

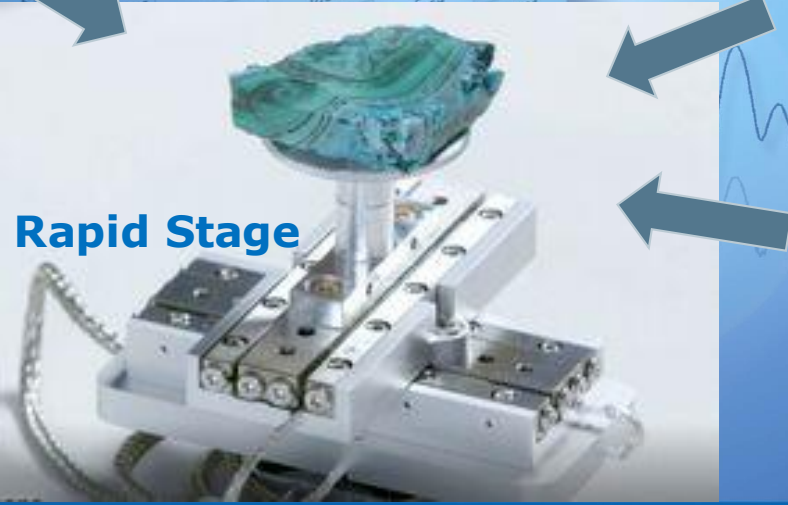
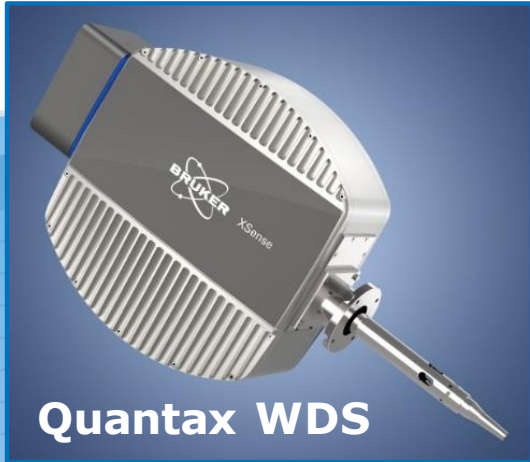
Large area SEM mapping using the Rapid Stage and its benefits for EDS, WDS and micro-XRF analysis



Bruker Nano Analytics, Berlin, Germany
Webinar, April 30th, 2020



At. No.	Line S.	EDS Mass [%] Norm.	XRF Mass [%] Norm.	Comb. Mass [%] Norm.	Certified Val. /M%
8	K-Series	45.71	45.58	46.03	46.82
11	K-Series	10.54	10.32	10.61	10.68
12	K-Series	2.32	2.27	2.33	2.22
	K-Series	1.34	0.89	0.89	0.95
	K-Series	33.94	34.99	34.18	33.70
	K-Series	0.16	0.12	0.12	0.11
	K-Series		0.35	0.35	0.34
	K-Series		0.35	0.35	5.08



Presenters



Stephan Boehm

Product Manager XTrace / XSense
Bruker Nano Analytics, Berlin, Germany



Michael Abratis, PhD

Sr. Applications Scientist WDS,
Bruker Nano Analytics, Berlin, Germany



Andrew Menzies, PhD

Sr. Applications Geology and Mining,
Bruker Nano Analytics, Berlin, Germany

Overview



- Terminology
- Introduction to Rapid Stage
- Types of Large Area Mapping on a SEM and Potential Issues
- Differences between SEM-EDS / SEM-WDS / SEM-XRF - Rapid Stage Technical Description
- Example Applications and Benefits
- Summary and Conclusion

Introduction

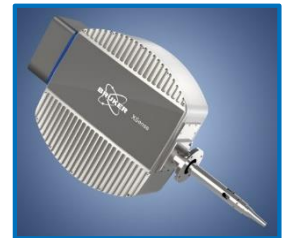
Terminology



SEM-EDS: Analysis based on the sample interaction with an electron beam source from the SEM and the resultant X-rays that are detected using an EDS (simultaneous element detection)



SEM-WDS: Analysis based on the sample interaction with an electron beam source from the SEM and the resultant X-rays that are detected using a WDS (sequential element detection)



SEM-XRF-EDS: MicroXRF on SEM (XTrace): Analysis based on the sample interaction with an X-ray beam source from the Micro XRF attached to the SEM and the resultant X-rays that are detected using an EDS (simultaneous element detection)



