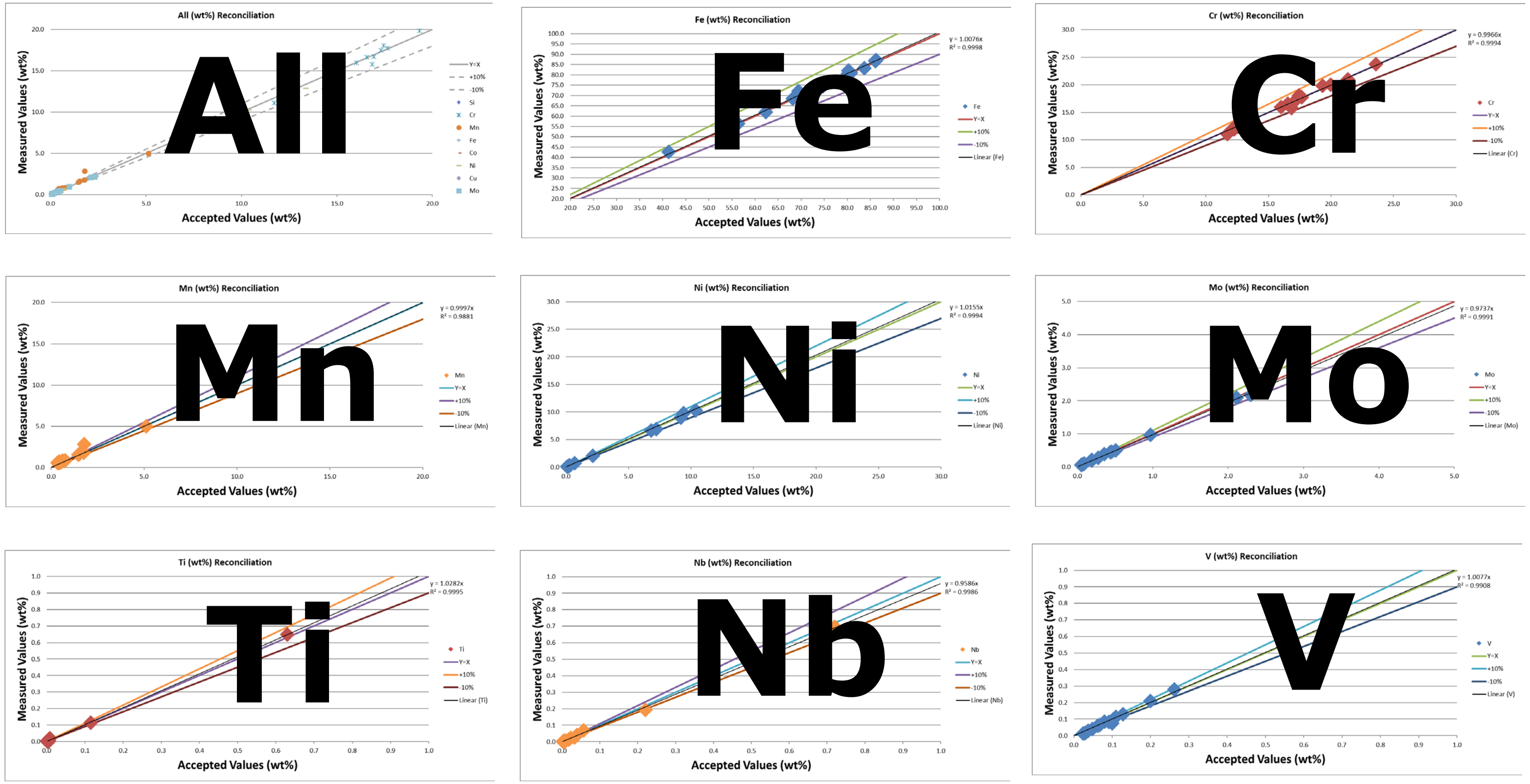
SAMPLES: Set of 51 ARMI steels with known (certified) compositions

Cast in Epoxy Resin and Polished

High-Fe, **Cr-Ni steels**, Cu-alloys

Analysis of Steels and Alloys
Individual Elements

Micro-XRF Excitation. EDS Detector. SEM-XRF-EDS.



Analysis of Steels and Alloys
Combined Analysis

Sample 32: AISI 422-205B

Element	Certified	MicroXRF	SEM-EDS	Combined
C	**0.22**			
N	**0.05**			
Al	**0.01**			
Si	**0.37**		0.34	**0.33**
P	**0.01**			
S	**0.00**			
Ti	**0.00**	0.003		**0.00**
V	**0.26**	0.279		**0.26**
Cr	**11.72**	11.084	11.37	**11.32**
Mn	**0.68**	0.797	0.87	**0.75**
Fe	**83.70**	83.243	84.55	**83.20**
Co	**0.03**	0.024	0.49	**0.02**
Ni	**0.70**	0.692	0.54	**0.67**
Cu	**0.15**	0.177		**0.15**
Nb	**0.02**	0.012		**0.01**
Mo	**0.97**	0.970	0.95	**0.94**

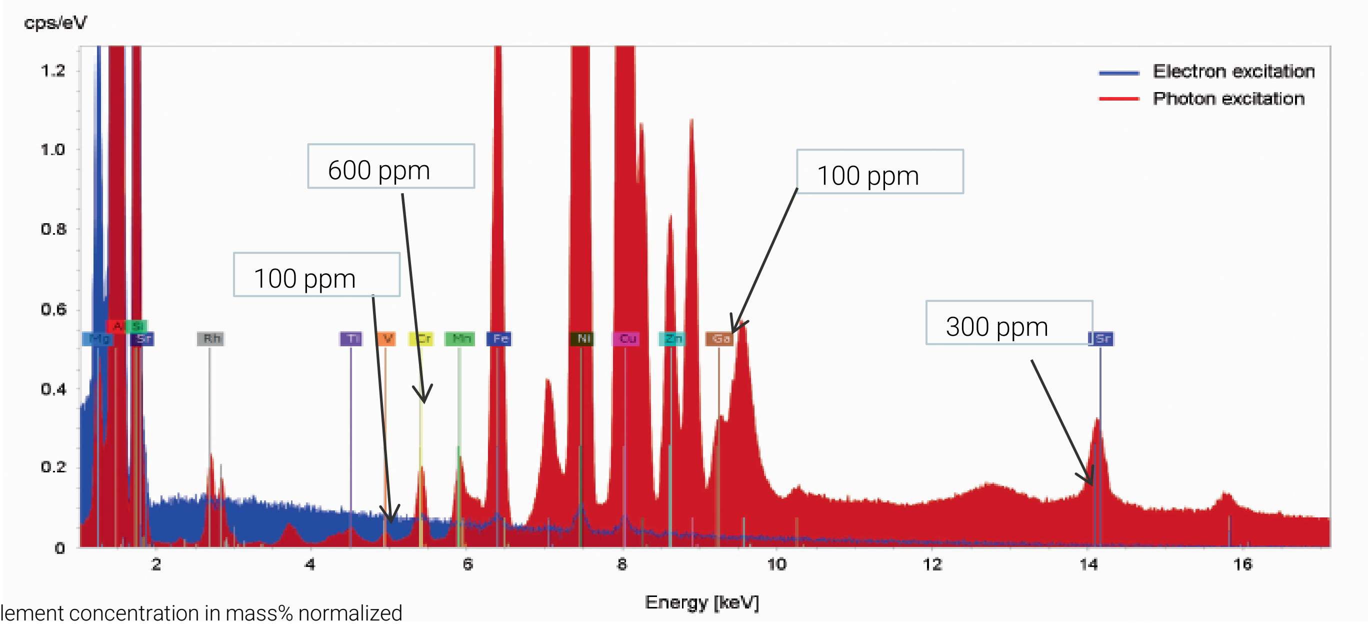
SEM-EDS/WDS

Low-Z elements

SEM-XRF

High-Z elements

Al Alloy
Improved LOD comparison EDS - XRF



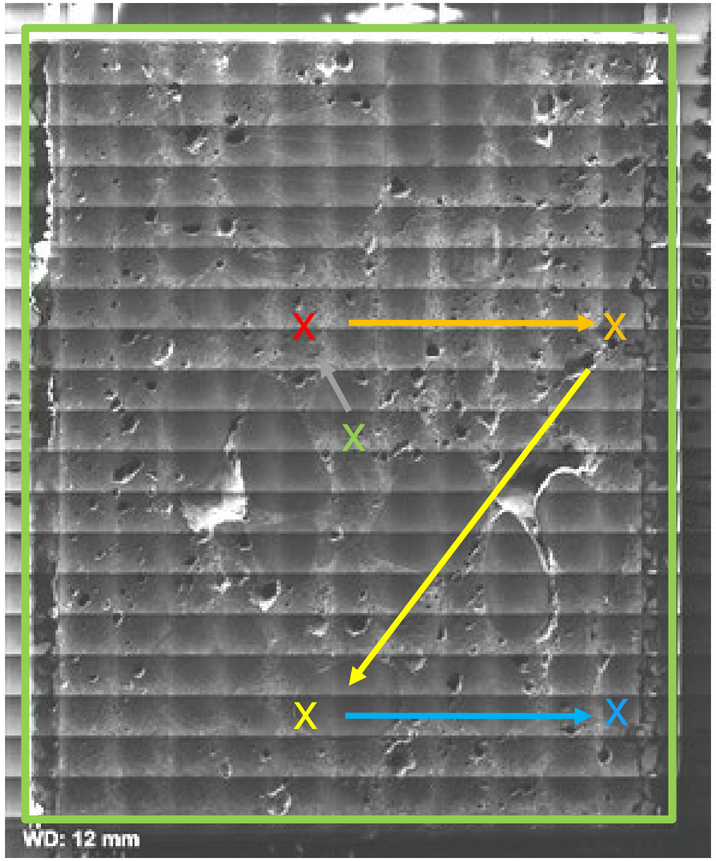
Element concentration in mass% normalized

	Mg	Al	Si	Ti	V	Cr	Mn	Fe	Ni	Cu	Zn	Ga	Sr
EDS mean concentration value	1.20	85.09	11.43	n.d.	n.d.	b.d.	n.d.	0.36	0.91	0.91	0.10	n.d.	n.d.
Micro-XRF mean concen-tration value	0.85	83.87	12.83	0.03	0.01	0.06	0.03	0.36	0.93	0.93	0.10	0.01	0.03
Certificied values	1.1	84.52	12.00	0.011	0.0099	0.051	0.033	0.31	0.89	0.89	0.098	0.02	0.026

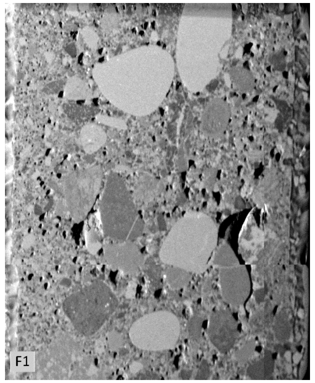
Certified aluminum standard

Fig. 1 Photograph of the analyzed specimen Alcoa Deltalloy® 4032

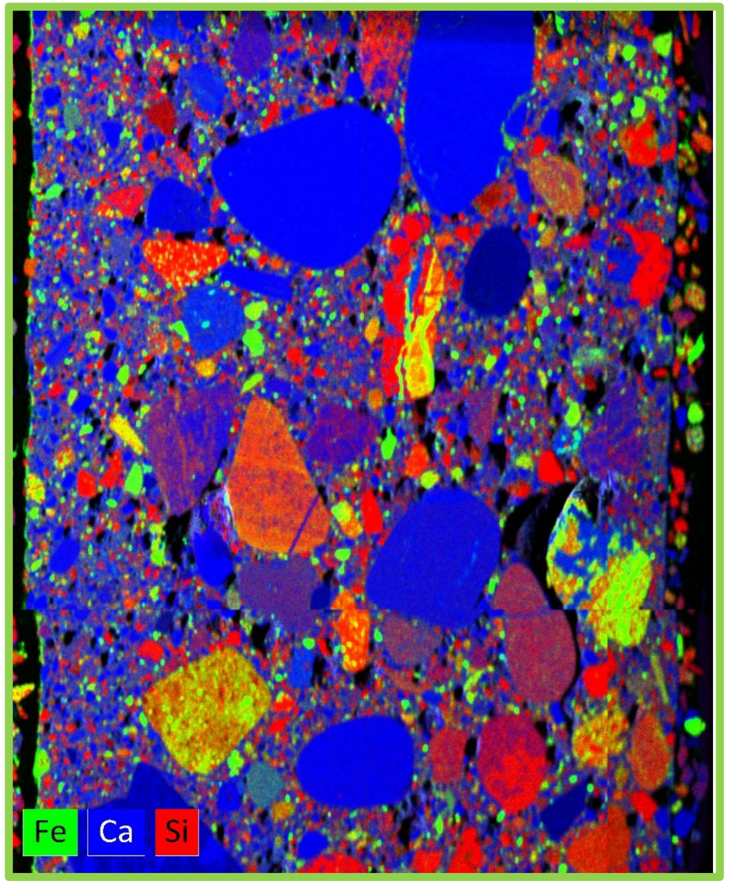
Large Area Maps
Rapid Stage + SEM Stage: SEM-XRF



Photograph of the sample



X-Ray Intensity Map



Large Samples:
Concrete Block: 61.8 mm x 74.4 mm

Such samples require a combination of the Specialised high speed stage + SEM Stage.

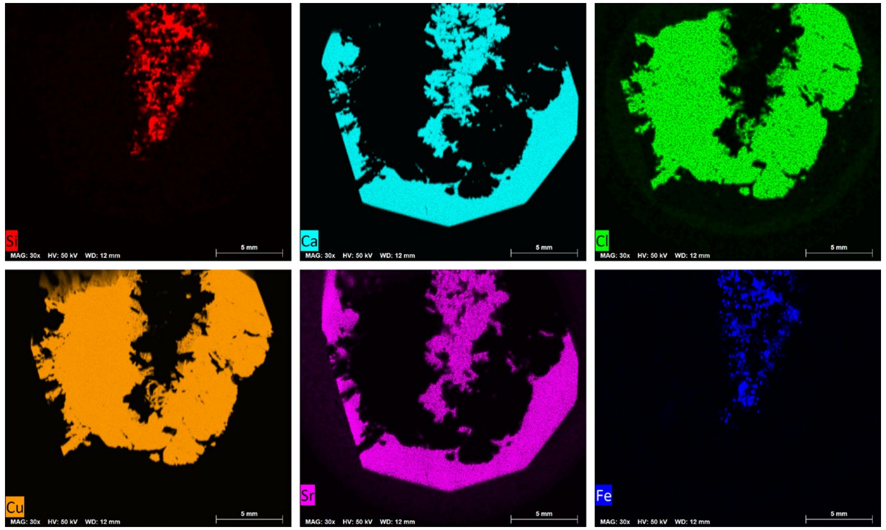
The sample is analysed in 4 maps which are mosaiced at the completion of the analysis.

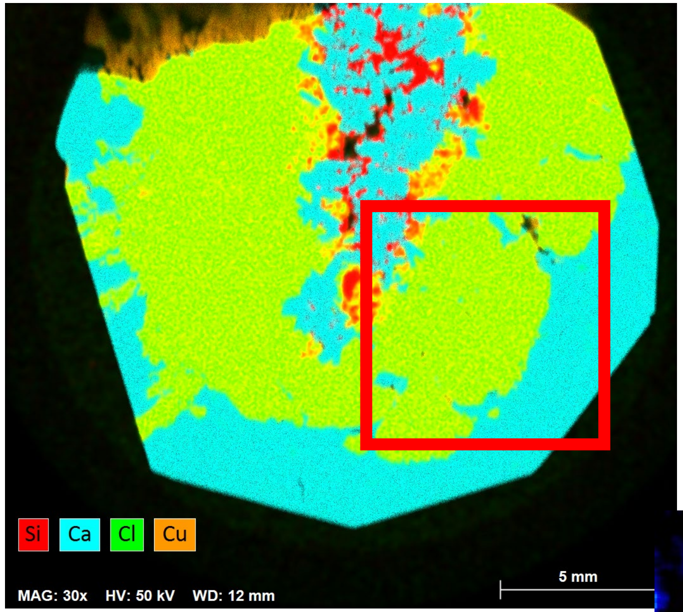
Image Extension: SEM is *14 x 22*

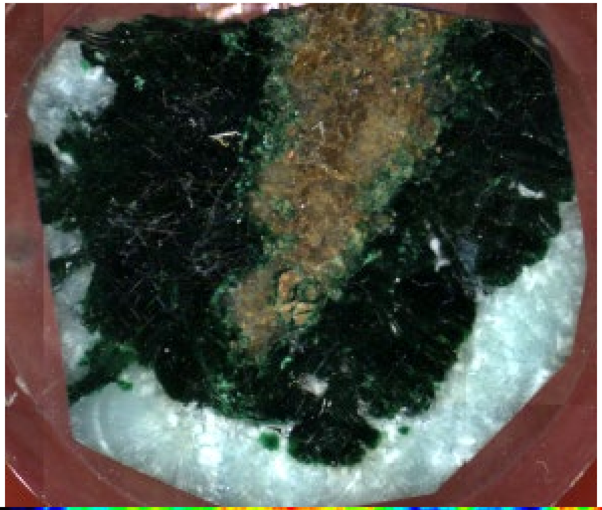
SEM-XRF (XTrace):
Archaeology and Art Conservation