Rapid Stage: New high speed stage with precision movement

SEM Stage: Standard stage that comes with the SEM



Analytical Parameters and Conditions

SEM-EDS vs SEM-WDS vs SEM-XRF



Parameter	EDS: E-beam (SEM-EDS)	WDS: E-beam (SEM-WDS)	EDS: Micro-XRF (SEM-XRF-EDS)
Analyzed Volume	Ø: few µm Information depth: µm; (depending primarily on electron energy)	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 $Z \geq 4$ (beryllium)	Atomic number $Z \geq 4$ (beryllium)	Atomic number $Z \geq 6$ (carbon)
Energy range	K- L -M - Lines (up to 20 keV)	70 eV – 3.6 keV (L- M- Lines)	K- L -M - Lines (up to 40 keV)
Concentration Range	Down to 1000 ppm	Down to 100 ppm	Down to 10 ppm
Quantification	Standard less and Standard based	Standard based	Standard less and standard based
Data collection	Simultaneously	Sequentially	Simultaneously
Sample Preparation	Sample needs to be electrically conductive (commonly carbon-coated), polishing required	Sample needs to be electrically conductive (commonly carbon-coated), polishing required	Electrical Conductivity not required, samples doesn't need to be polished
Sample Stress	Heating due to absorbed electrons	Heating due to absorbed electrons	Minimal
Typical SEM beam current	Variable	Variable > 10 nA	N/A

Introduction

Historic and Current Webinars



www.bruker.com/events/webinars.html

Filter: EDS, WDS, EBSD, Micro-XRF on SEM

High Speed Mapping Using
Micro-XRF on SEM



Bruker Nano Analytics, Berlin, Germany
Webinar, November 6th, 2019

Advanced elemental analysis of geological
samples using QUANTAX WDS for SEM



Bruker Nano Analytics, Berlin, Germany
Webinar, April 25, 2019

Microanalysis with high spectral resolution:
the power of QUANTAX WDS for SEM



Bruker Nano Analytics, Berlin, Germany
Webinar, September 14, 2017

Advancements in Microanalysis with
micro-XRF on SEM



Bruker Nano Analytics, Berlin, Germany
Webinar, April 18th 2018

Microanalysis with high spectral resolution:
the power of QUANTAX WDS for SEM

Bruker Nano Analytics, Berlin, Germany
Webinar, September 14, 2017

WDS

Innovation with Integrity

Element	Al. No.	Line S.	WDS Ratio	WDS Ratio	WDS Ratio
Na	11	K	0.15	0.15	0.15
Mg	12	K	0.15	0.15	0.15
K	19	L	0.15	0.15	0.15
Ca	20	L	0.15	0.15	0.15
Sc	21	L	0.15	0.15	0.15
Ti	22	L	0.15	0.15	0.15
Rb	37	L	0.15	0.15	0.15
Sr	38	L	0.15	0.15	0.15
Y	39	L	0.15	0.15	0.15
Zr	40	L	0.15	0.15	0.15
Cs	55	L	0.15	0.15	0.15
Ba	56	L	0.15	0.15	0.15
La	57	L	0.15	0.15	0.15
Hf	72	L	0.15	0.15	0.15
Fr	87	L	0.15	0.15	0.15
Ra	88	L	0.15	0.15	0.15
Ac	89	L	0.15	0.15	0.15
Ce	58	L	0.15	0.15	0.15
Pr	59	L	0.15	0.15	0.15
Nd	60	L	0.15	0.15	0.15
Pm	61	L	0.15	0.15	0.15
Sm	62	L	0.15	0.15	0.15
Eu	63	L	0.15	0.15	0.15
Gd	64	L	0.15	0.15	0.15
Tb	65	L	0.15	0.15	0.15
Dy	66	L	0.15	0.15	0.15
Ho	67	L	0.15	0.15	0.15
Er	68	L	0.15	0.15	0.15
Tm	69	L	0.15	0.15	0.15
Yb	70	L	0.15	0.15	0.15
Lu	71	L	0.15	0.15	0.15
Th	90	L	0.15	0.15	0.15
Pa	91	L	0.15	0.15	0.15
U	92	L	0.15	0.15	0.15
Np	93	L	0.15	0.15	0.15
Pu	94	L	0.15	0.15	0.15
Am	95	L	0.15	0.15	0.15
Cm	96	L	0.15	0.15	0.15
Bk	97	L	0.15	0.15	0.15
Cf	98	L	0.15	0.15	0.15
Es	99	L	0.15	0.15	0.15
Fm	100	L	0.15	0.15	0.15