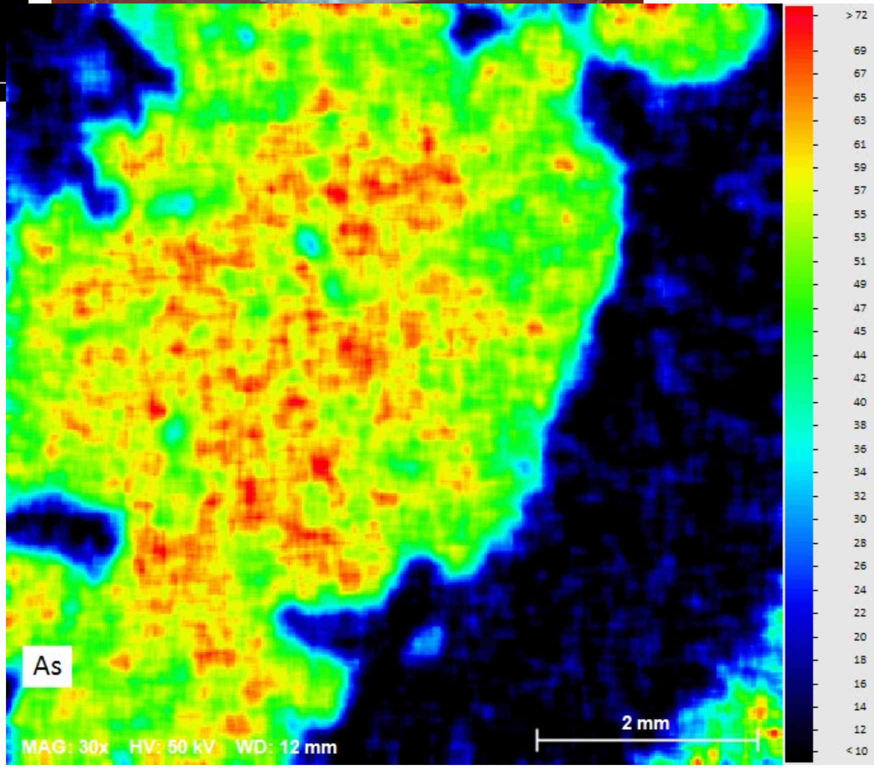
Analysis of Cu-bearing Ores
Atacamite

Analysis of Atacamite:
Use of Filters for Trace elements

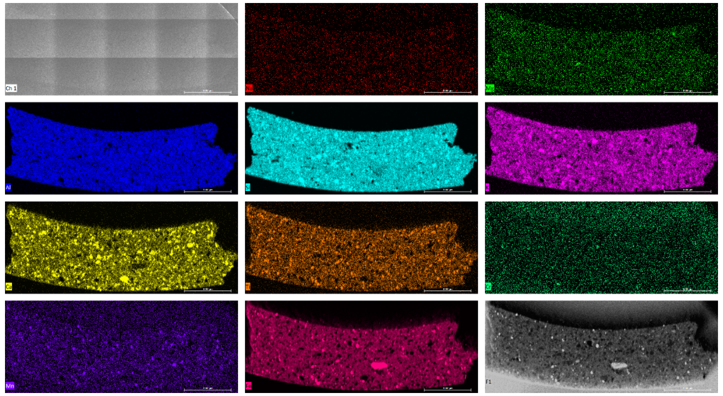


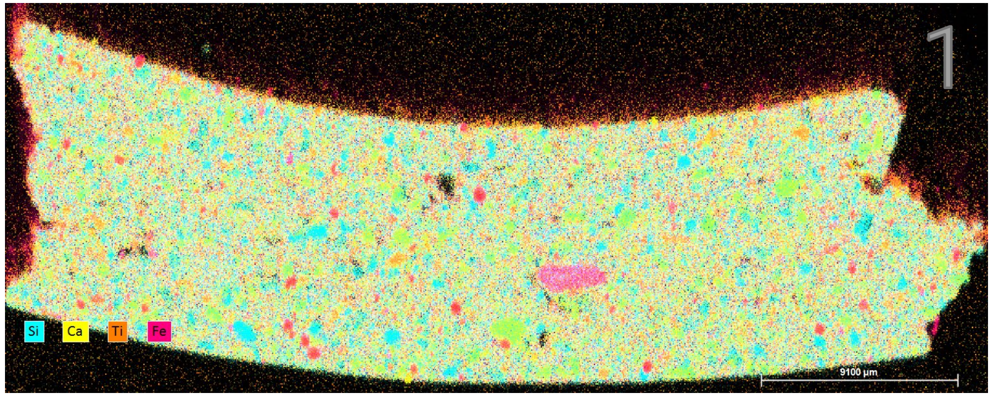






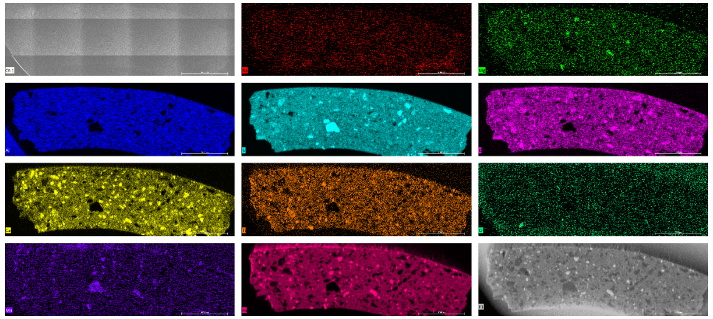
Analysis of Ceramics: Large Area Maps

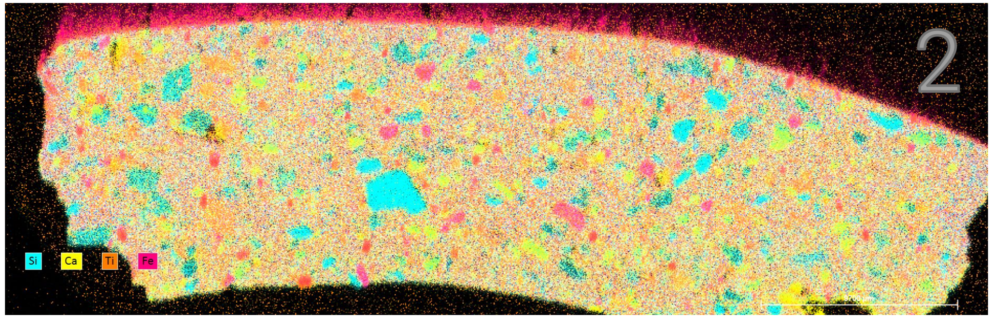


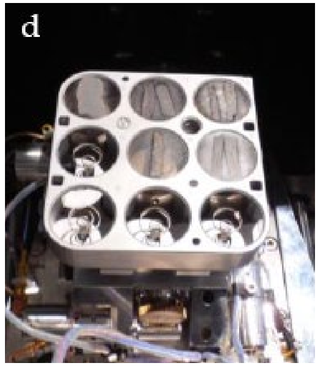


Ceramic Samples from Northern Chile

Identify different mineral phases – probable different source material



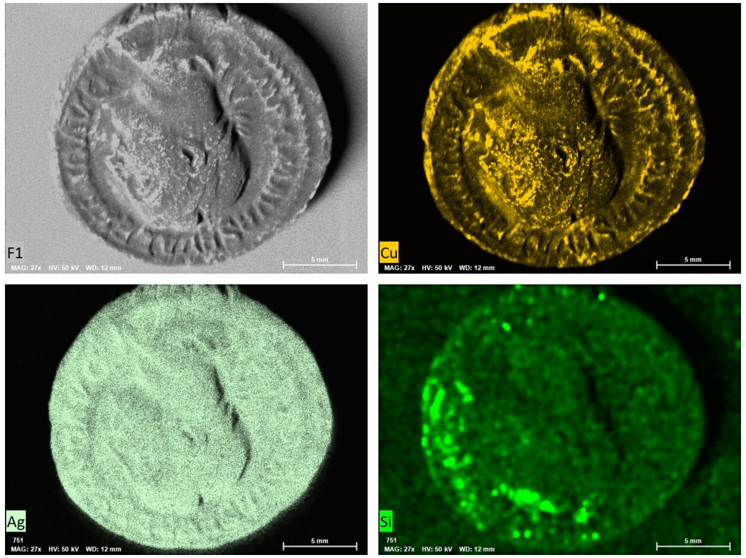


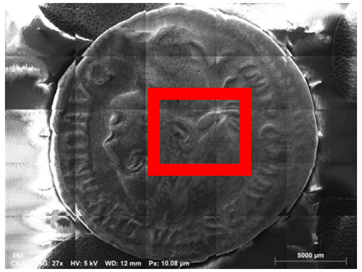


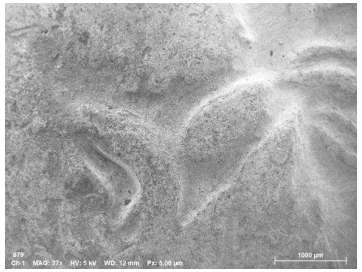
Top Row: SEM, Na, Mg; Second Row: Al, Si, K;

Third Row: Ca, Ti, Cr; Bottom Row: Mn, Fe, F1

SEM-XRF:
Analysis of Roman Coins

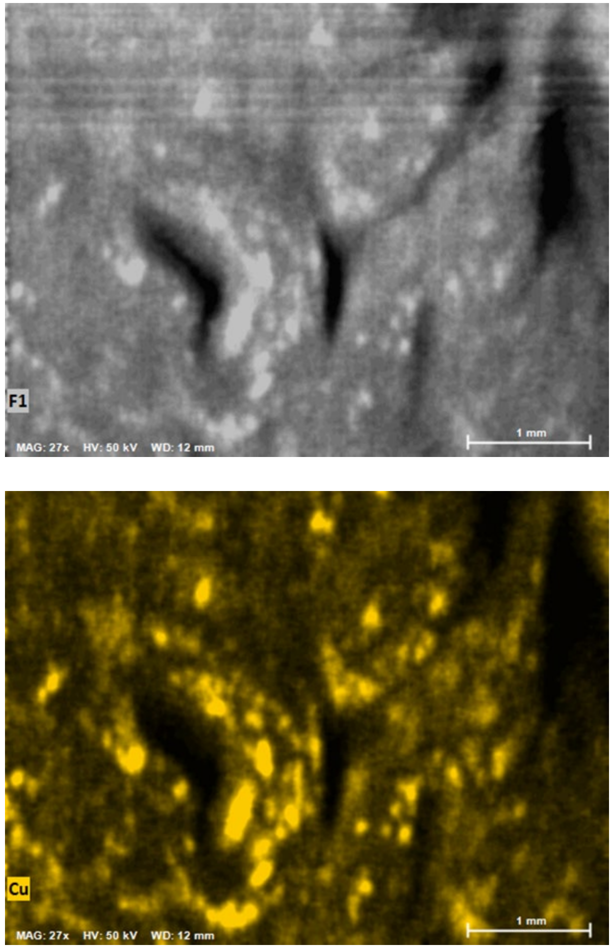


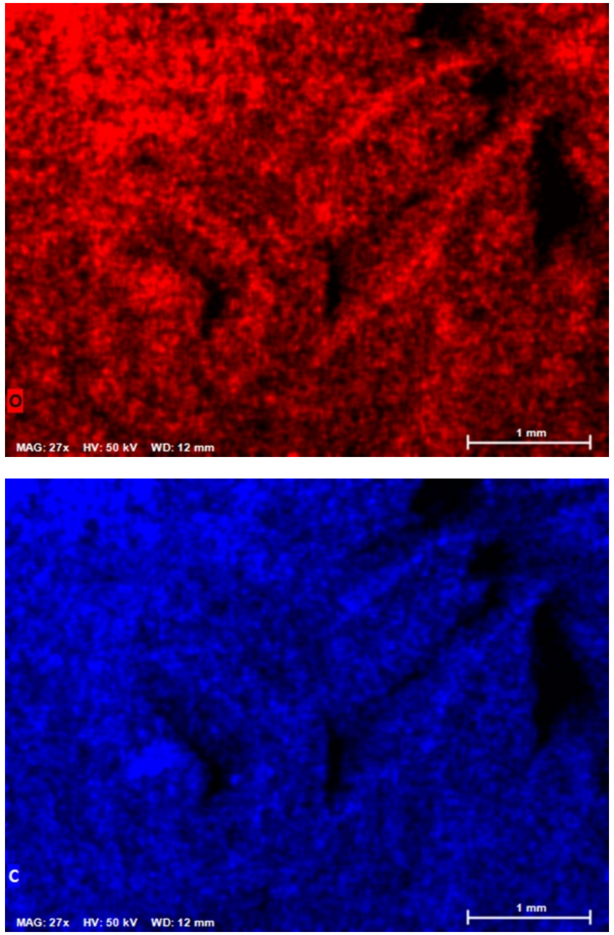




Areas of Combined XRF and e-Beam analysis

Dominated by XRF Signal

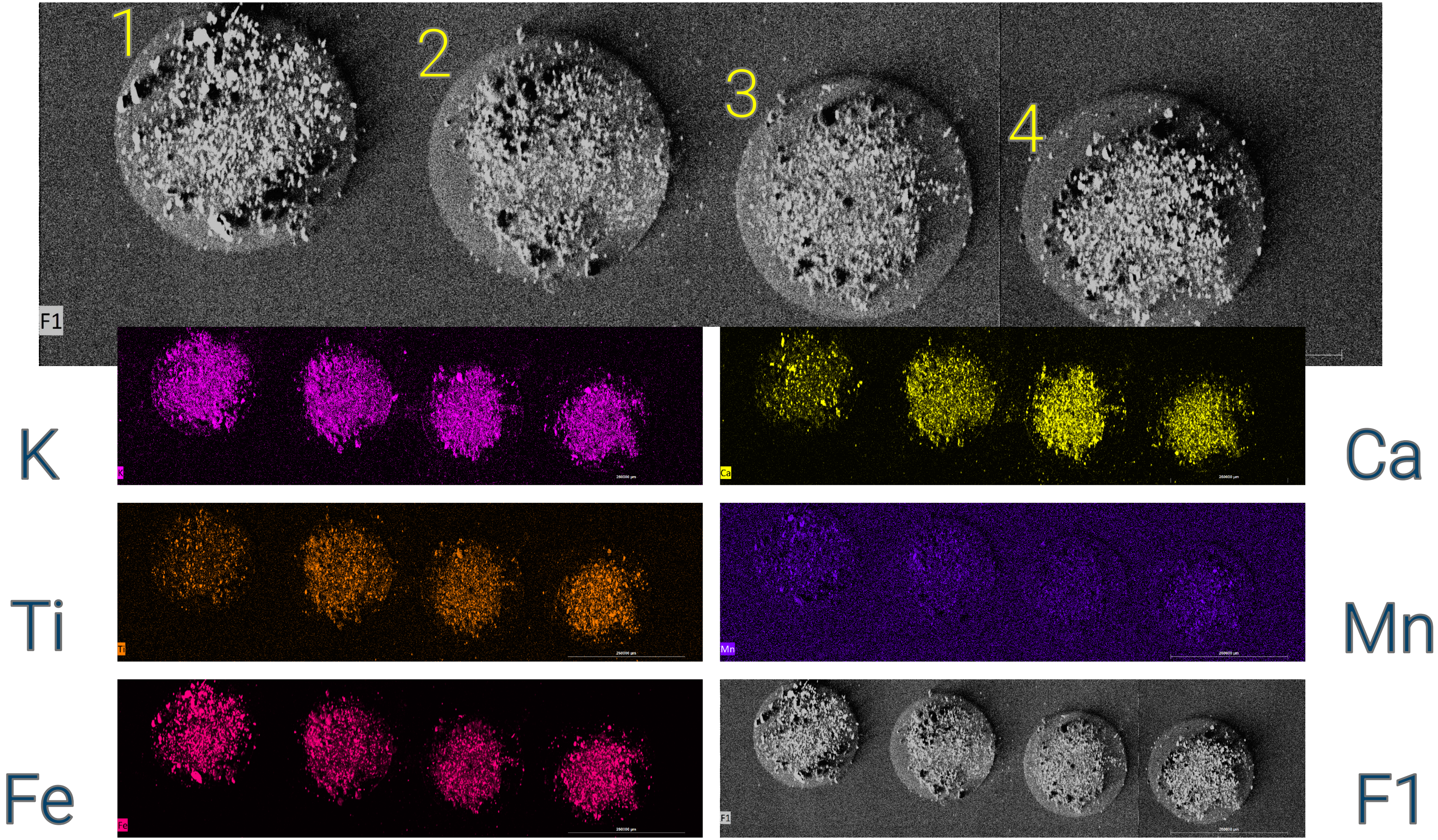




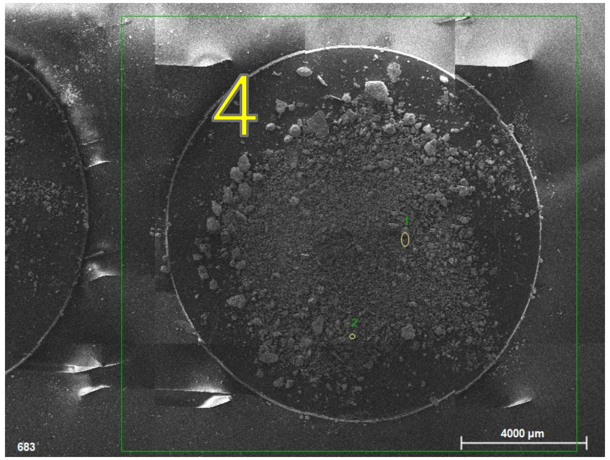
Dominated by eBeam Signal

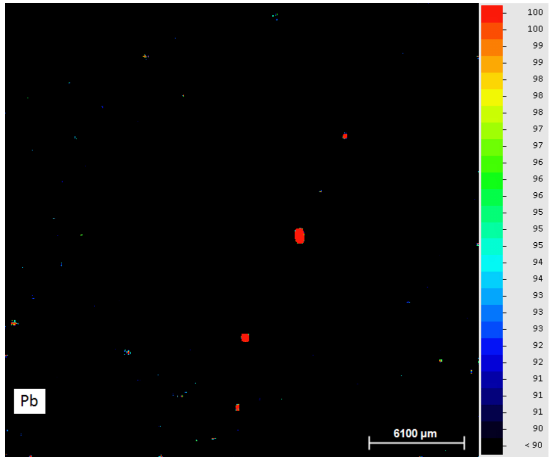
SEM-XRF (XTrace): Environmental Science

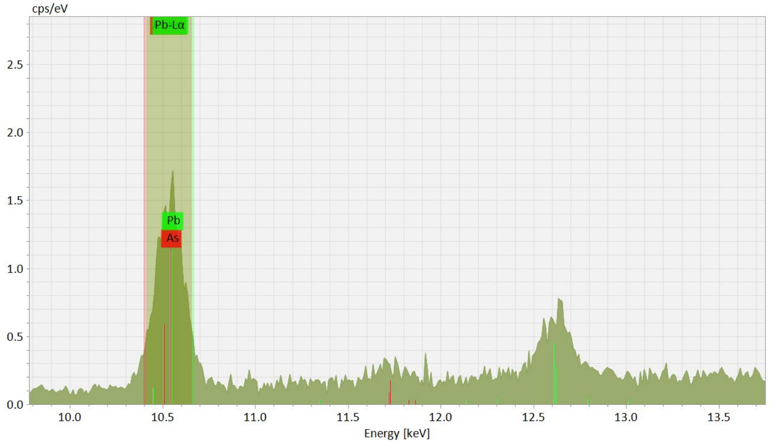
Analysis of Soil Samples:
Large Area Maps

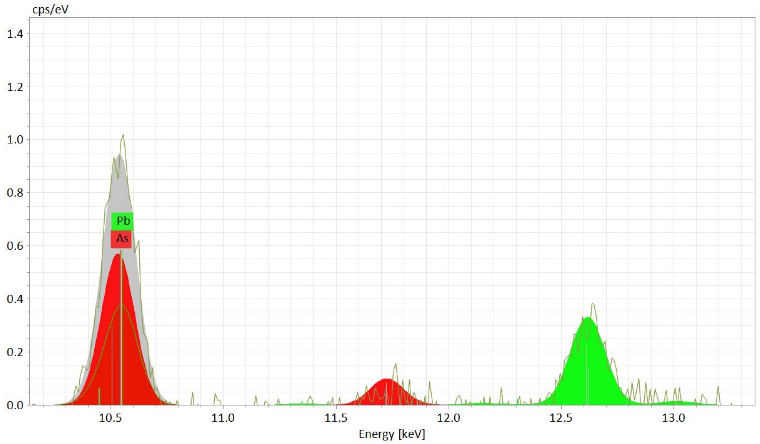


Analysis of Soil Samples:
Large Area Maps









After Maximum Pixel Spectra determines presence of Trace elements.

Detailed investigation confirms presence of both Pb and As

Analysis of Soil Bedrock:
Large Area Maps

Polished Sections:

Standard Size: 45 x 30 mm

Such samples can be completely analysed using the Specialised high speed stage only.