Advancements in Microanalysis with
micro-XRF on SEM

Bruker Nano Analytics, Berlin, Germany
Webinar, April 18th 2018

Micro-XRF on SEM

Element	Al. No.	Line S.	WDS Ratio	WDS Ratio	WDS Ratio
Oxygen	8	K	0.15	0.15	0.15
Fluorine	9	L	0.15	0.15	0.15
Neon	10	L	0.15	0.15	0.15
Sodium	11	K	0.15	0.15	0.15
Magnesium	12	K	0.15	0.15	0.15
Aluminum	13	K	0.15	0.15	0.15
Silicon	14	K	0.15	0.15	0.15
Phosphorus	15	K	0.15	0.15	0.15
Sulfur	16	K	0.15	0.15	0.15
Chlorine	17	K	0.15	0.15	0.15
Potassium	19	L	0.15	0.15	0.15
Calcium	20	L	0.15	0.15	0.15
Titanium	22	L	0.15	0.15	0.15
Vanadium	23	L	0.15	0.15	0.15
Chromium	24	L	0.15	0.15	0.15
Manganese	25	L	0.15	0.15	0.15
Iron	26	L	0.15	0.15	0.15
Cobalt	27	L	0.15	0.15	0.15
Nickel	28	L	0.15	0.15	0.15
Copper	29	L	0.15	0.15	0.15
Zinc	30	L	0.15	0.15	0.15
Gallium	31	L	0.15	0.15	0.15
Germanium	32	L	0.15	0.15	0.15
Arsenic	33	L	0.15	0.15	0.15
Selenium	34	L	0.15	0.15	0.15
Bromine	35	L	0.15	0.15	0.15
Krypton	36	L	0.15	0.15	0.15
Rubidium	37	L	0.15	0.15	0.15
Strontium	38	L	0.15	0.15	0.15
Yttrium	39	L	0.15	0.15	0.15
Zirconium	40	L	0.15	0.15	0.15
Niobium	41	L	0.15	0.15	0.15
Molybdenum	42	L	0.15	0.15	0.15
Technetium	43	L	0.15	0.15	0.15
Ruthenium	44	L	0.15	0.15	0.15
Rhodium	45	L	0.15	0.15	0.15
Palladium	46	L	0.15	0.15	0.15
Silver	47	L	0.15	0.15	0.15
Cadmium	48	L	0.15	0.15	0.15
Indium	49	L	0.15	0.15	0.15
Tin	50	L	0.15	0.15	0.15
Antimony	51	L	0.15	0.15	0.15
Tellurium	52	L	0.15	0.15	0.15
Iodine	53	L	0.15	0.15	0.15
Xenon	54	L	0.15	0.15	0.15
Barium	56	L	0.15	0.15	0.15
Lanthanum	57	L	0.15	0.15	0.15
Cerium	58	L	0.15	0.15	0.15
Praseodymium	59	L	0.15	0.15	0.15
Neodymium	60	L	0.15	0.15	0.15
Europium	63	L	0.15	0.15	0.15
Gadolinium	64	L	0.15	0.15	0.15
Terbium	65	L	0.15	0.15	0.15
Dysprosium	66	L	0.15	0.15	0.15
Ytterbium	68	L	0.15	0.15	0.15
Lutetium	69	L	0.15	0.15	0.15
Hafnium	72	L	0.15	0.15	0.15
Tantalum	73	L	0.15	0.15	0.15
Tungsten	74	L	0.15	0.15	0.15
Rhenium	75	L	0.15	0.15	0.15
Osmium	76	L	0.15	0.15	0.15
Iridium	77	L	0.15	0.15	0.15
Platinum	78	L	0.15	0.15	0.15
Gold	79	L	0.15	0.15	0.15
Mercury	80	L	0.15	0.15	0.15
Thallium	81	L	0.15	0.15	0.15
Lead	82	L	0.15	0.15	0.15
Bismuth	83	L	0.15	0.15	0.15
Polonium	84	L	0.15	0.15	0.15
Astatine	85	L	0.15	0.15	0.15
Radium	88	L	0.15	0.15	0.15
Actinium	89	L	0.15	0.15	0.15
Thorium	90	L	0.15	0.15	0.15
Protactinium	91	L	0.15	0.15	0.15
Uranium	92	L	0.15	0.15	0.15
Niobium	41	L	0.15	0.15	0.15
Molybdenum	42	L	0.15	0.15	0.15
Technetium	43	L	0.15	0.15	0.15
Ruthenium	44	L	0.15	0.15	0.15
Rhodium	45	L	0.15	0.15	0.15
Palladium	46	L	0.15	0.15	0.15
Silver	47	L	0.15	0.15	0.15
Cadmium	48	L	0.15	0.15	0.15
Indium	49	L	0.15	0.15	0.15
Tin	50	L	0.15	0.15	0.15
Antimony	51	L	0.15	0.15	0.15
Tellurium	52	L	0.15	0.15	0.15
Iodine	53	L	0.15	0.15	0.15
Xenon	54	L	0.15	0.15	0.15
Barium	56	L	0.15	0.15	0.15
Lanthanum	57	L	0.15	0.15	0.15
Cerium	58	L	0.15	0.15	0.15
Praseodymium	59	L	0.15	0.15	0.15
Neodymium	60	L	0.15	0.15	0.15
Europium	63	L	0.15	0.15	0.15
Gadolinium	64	L	0.15	0.15	0.15
Terbium	65	L	0.15	0.15	0.15
Dysprosium	66	L	0.15	0.15	0.15
Ytterbium	68	L	0.15	0.15	0.15
Lutetium	69	L	0.15	0.15	0.15
Hafnium	72	L	0.15	0.15	0.15
Tantalum	73	L	0.15	0.15	0.15
Tungsten	74	L	0.15	0.15	0.15
Rhenium	75	L	0.15	0.15	0.15
Osmium	76	L	0.15	0.15	0.15
Iridium	77	L	0.15	0.15	0.15
Platinum	78	L	0.15	0.15	0.15
Gold	79	L	0.15	0.15	0.15
Mercury	80	L	0.15	0.15	0.15
Thallium	81	L	0.15	0.15	0.15
Lead	82	L	0.15	0.15	0.15
Bismuth	83	L	0.15	0.15	0.15
Polonium	84	L	0.15	0.15	0.15
Astatine	85	L	0.15	0.15	0.15
Radium	88	L	0.15	0.15	0.15
Actinium	89	L	0.15	0.15	0.15
Thorium	90	L	0.15	0.15	0.15
Protactinium	91	L	0.15	0.15	0.15
Uranium	92	L	0.15	0.15	0.15

Application of Rapid Stage

Motivation



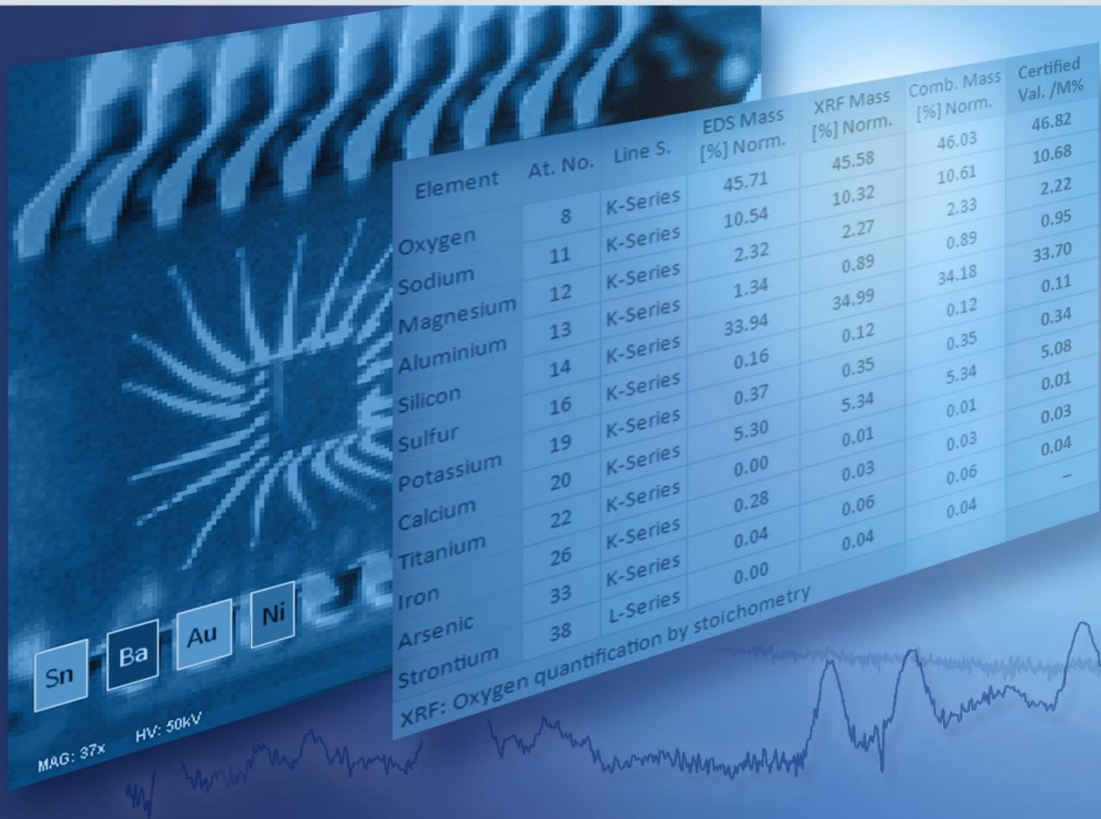
Why using Rapid Stage for SEM-EDS and SEM-WDS?