Example: *Soil Sample from Korea*

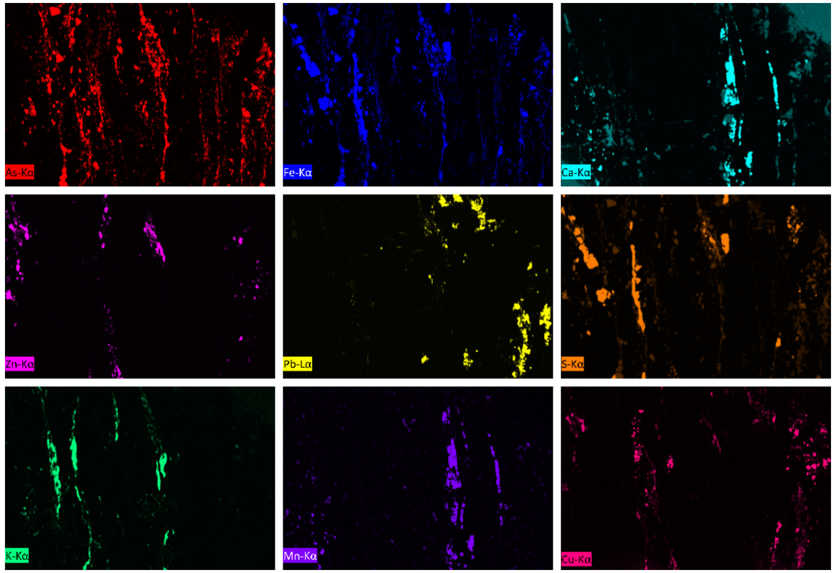
Analytical Parameters:

Tube Voltage: Rh at 50 kV

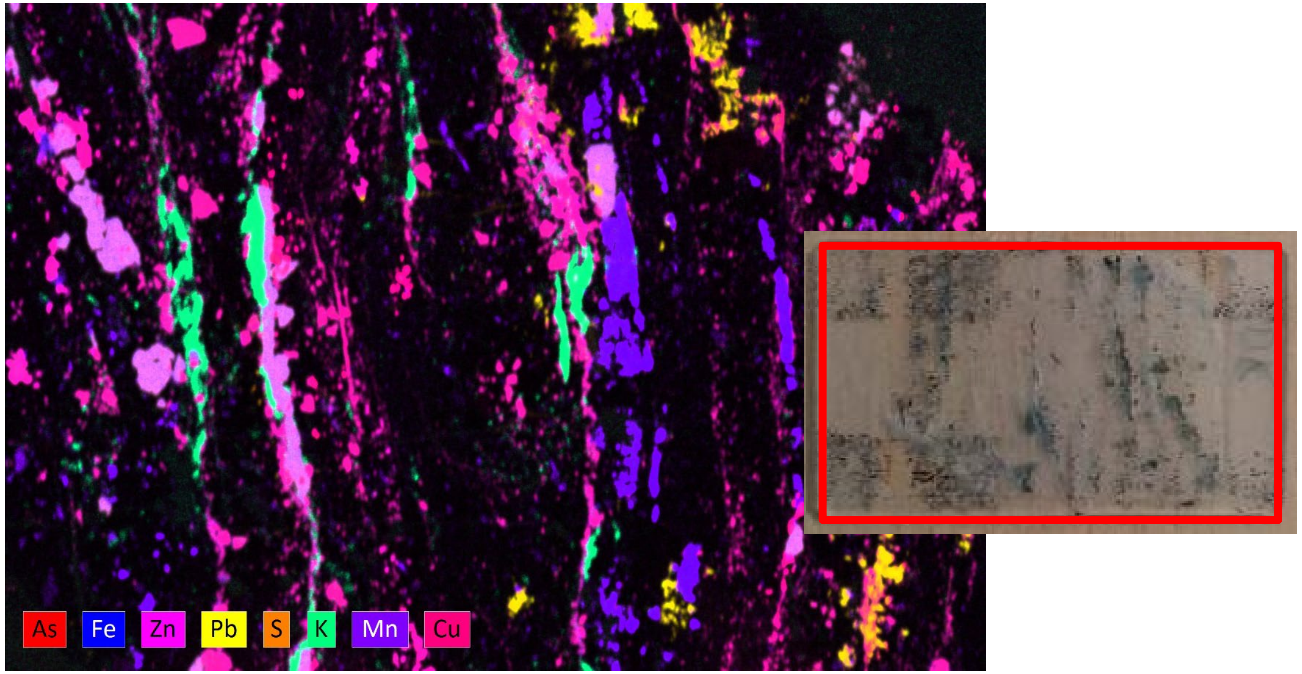
Anode Current: 600 uA

Pixel Spacing: 25 um

Analytical Time: 755 mins

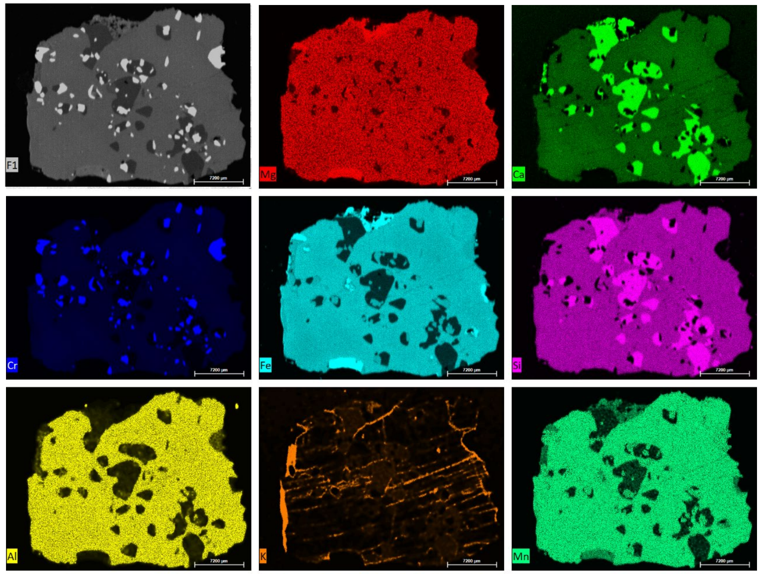


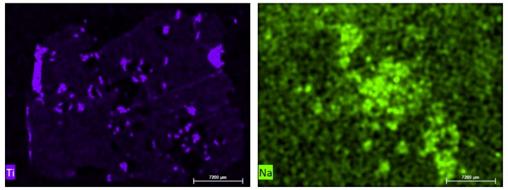
Top: Elemental Maps; Bottom Left: Mixed Elemental Map; Bottom, Right: X-Ray Intensity Map.



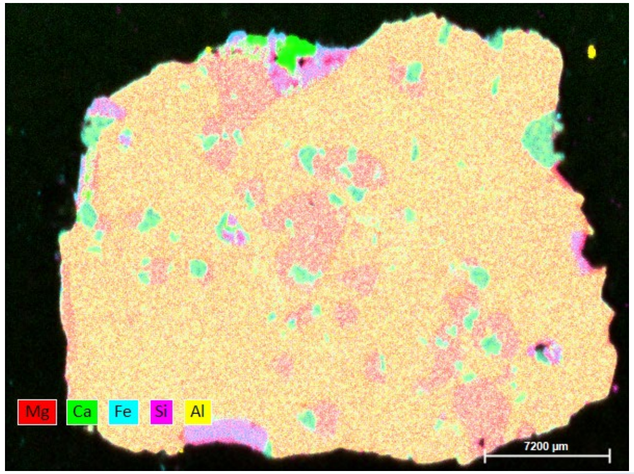
SEM-XRF (XTrace): Geology

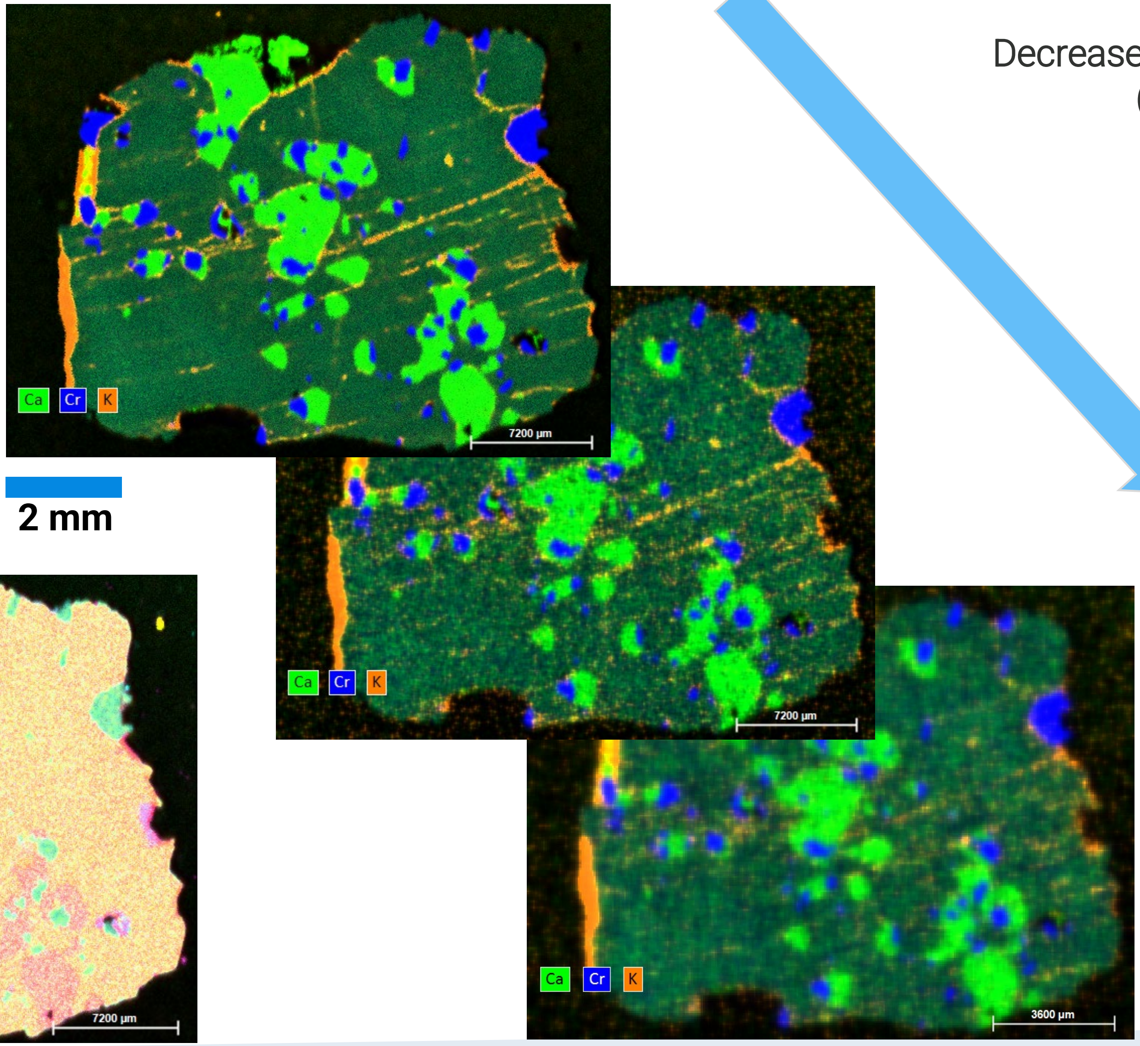
SEM-XRF: Hypermap Results
Analytical Parameters





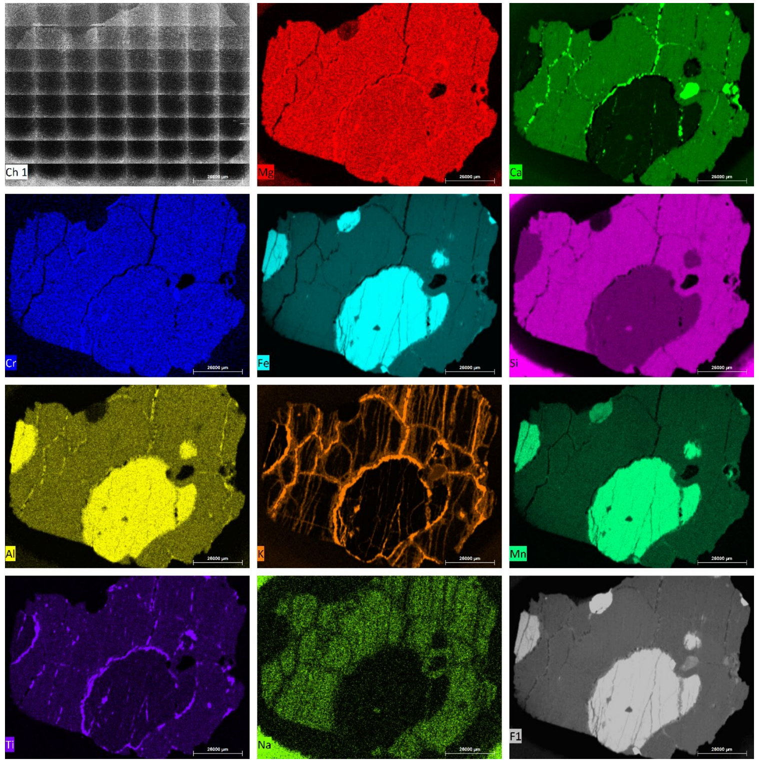
Mantle Peridotite:
Garnet
Chromite
Clinopyroxene
Olivine





Decreased Analytical Time :
(minutes)
577
23
11

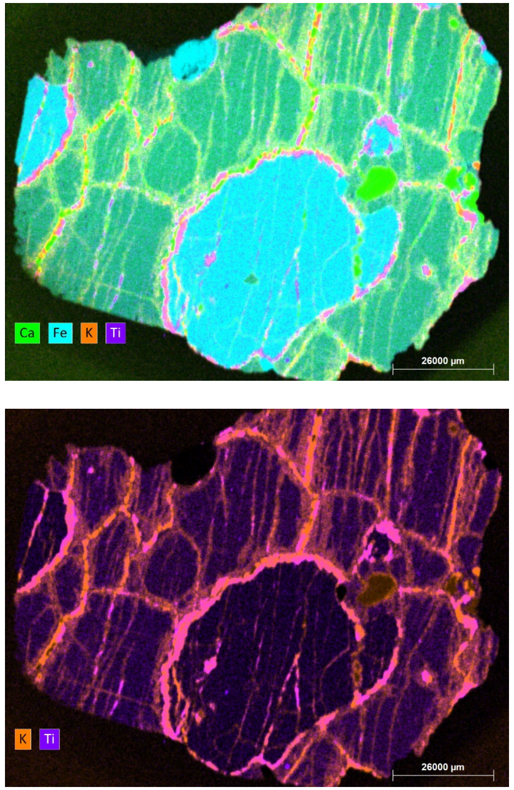
SEM-XRF-EDS: Hypermap Results
Analytical Parameters



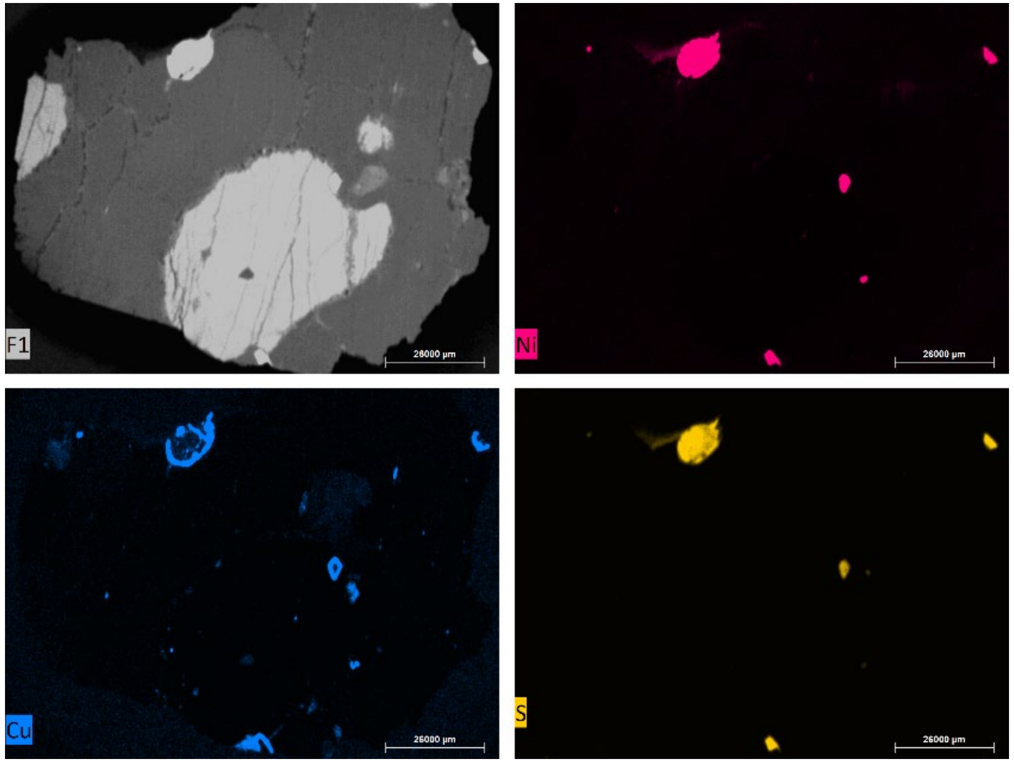
Mantle Eclogite:

Clinopyroxene

Garnet



Metasomatic Interaction



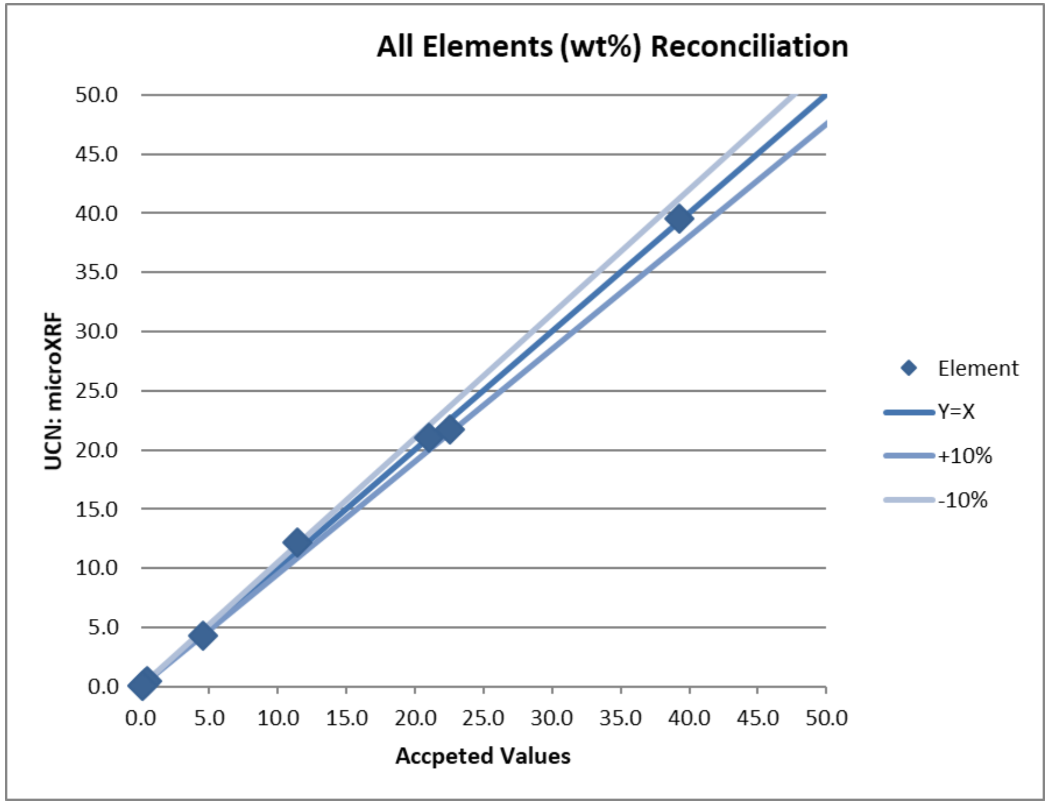
2 mm

Trace Phases

Quantitative Microanalysis with SEM-XRF
Point Analysis - major elements

Comparison XRF-EDS spectra for the same point: analytical precision

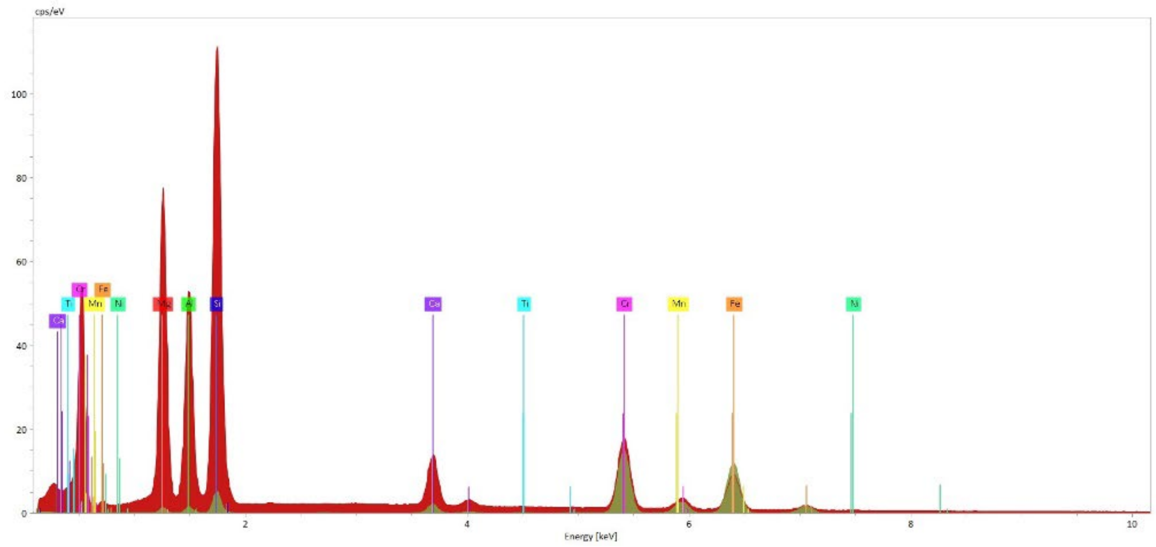
Element	Unit	EPMA Values	XRF-EDS Values	Std. Dev.	Maximum	Minimum	Range
SiO2	(%)	39.28	39.22	0.18	39.48	38.89	0.58
TiO2	(%)	0.28	0.30	0.02	0.33	0.26	0.07
Al2O3	(%)	22.51	21.68	0.31	22.21	21.23	0.98
Cr2O3	(%)	0.12	0.11	0.01	0.11	0.09	0.02
FeO	(%)	21.00	21.41	0.20	21.85	21.18	0.67
MnO	(%)	0.47	0.47	0.01	0.50	0.46	0.04
MgO	(%)	11.44	12.22	0.32	12.62	11.57	1.05
CaO	(%)	4.57	4.36	0.05	4.45	4.29	0.16

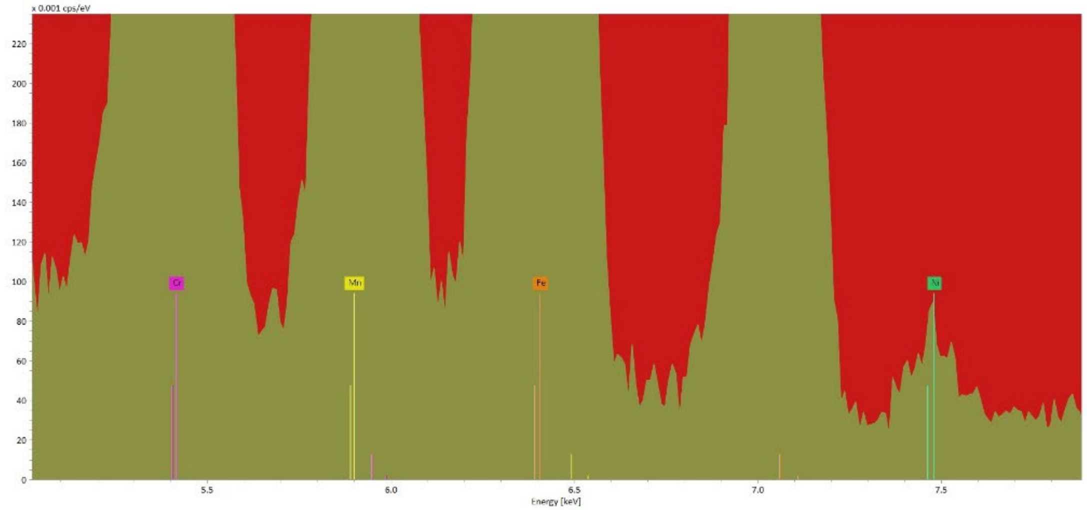


Quantitative Microanalysis with SEM-XRF
Point Analysis – major and trace elements

Trace elements possible with Micro-XRF

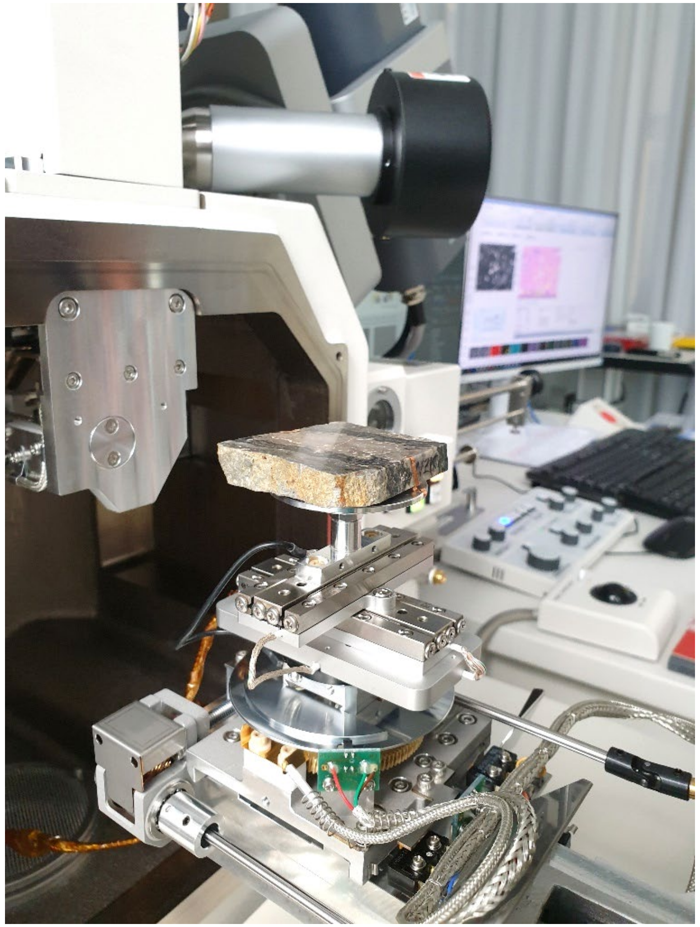
Element	Unit	90 sec	120 sec	180 sec
SiO2	(%)	39.04	39.17	39.20
TiO2	(%)	0.28	0.28	0.29
Al2O3	(%)	22.23	21.97	21.87
Cr2O3	(%)	0.11	0.11	0.11
FeO	(%)	21.16	21.05	21.02
MnO	(%)	0.49	0.48	0.48
MgO	(%)	12.29	12.57	12.63
CaO	(%)	4.35	4.31	4.33
Ni	(ppm)	26	18	28
Cu	(ppm)	3	5	4
Zn	(ppm)	173	143	150
Ga	(ppm)	7	0	28
Ge	(ppm)	17	22	17
As	(ppm)	28	28	28
Rb	(ppm)	41	69	59
Sr	(ppm)	28	0	28
Y	(ppm)	2	28	3
Zr	(ppm)	157	157	171
Nb	(ppm)	1	28	0



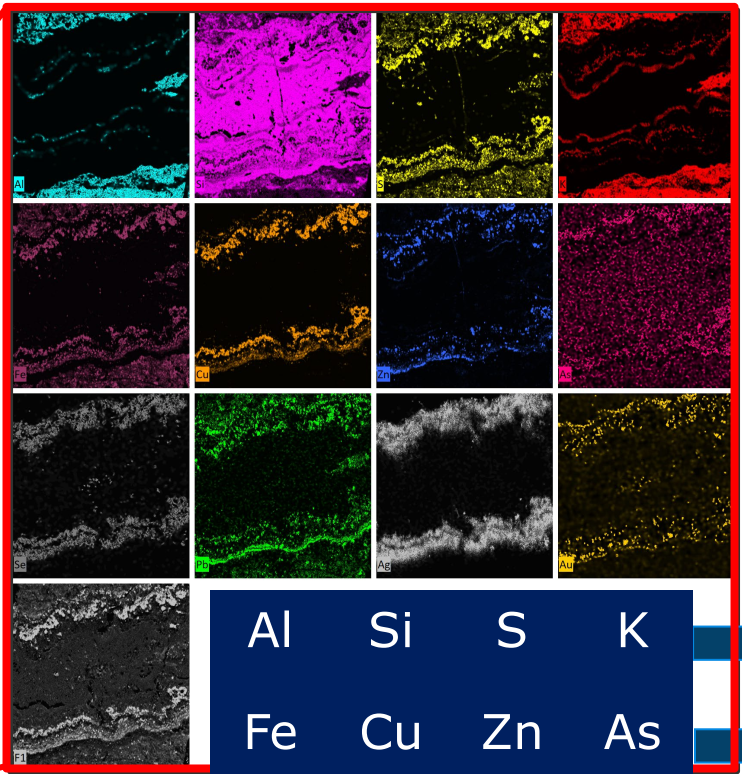


Case Study 1: Gold (Au)
Epithermal Gold

Mineral	Formula
Native Gold	Au
Native Silver	Ag
Sulphides	
Pyrite	FeS_2
Chalcopyrite	$CuFeS_2$
Galena	PbS
Sphalerite	ZnS
Gangue Mineralogy	
Quartz	SiO_2
Adularia	$KAlSi_3O_8$



SEM Micro-XRF Analysis: Epithermal Au
Large Area Mapping



Beam:	X-ray
High Voltage:	50 kV
Anode Current:	600 µA
Analytical Spacing:	100 µm
Dwell Time:	64000 µs (64 ms)
Analytical Area:	4.5 x 4.5 cm
Total Analytical Time:	188 minutes
Spot Size:	25 µm
Interaction Depth:	10 – 100 µm

Al	Si	S	K
Fe	Cu	Zn	As
Se	Pb	Ag	Au

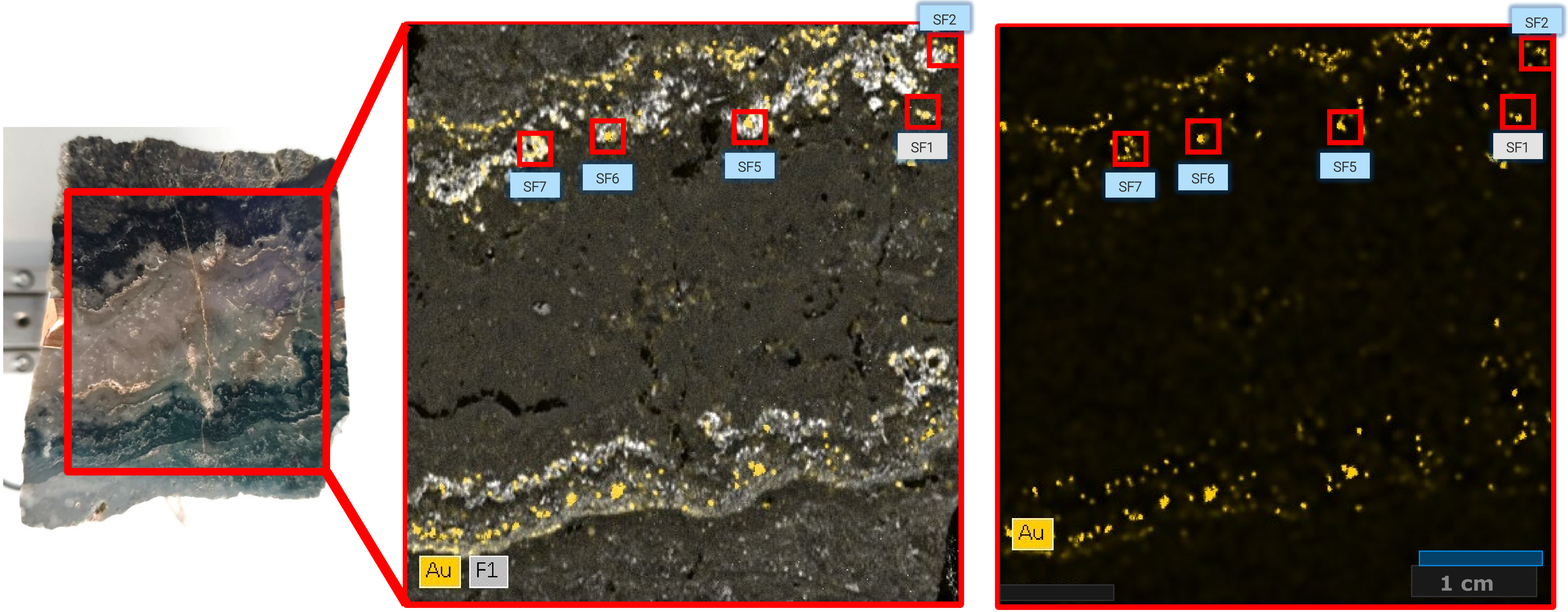
Host Rock Elements: Al, Si, K

Mineralisation: S, Fe, Cu, Zn, As

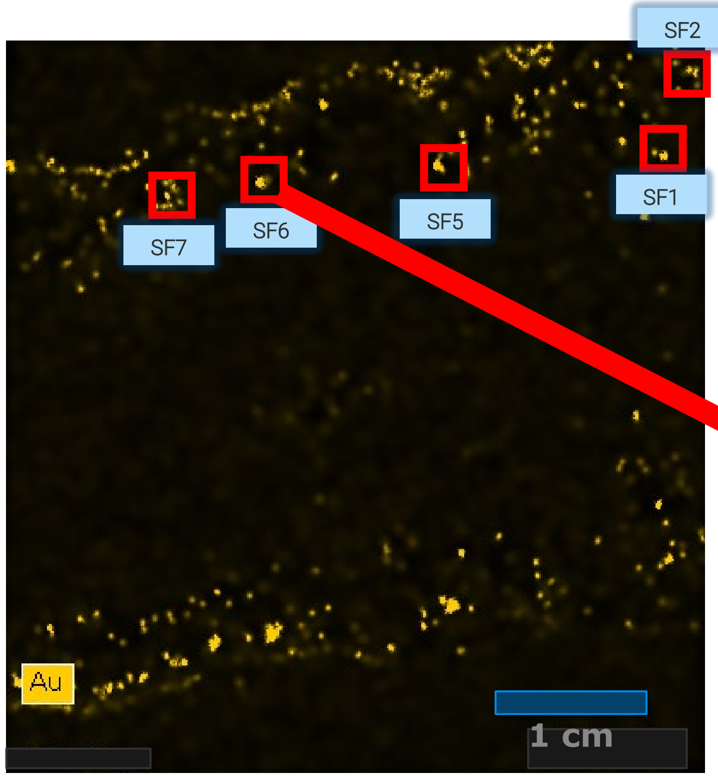
Economic Mineralisation: Au, Ag, Se

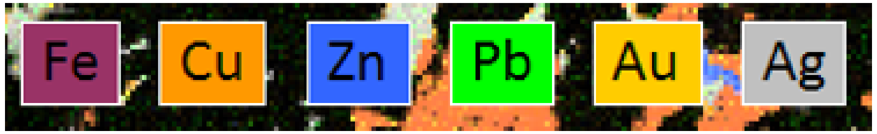
Epithermal Gold-bearing rock sample from Karangahake, New Zealand

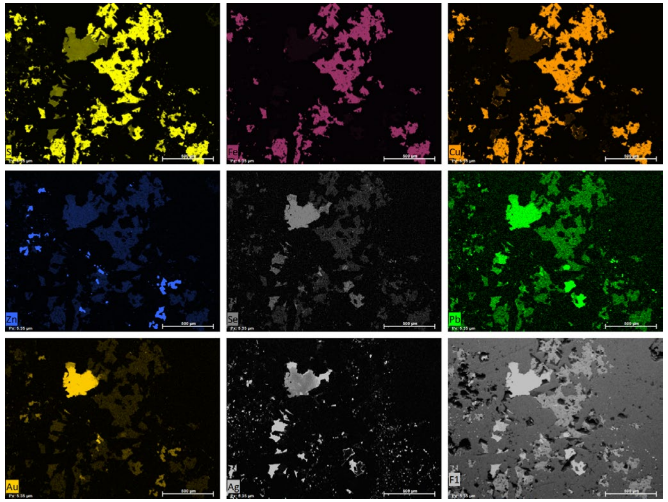
Micro-XRF on SEM (X-ray Beam)
Identifying Gold (Au) in the Sample

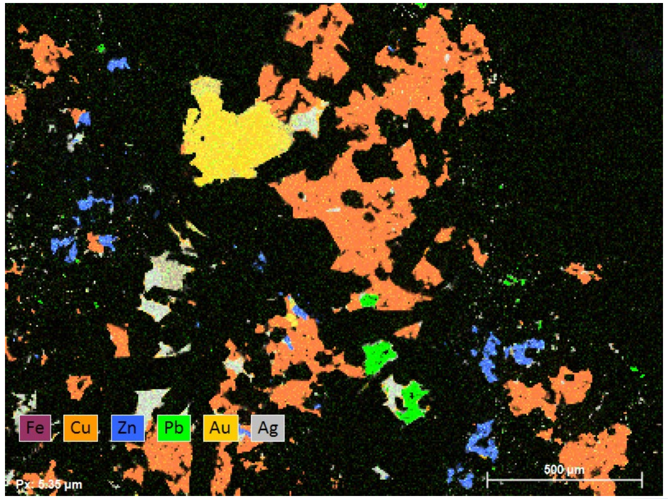


SEM-EDS (e-beam)
Identifying Gold (Au) in the Sample









Single Field 6

Large Gold Grain;

Associated with Silver

Other mineralization:

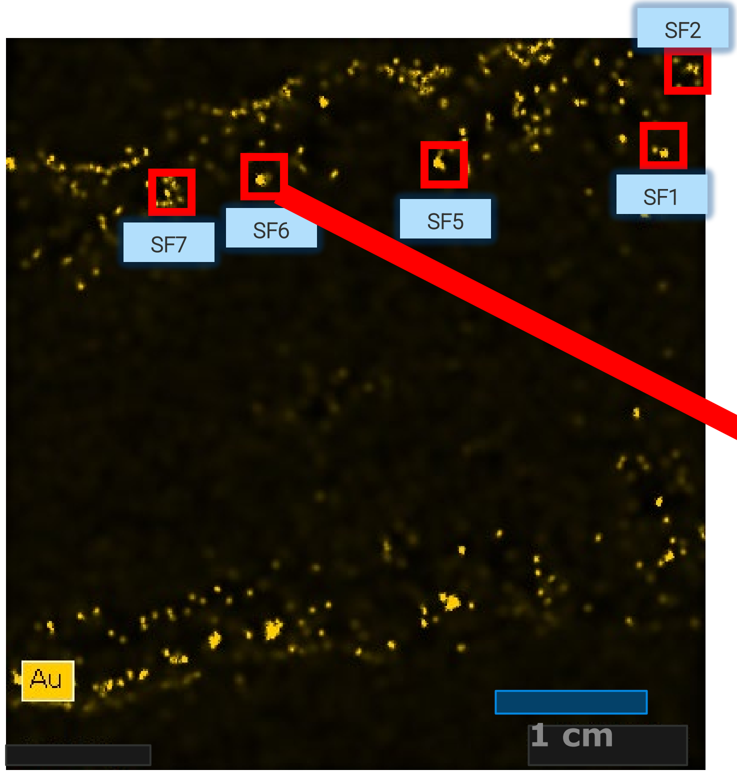
Pyrite (FeS2),

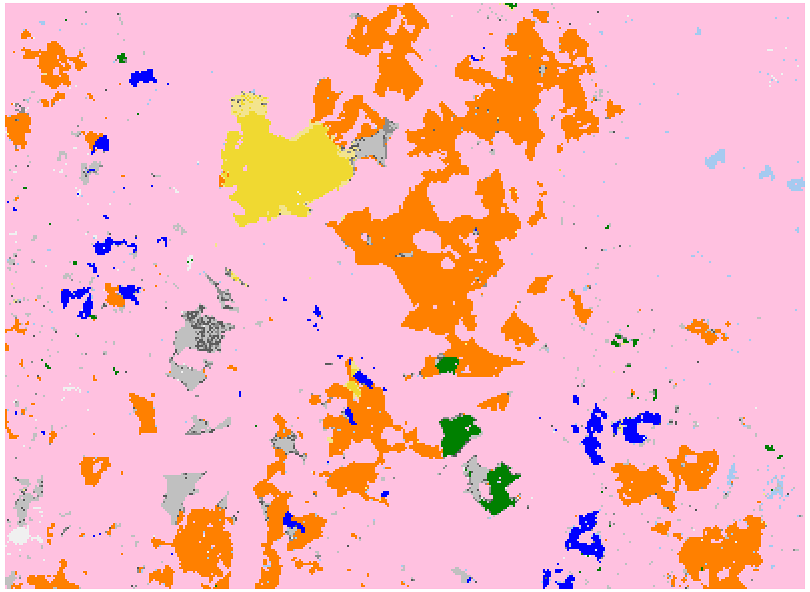
Chalcopyrite (CuFeS2),

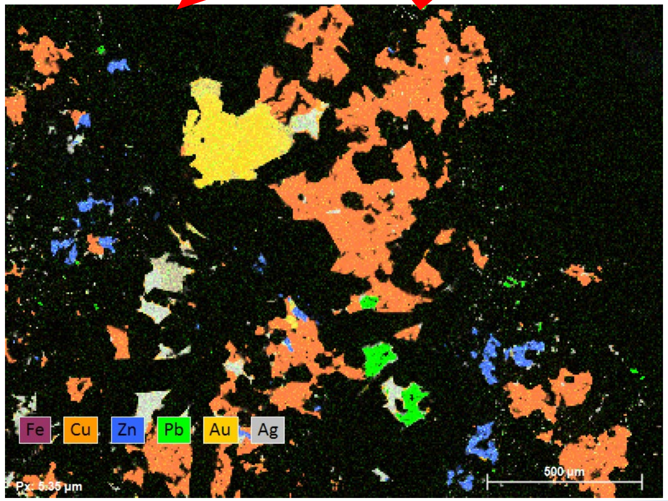
Galena (PbS),

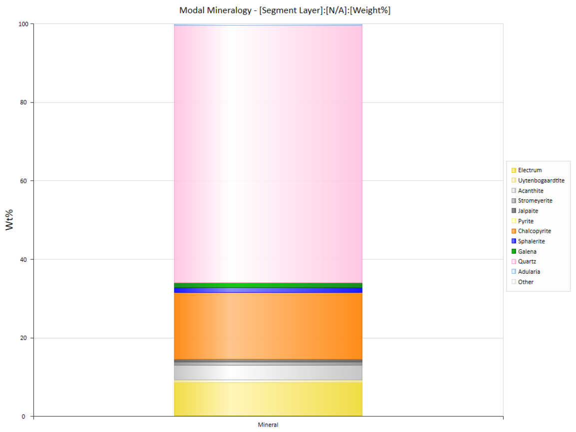
Sphalerite (ZnS)

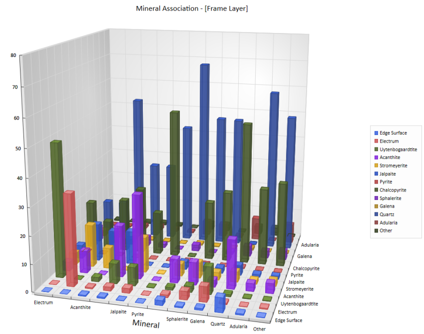
SEM-EDS (e-beam) and AMICS
Area: SF6

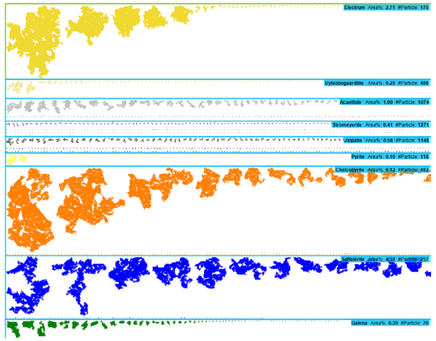












SEM-XRF (XTrace): Forensics

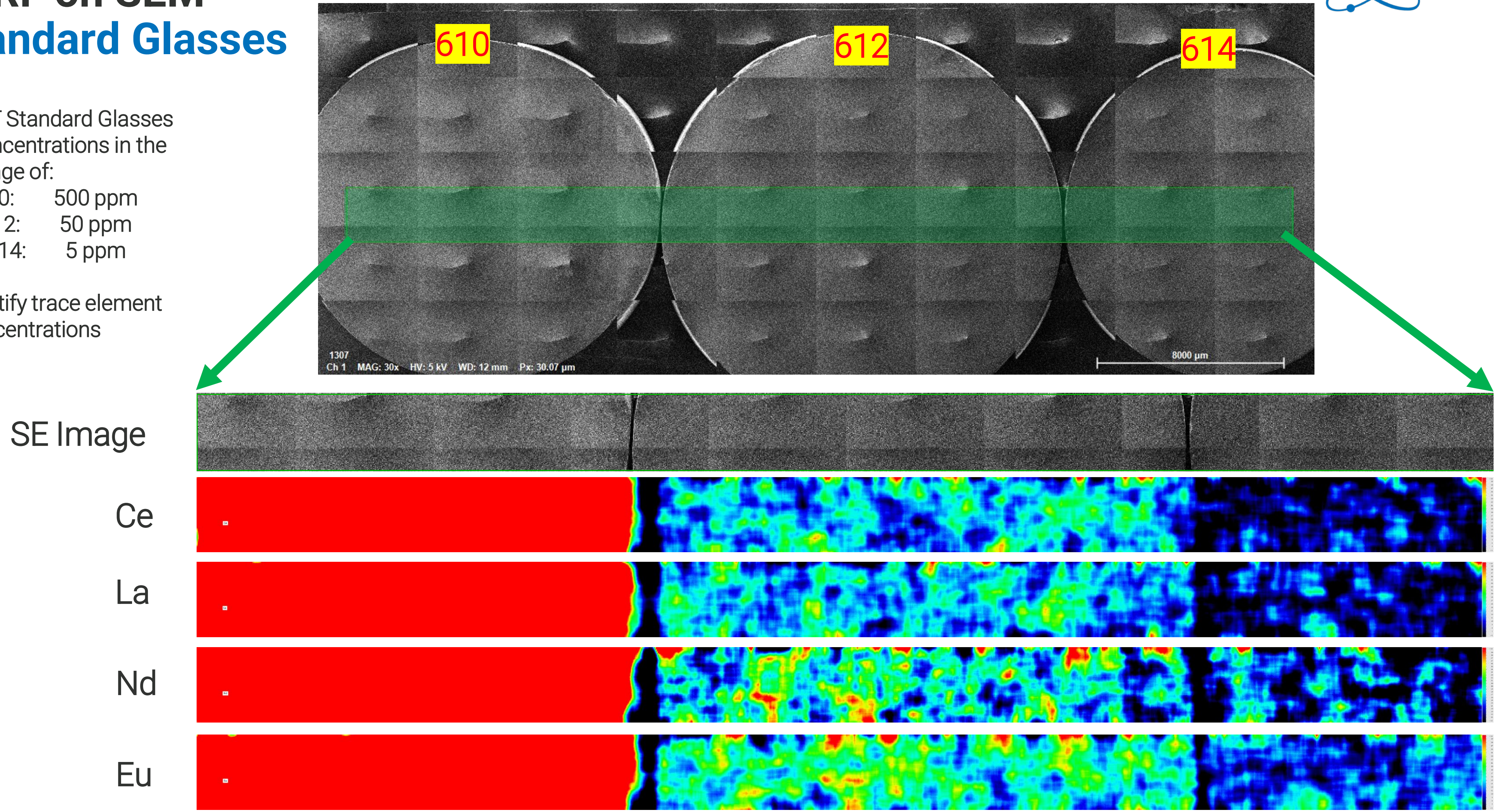
Micro-XRF on SEM
NIST Standard Glasses

Analysis of NIST Standard Glasses with dopped concentrations in the approximate range of:

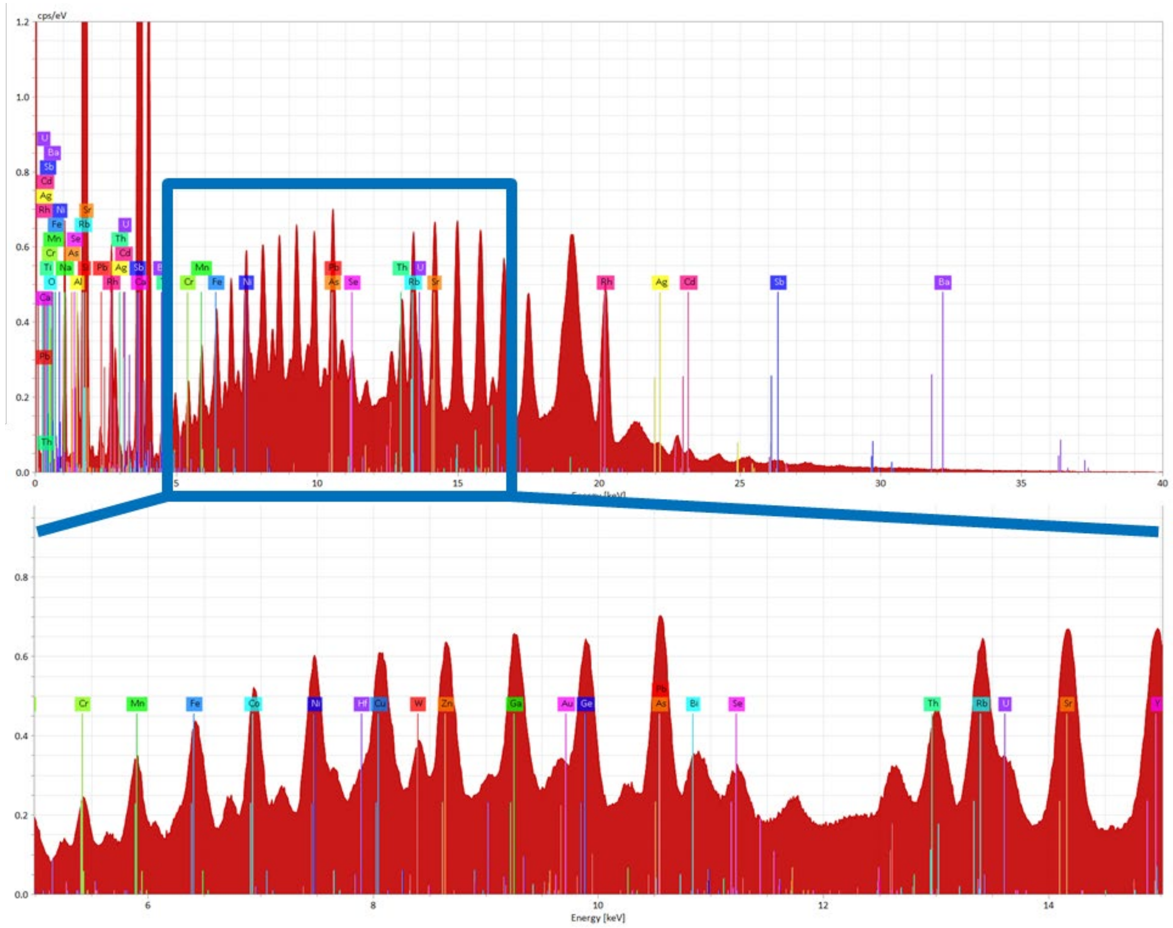
NIST 610:	500 ppm
NIST 612:	50 ppm
NIST 614:	5 ppm

Easily identify trace element concentrations

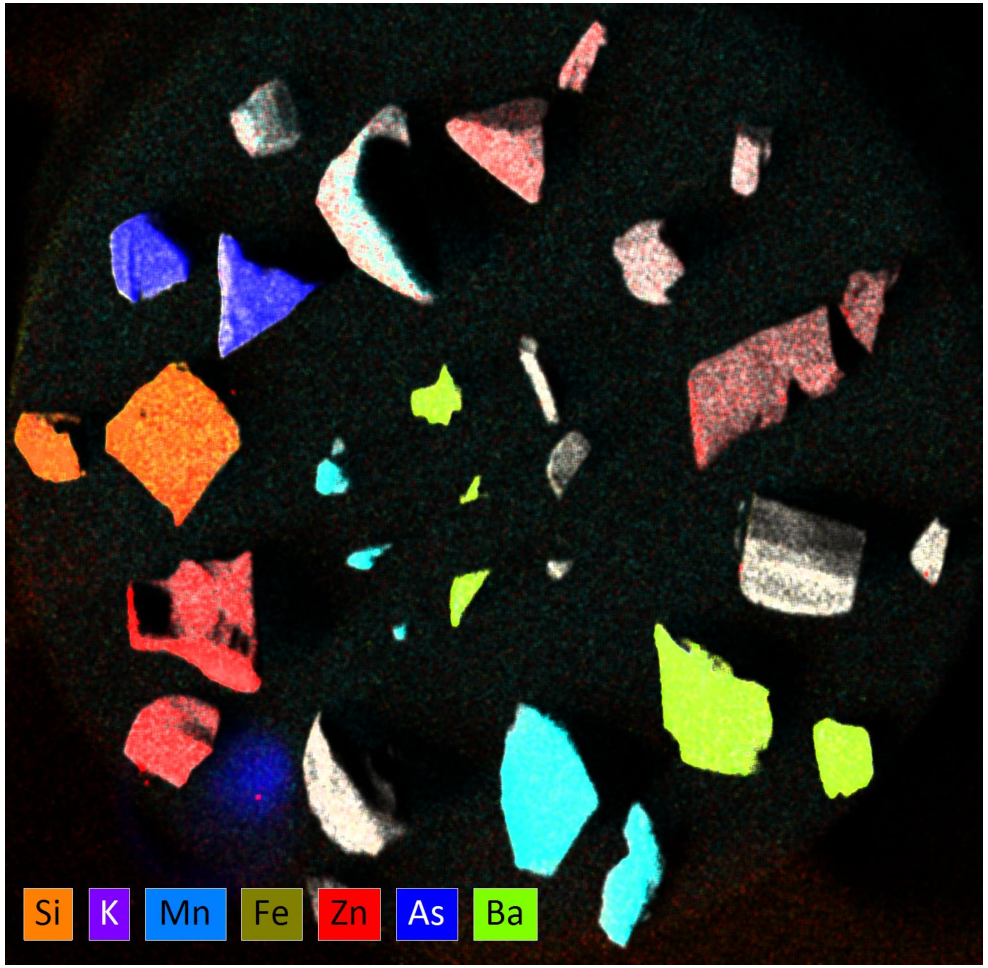
NIST Glass Standards



Micro-XRF on SEM
Applications: Trace Elements



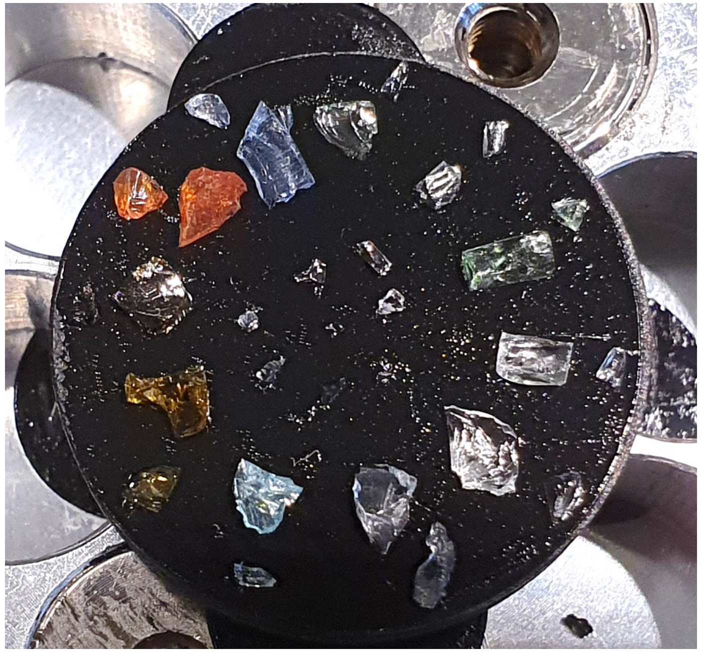
Glass analysis: NIST 610

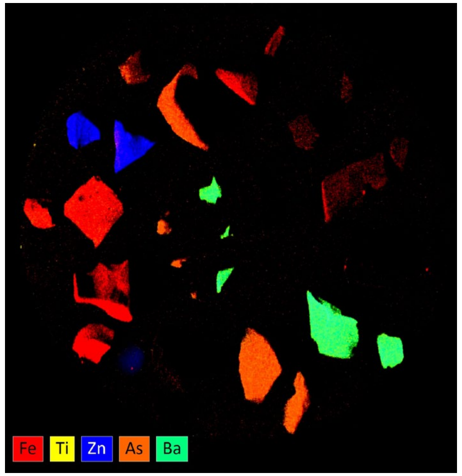


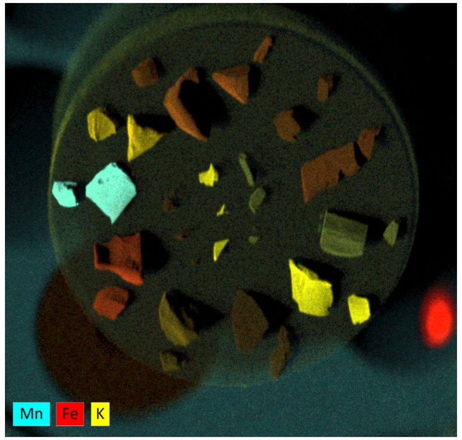
Forensics: Glass fragment analysis

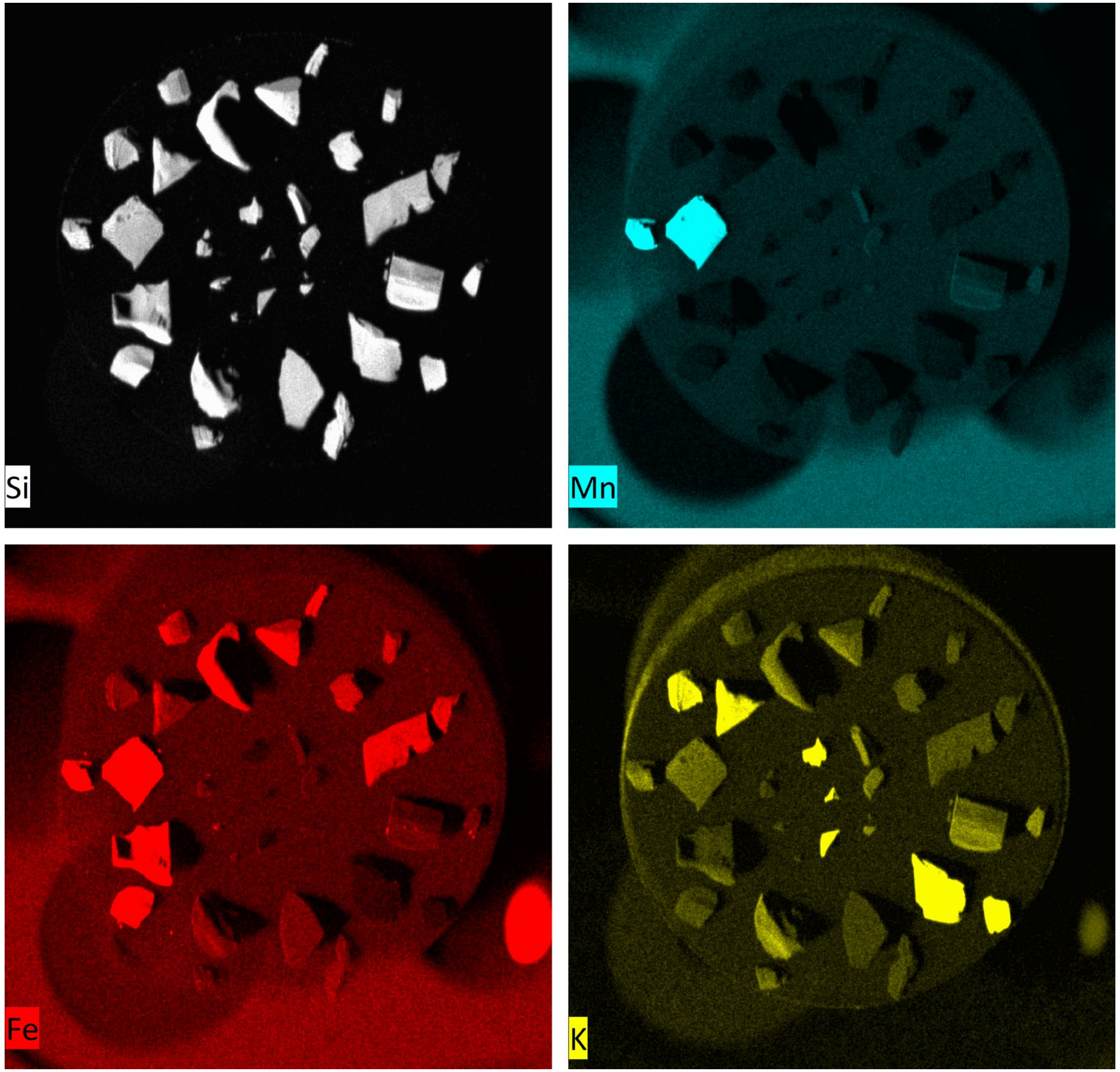
Micro-XRF on SEM
Applications: Analysis of Glass

Glasses mounted for analysis





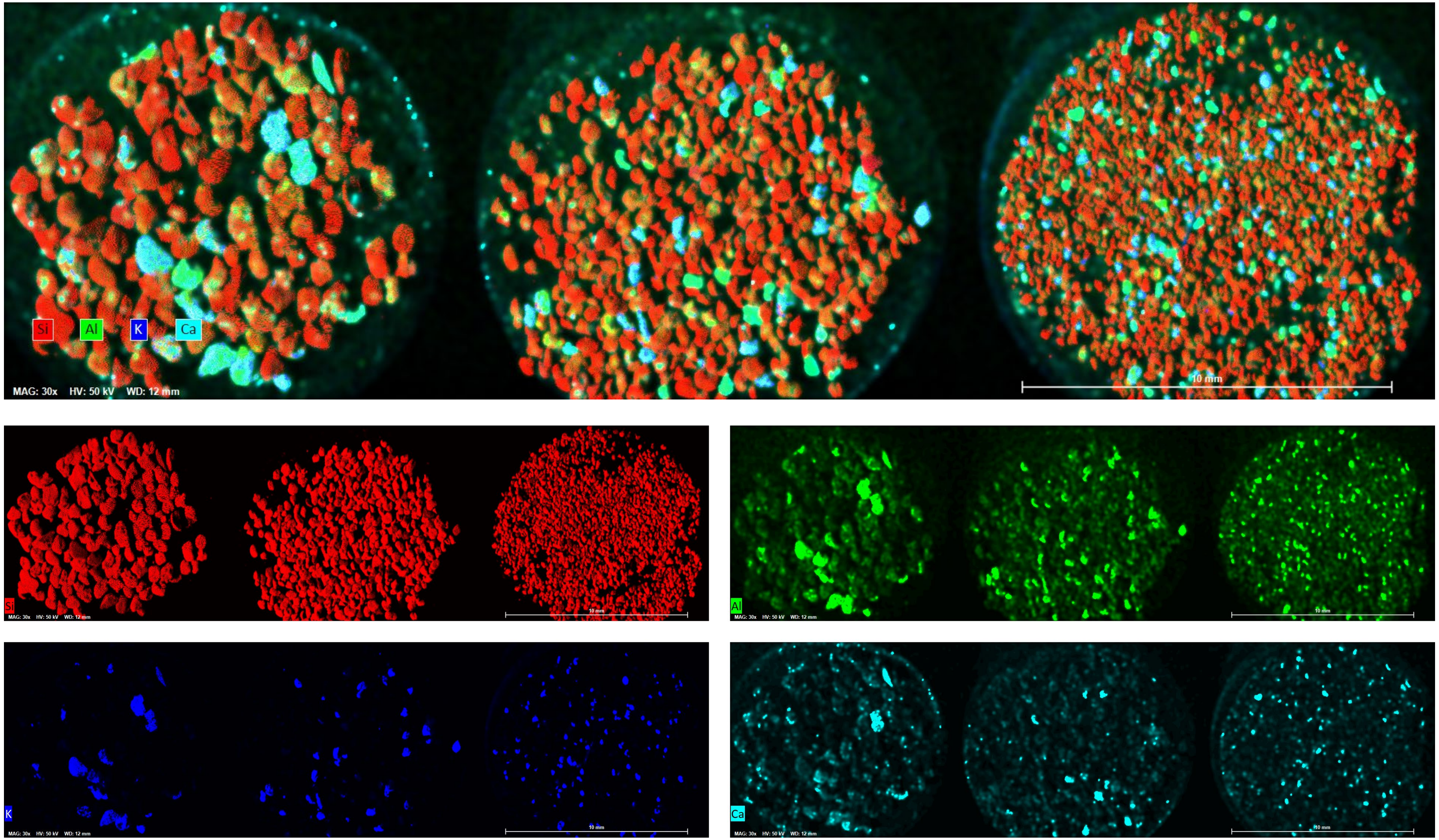




SEM-XRF:
Analysis of Beach Sands

Analysis of Beach Sand

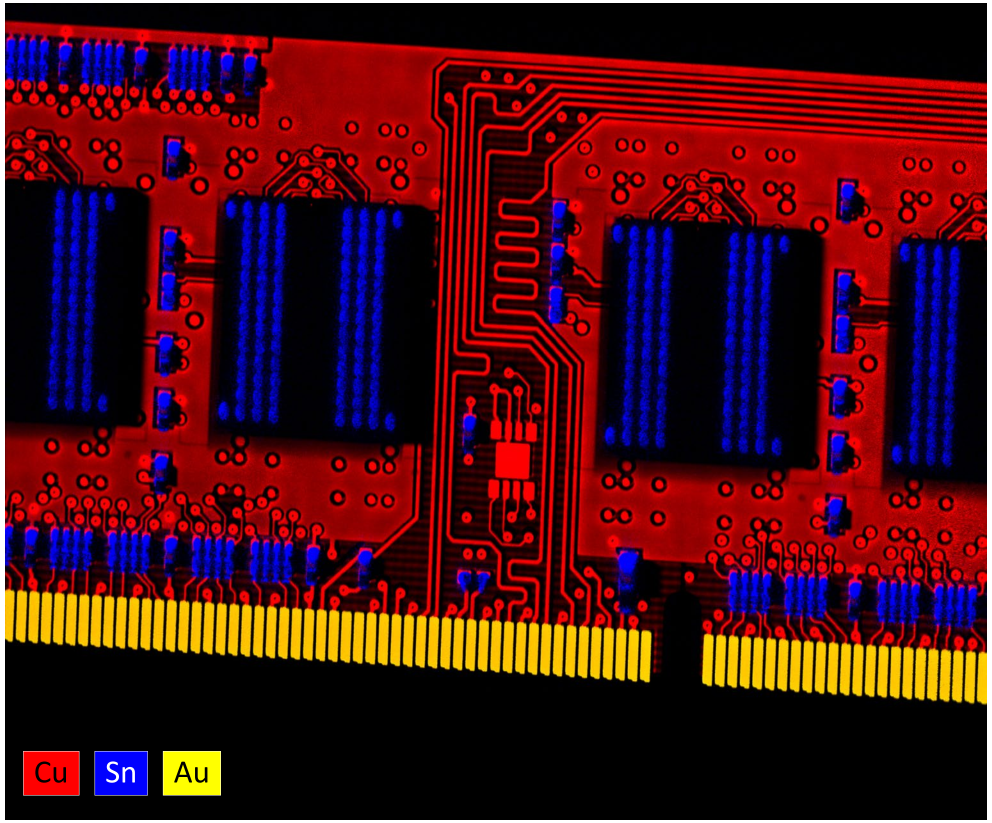
Loose Grains
Various Size Fractions
Uncoated
Large Area
High Speed Stage Movement



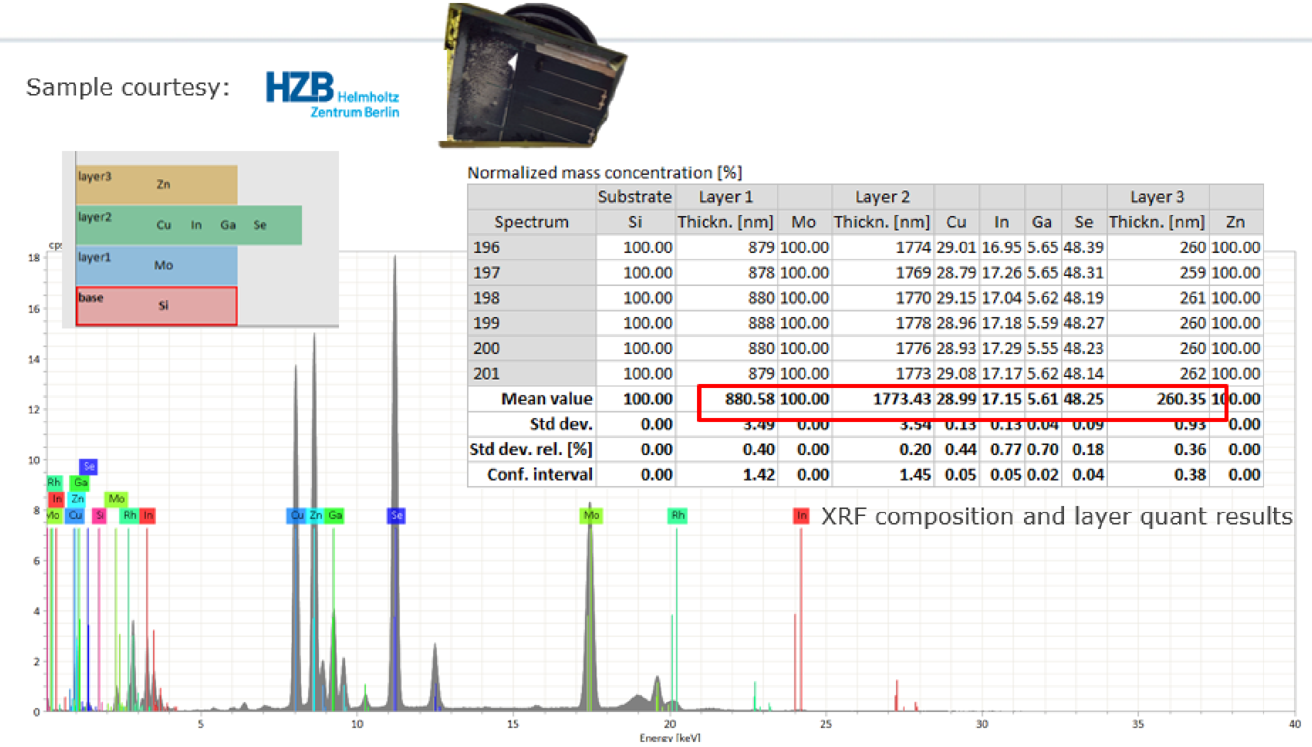
SEM-XRF (XTrace):
Electronics and Semiconductor Industry

Micro-XRF on SEM

Applications: Electronics and Semiconductors (Layer Analysis)



Electronics: Failure analysis on PCB

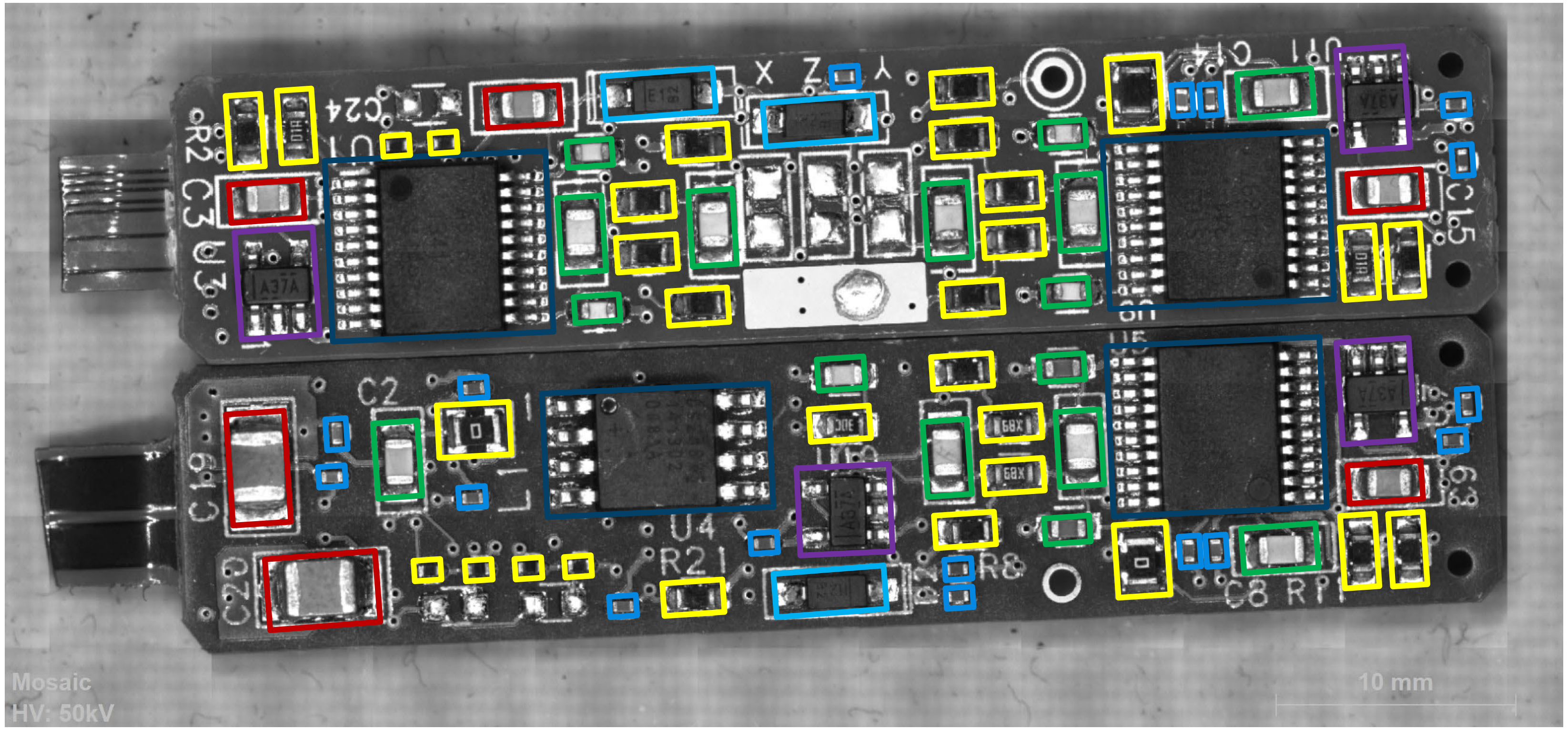


Normalized mass concentration [%]

	Substrate	Layer 1		Layer 2					Layer 3	
Spectrum	Si	Thickn. [nm]	Mo	Thickn. [nm]	Cu	In	Ga	Se	Thickn. [nm]	Zn
196	100.00	879	100.00	1774	29.01	16.95	5.65	48.39	260	100.00
197	100.00	878	100.00	1769	28.79	17.26	5.65	48.31	259	100.00
198	100.00	880	100.00	1770	29.15	17.04	5.62	48.19	261	100.00
199	100.00	888	100.00	1778	28.96	17.18	5.59	48.27	260	100.00
200	100.00	880	100.00	1776	28.93	17.29	5.55	48.23	260	100.00
201	100.00	879	100.00	1773	29.08	17.17	5.62	48.14	262	100.00
Mean value	**100.00**	**880.58**	**100.00**	**1773.43**	**28.99**	**17.15**	**5.61**	**48.25**	**260.35**	**100.00**
Std dev.	**0.00**	**3.49**	**0.00**	**3.54**	**0.13**	**0.13**	**0.04**	**0.09**	**0.93**	**0.00**
Std dev. rel. [%]	**0.00**	**0.40**	**0.00**	**0.20**	**0.44**	**0.77**	**0.70**	**0.18**	**0.36**	**0.00**
Conf. interval	**0.00**	**1.42**	**0.00**	**1.45**	**0.05**	**0.05**	**0.02**	**0.04**	**0.38**	**0.00**

Electronic & Semiconductors: Thin film analysis on various layer structures (solar cells, electronic contacts etc.)