- Enhancing speed for mapping applications
- Enhancing EDS / WDS usability
- Enabling WDS mapping with vertical beam at the speed of a beammap
- Avoiding Bragg's law violation
- Avoiding lateral intensity loss
- Enabling large scale mapping

Why using Rapid Stage for SEM-XRF?

- Enhancing speed for mapping applications as only stage mapping is possible as the X-ray beam is fixed in space and can not be rastered

Rapid Stage for SEM's Introduction

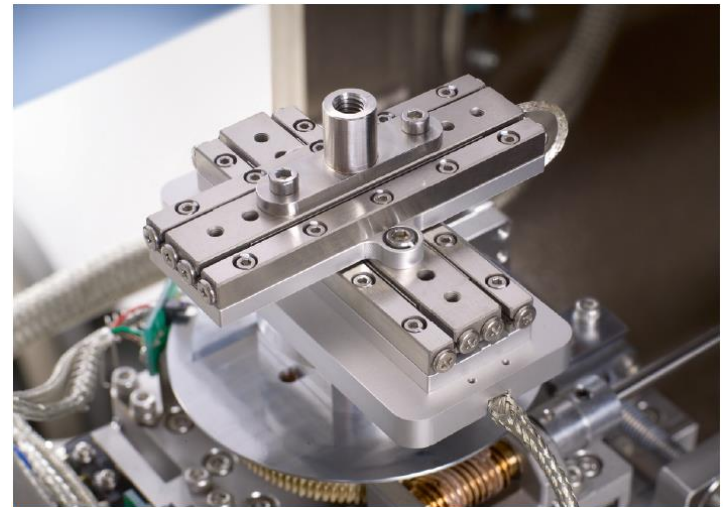
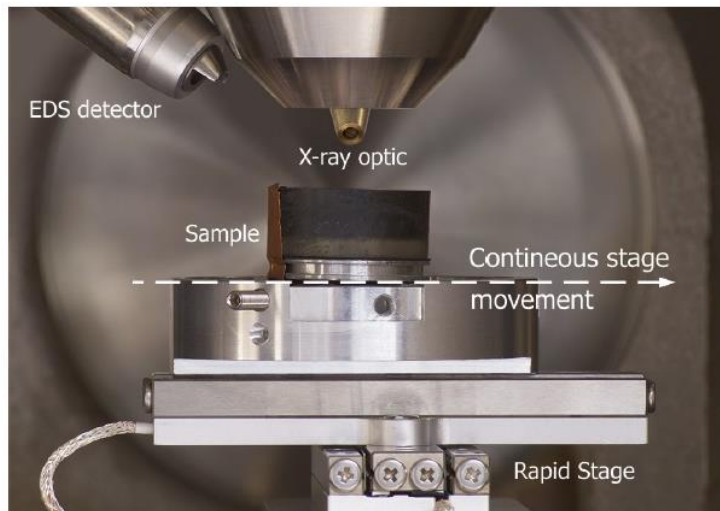


Introduction

Rapid Stage



- The **Rapid Stage** has been developed to enable high-speed mapping over large areas via Stage movement
- It is mounted on top of an existing SEM stage, including stage adaption and sample holder.
- The Rapid Stage is controlled independently from the SEM stage and can operate up to a maximum travel speed of 4 mm/s.