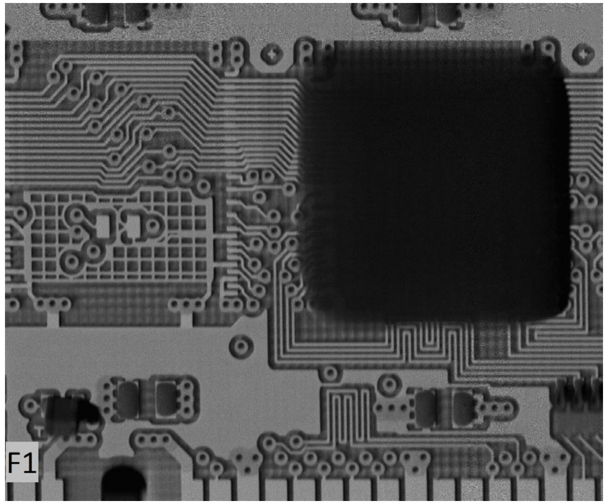
SEM-XRF Analysis of Rare Earth Elements (REE´s): Applications – Electronics

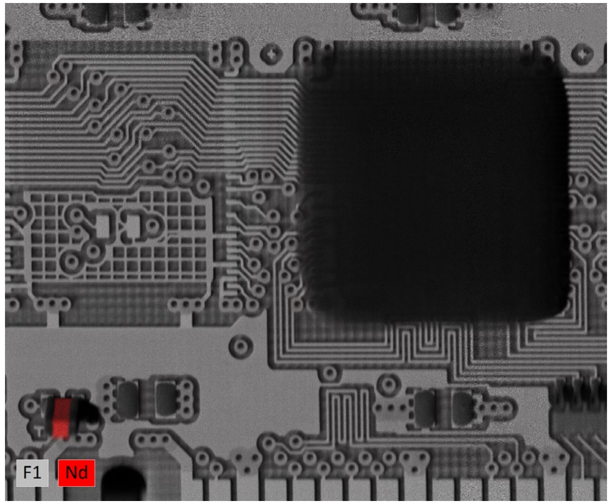


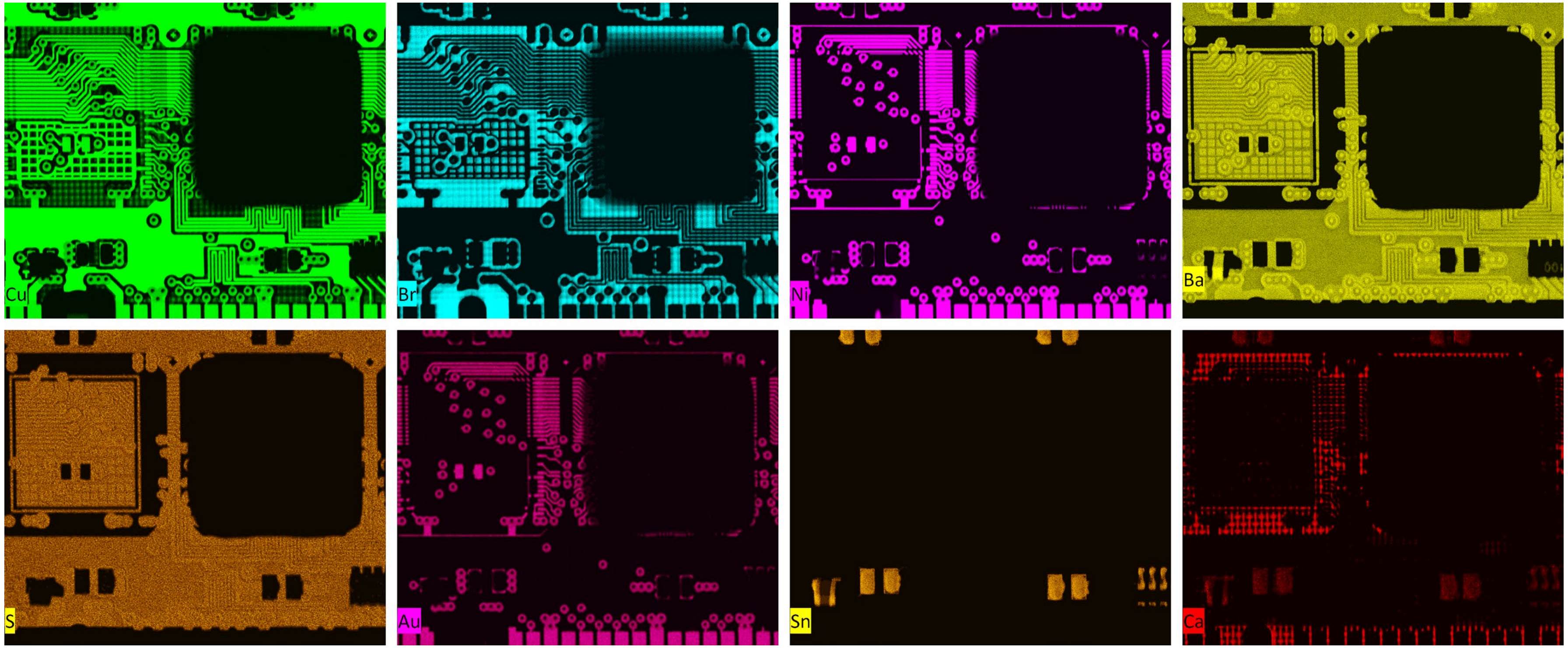
Diodes | Integrated circuit | Small IC | White Capacitor | Resistors | Small EC | Brown Capacitor

Image courtesy of Benjamin Monneron-Enaud, TU Bergakademie Freiberg, Germany.

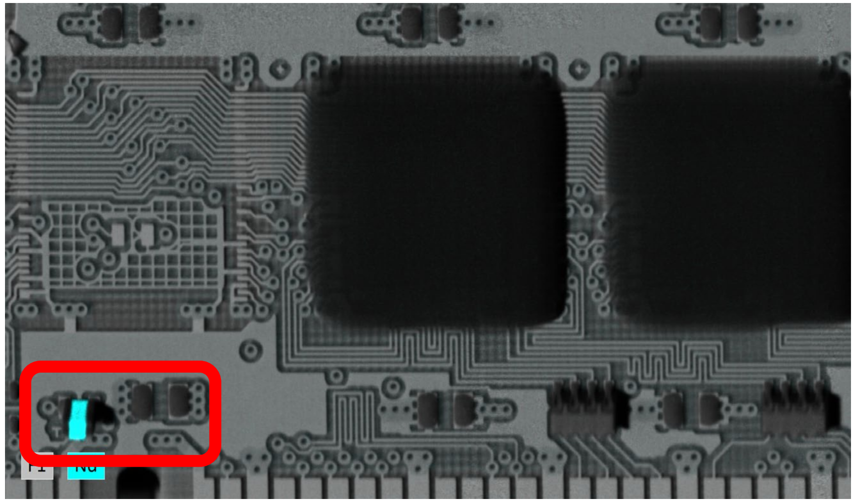
SEM-XRF Analysis of Rare Earth Elements (REE´s):
Applications – Electronics

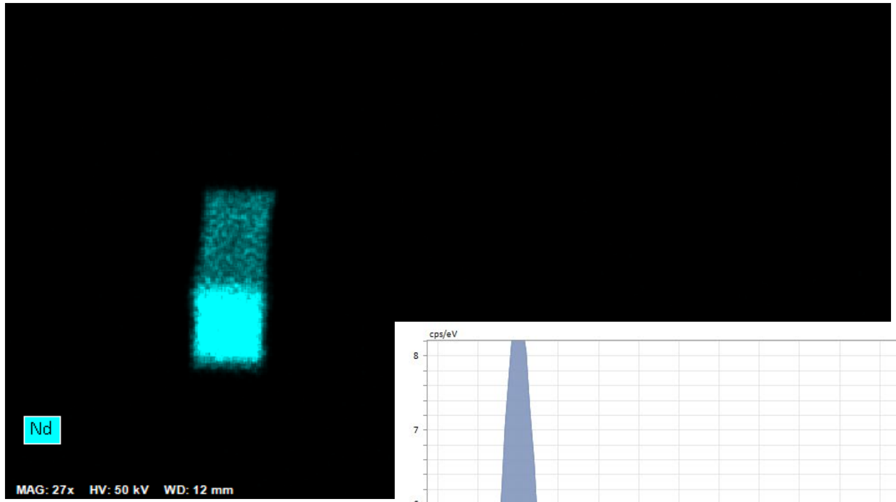


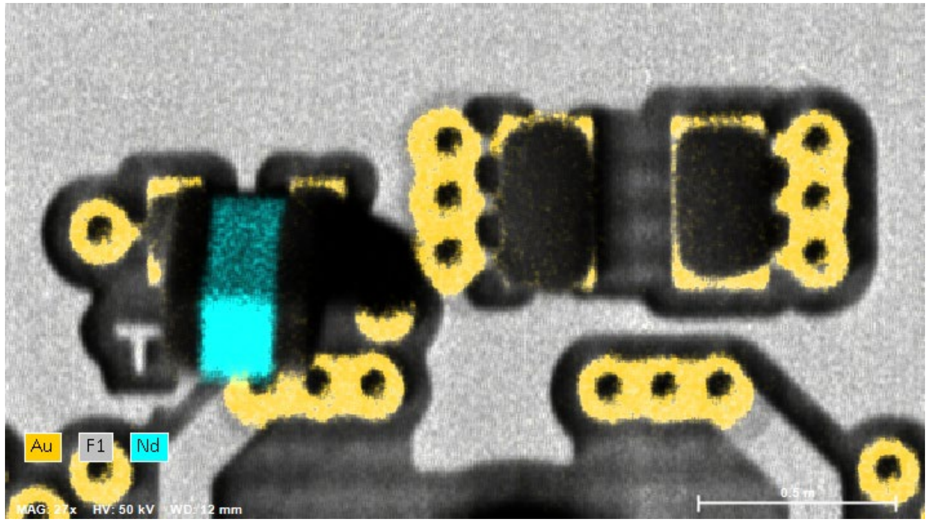


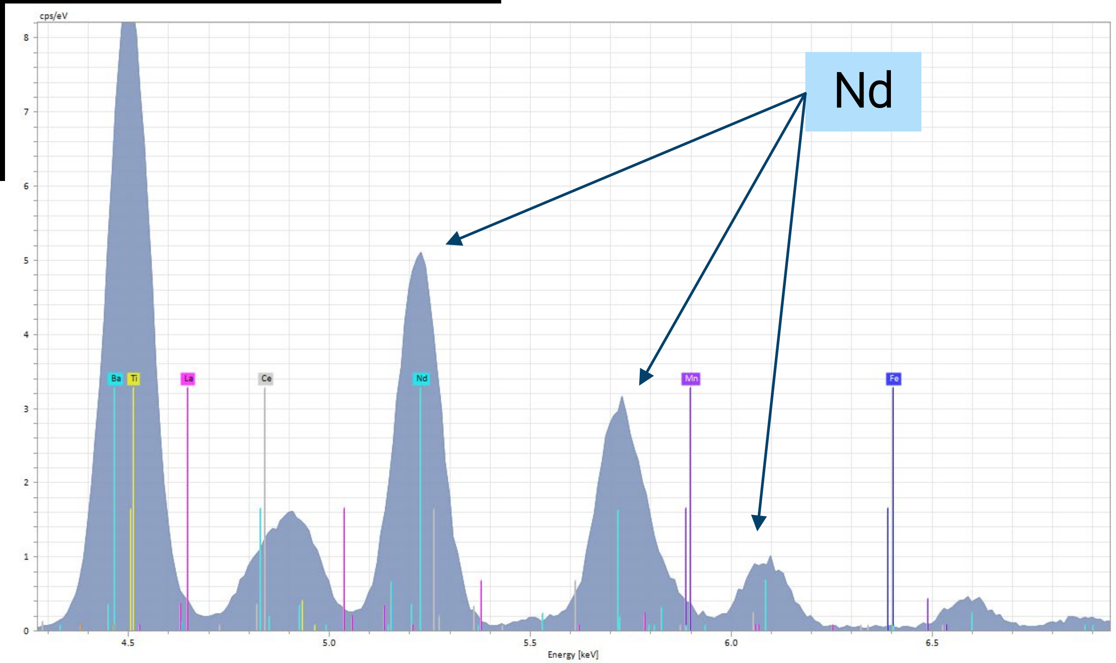


REEs Example:
Applications – Electronics









SEM-XRF (XTrace): Summary and Conclusions

Summary and Conclusions: Micro-XRF on SEM

2 Excitation Sources:

Electron Beam (e-beam)

Micro-XRF (X-ray beam)

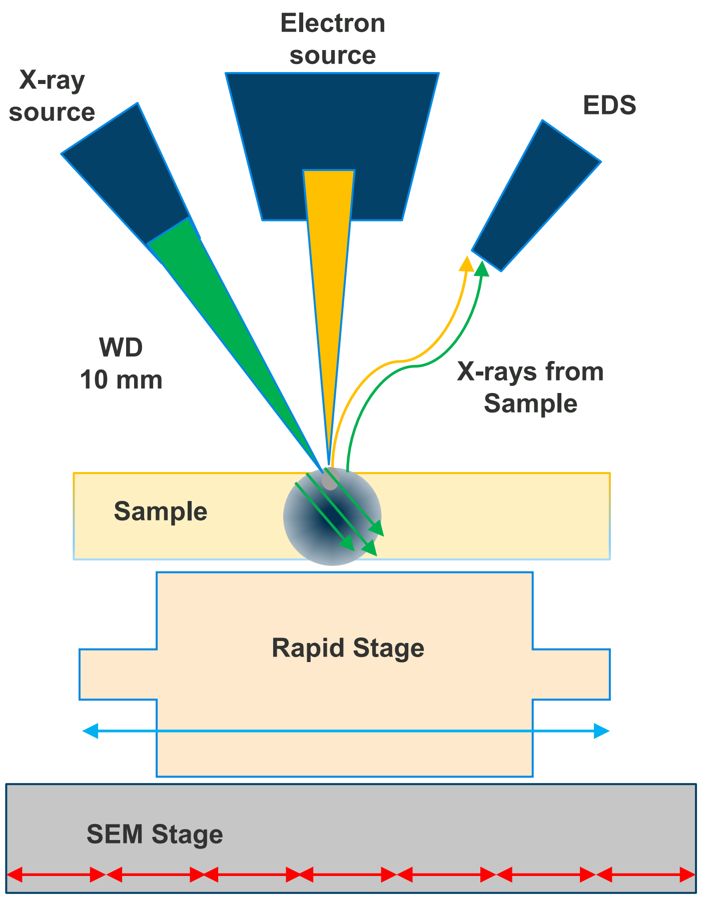
1 Detector:

Energy Dispersive Spectrometer (EDS)

2 Stages:

SEM Stage

Rapid Stage



Micro-XRF Benefits:

- Non-destructive analytical technique
- No charging effects
- Minimal Sample Preparation Required
- Lower detection limits (down to 5 ppm)
- High Energy Lines Detection (Full Spectrum Range up to 40 keV)
- Ideal for Low kV or Beam sensitive samples
- Fast Large Area Mapping
- Micrometer scale measurement over cm

Workflow: Correlating Micro-XRF / e-beam / EDS / WDS analysis

X-ray beam (Micro-XRF):
Fast over large area
Sensitive for traces

E-beam (SEM-EDS):
Spatial resolution

E-beam (SEM-WDS):
Spectral resolution

Correlation:
Compile, process and interpret Hypermaps

Software:
Esprit (Elemental) and AMICS (Mineralogical)

Micro-XRF (M6 JETSTREAM, M4 TORNADO, SEM-XRF (XTRACE))
- Fast analysis over large area
- Confirm presence of elements of interest
- Identify areas for further analysis
- Store stage positions of those areas

SEM-EDS
- High spatial resolution
- Fast analysis over small area
- Identify elemental and mineralogical relationships and associations on the micro- nano- scale.

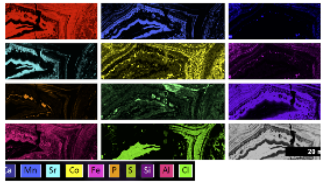
SEM-WDS
- High spatial resolution (similar to EDS)
- Resolution of peak overlaps
- Low detection limits
- High sensitivity for low X-ray energy range

Micro-XRF on SEM (XTrace): Further Information

LinkedIn Posts: #BrukerXTrace

https://www.bruker.com/

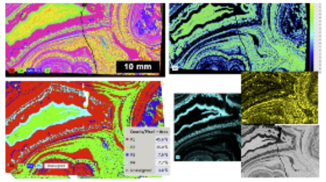
Search for: QUANTAX Micro-XRF



Large Area Mapping of Mineralogical Samples

The new Rapid Stage is specifically designed for SEMs to enable large area mapping over millimeter (mm) to centimeter (cm) scales. This will eliminate potential SEM X-ray intensity variation artifacts associated with low magnification mapping and thus enhance elemental and mineralogical information in a timeous manor that was previously not possible.

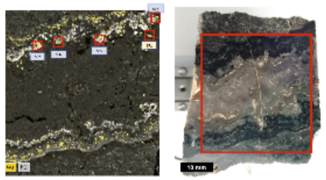
→ READ MORE



Elemental and Mineral distribution in Exotic-Cu Deposits

The ability to observe elemental changes within samples is important to understand geological processes and ore deposit genesis. The dual source system which incorporates a micro-XRF on a SEM enables elemental X-ray mapping over large areas, which shows major, minor and also trace elements on the ppm scale.

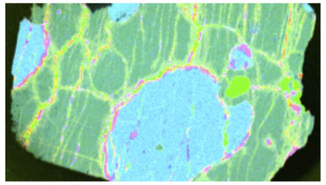
→ READ MORE



Dual Source Applications for Exploration and Mining: Au-bearing Epithermal Samples

The combination of micro-XRF with SEM enables the potential to analyze samples at multiple scales, from centimeters (cm) to millimeters (mm) to micrometers (µm) and below within a solitary system. Thus, by adding the micro-XRF to an SEM you convert your SEM to a dual source system, meaning that there are 2 excitations sources, the e-beam and photon beam. Either source can be used individually, or simultaneously, to generate sample X-rays that will be measured using the same EDS detector.

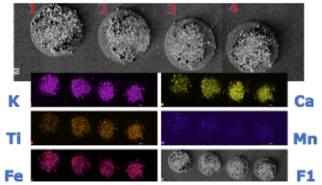
→ READ MORE



Mantle Petrology and the Source of Diamonds

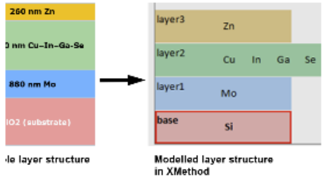
We present a SEM-XRF element map of a mantle garnet-spinel peridotite from the diamond-bearing Newlands kimberlite (South Africa, Kaapvaal Craton). The intensity of the various elements indicates certain minerals that are present in the sample.

→ READ MORE



Identification of Contaminants and Toxins in Soils

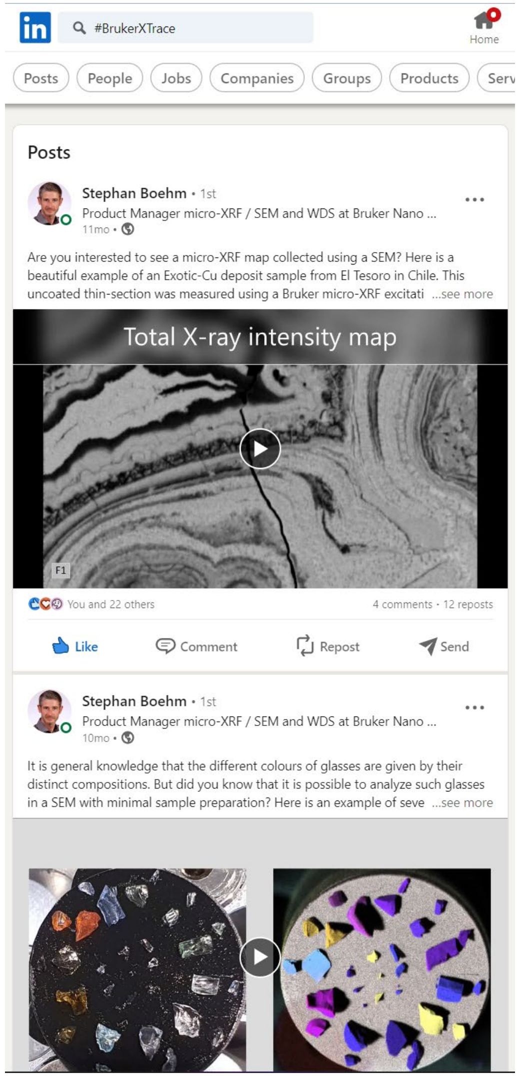
Large Area Mapping (Hypermaps) using SEM-XRF can be performed on samples with topography. That is, minimal sample preparation is required and the sample can be analyzed directly without any degradation. This is particularly relevant in the analysis of soils, where any form of sample preparation, such as mounting and polishing or carbon coating, may alter the specimen.



Thin Film Analysis with SEM micro-XRF

As X-rays may pass through matter, X-ray Fluorescence (XRF) allows the determination of layer thickness. Using micro-XRF on SEM, the layer analysis (thickness and composition) is rendered feasible with spatial resolution at the micrometer scale. Layer analysis is strongly based on quantification using atomic fundamental parameter (FP).

→ READ MORE

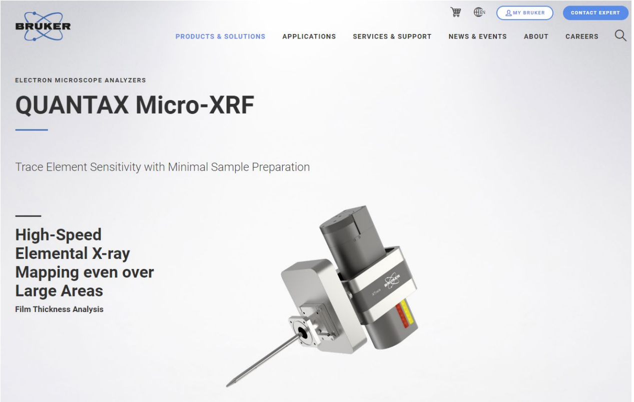


Micro-XRF General Information
Further Information

Web Site

https://www.bruker.com/

Search for:
QUANTAX Micro-XRF



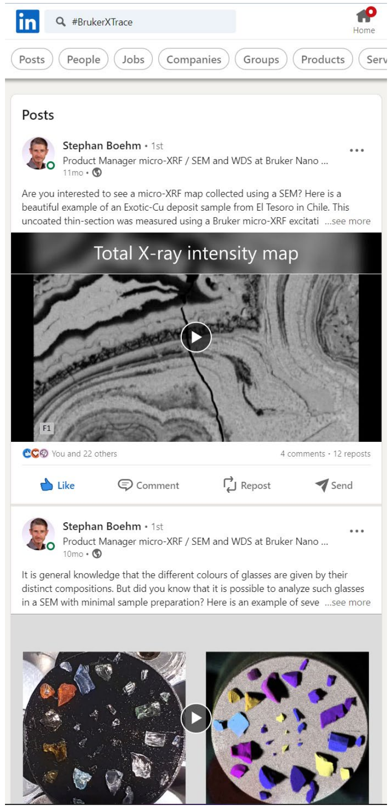
Upcoming Webinars:

Back To The Roots, Part V:
Advantages of standard-supported micro-XRF quantification: Where are we today in terms of performance of FP quantification?

Date: 02.05.2023 (10 am, 5 pm)

And a new SEM-XRF webinar in June

LinkedIn Posts: #BrukerXTrace



More Information

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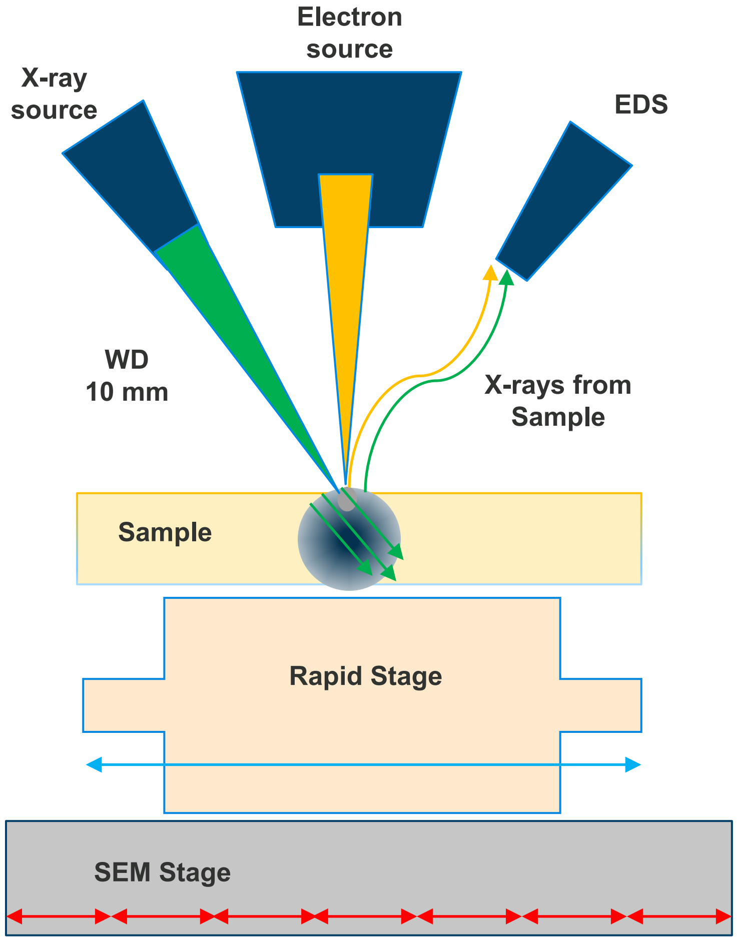
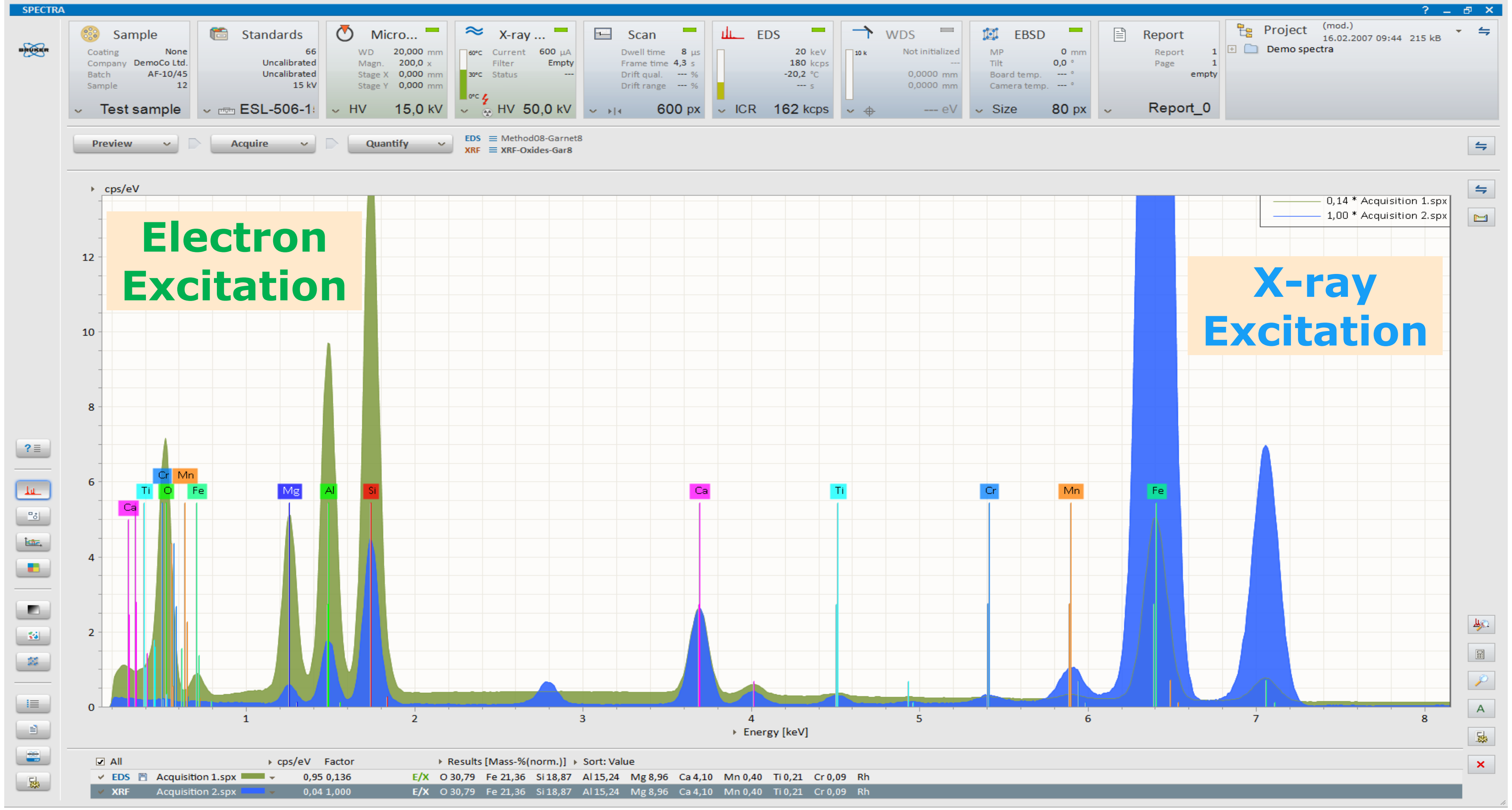
Innovation with Integrity

X-ray Fluorescence and Electron Excitation Analysis

- Excitation with either electrons or X-rays generate fluorescence radiation of the irradiated material.
- Detection is normally performed with energy dispersive spectrometers (EDS), independent of the excitation source. Signal collection and spectral presentation is identical, but quantification is different.
- Main differences:
  - Spot Size
  - Information depth
  - Elemental Range (Energy)
  - Limits of detection (Concentration)
  - Spectral Background
  - Sample Handling



Energy Dispersive Spectra
Comparison: Electron vs. X-ray Excitation

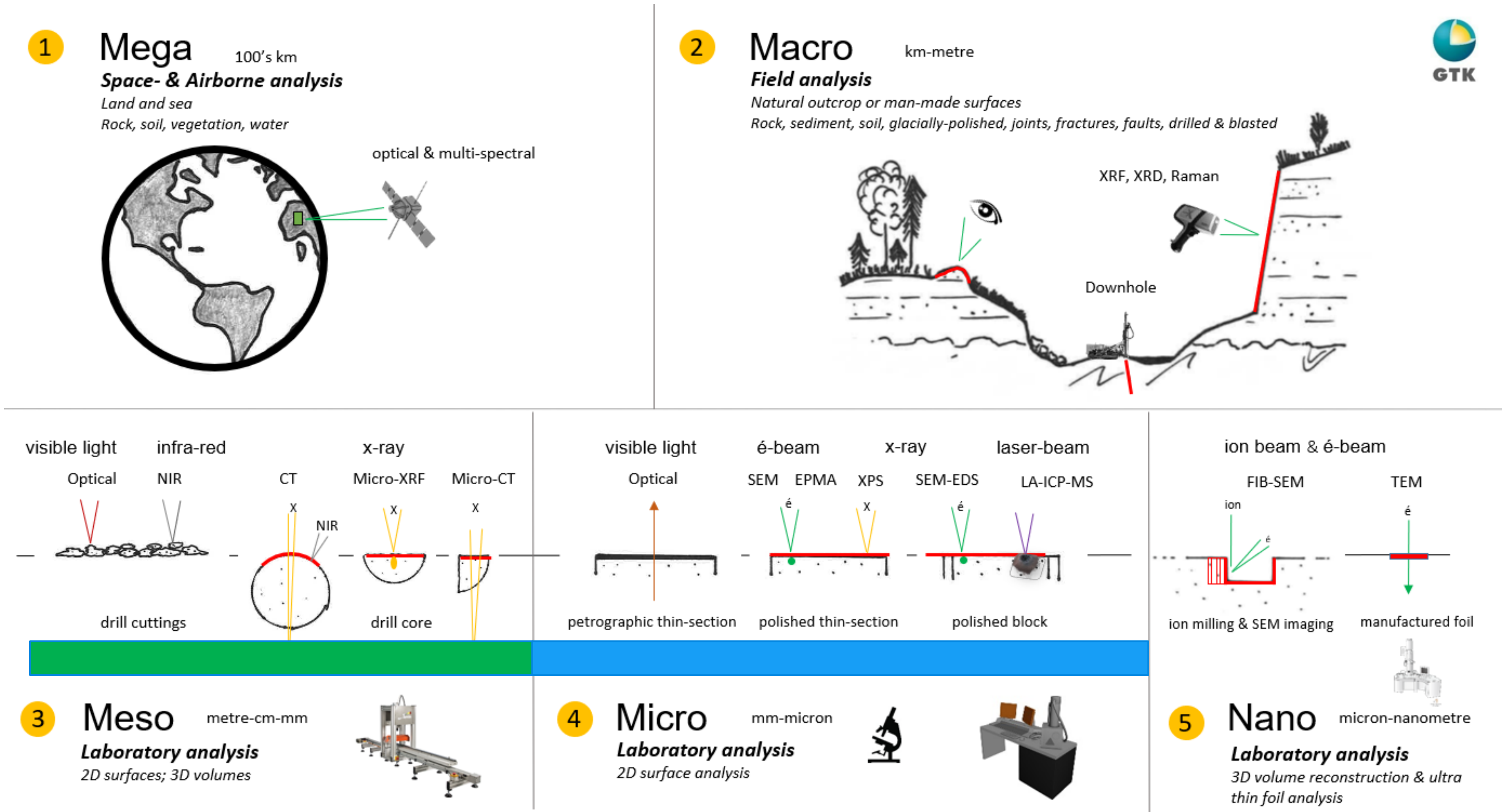


The garnet has:
40 wt% SiO2 and
20 wt% FeO.

The different spectrum profiles are obvious.
For example, the e-beam spectra (in green) the lighter elements are more intense.

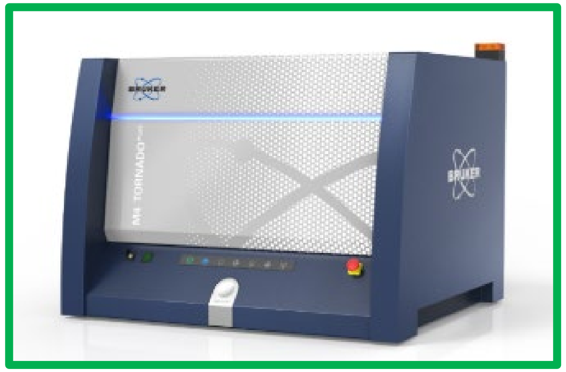
Whereas for the heavier elements the X-ray spectrum (in blue) has a significantly more intense signal.

Overview:
Characterization Workflow of a multiscale approach



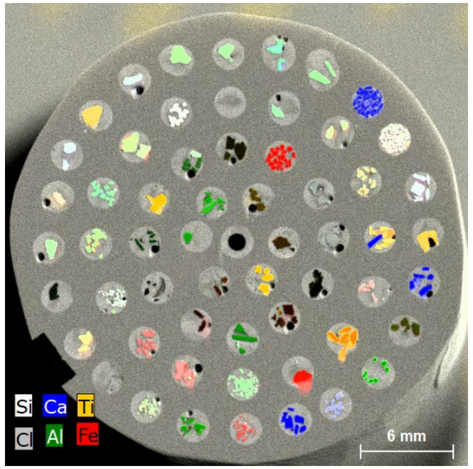
Butcher AR (2020) Upscaling of 2D mineralogical information to 3D volumes for geoscience applications using a multi-scale, multi-modal and multi-dimensional approach. *EMAS 2019, Conference Proceedings Volume, Trondheim*, 19-23 May 2019.

Micro-XRF **M4 Tornado Plus**

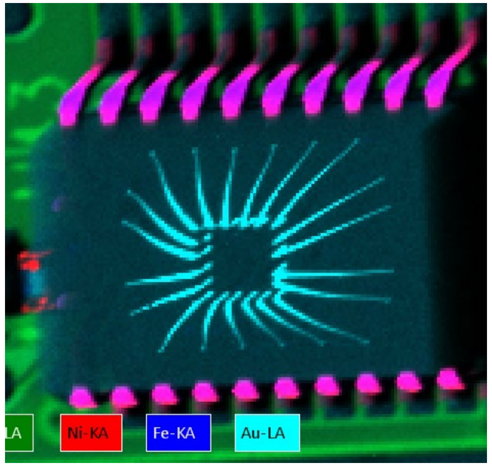


SEM-EDS-Micro-XRF-WDS

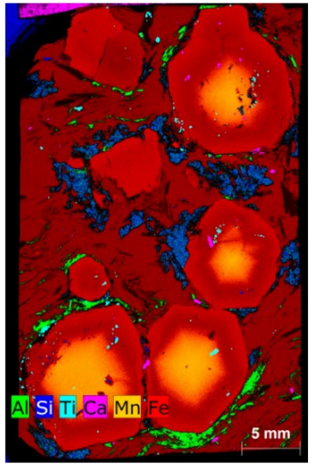
Micro-XRF Possibilities



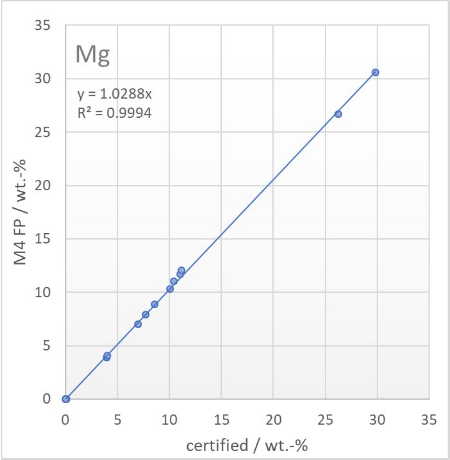
No sample preparation



Information from the depth of the sample



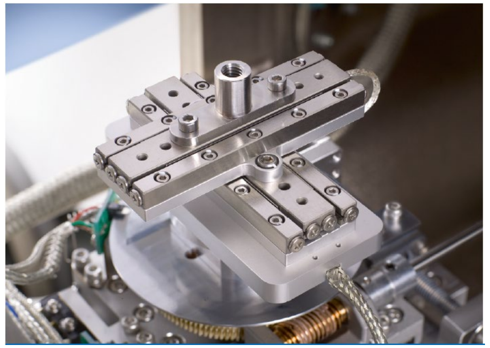
Trace element sensitive



Reference samples and standard supported quantification options

Micro-XRF: XTrace

Rapid Stage



- XTrace allows to combine the advantages of micro-XRF with the associated SEM options (high spatial resolution of the E-Beam and resolution of the WDS)
- X-ray beam is fixed in space and cannot raster as a e-beam can do, element distribution measurements will be performed via stage movement (either SEM stage or Rapid Stage)