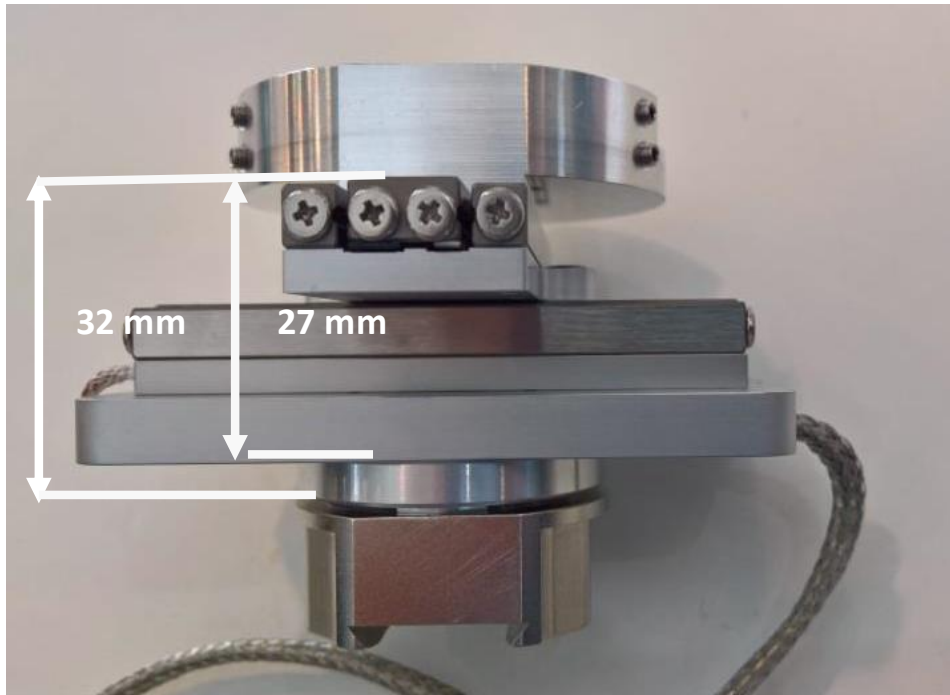
Rapid Stage Dimensions



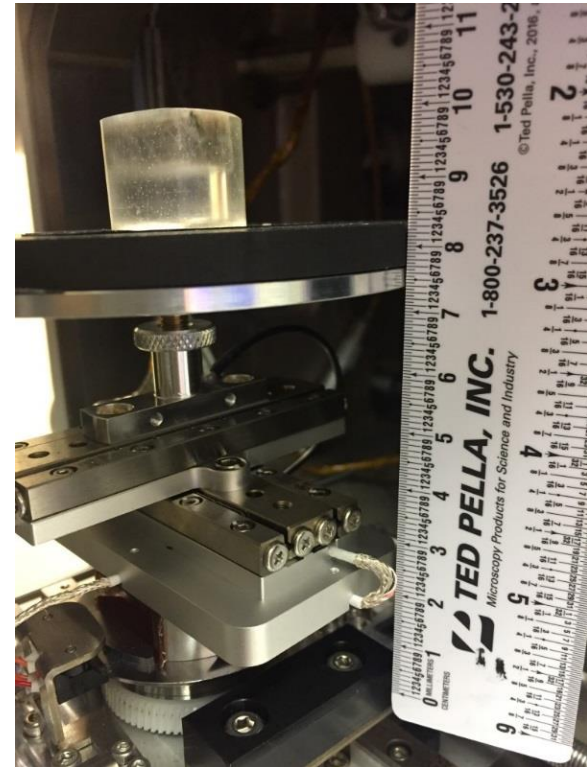
Stage itself (including x- and y linear positioners and basis plate): **27 mm**

Including footplate: **32 mm**

Without dovetail and sample holder → SEM depending



for Jeol IT 500 setup: **60 mm**



for Hitachi S3700N setup: **73 mm**

Rapid Stage Integration in ESPRIT



MAPPING

Sample: Coating None

Standards: 66
 No of standards: 66
 Calib. date: Uncalibrated
 Calib. time: Uncalibrated
 HV: 15 kV
 Geometry: OK
 ESL-506-15k

Microsc...
 WD: 12.000 mm
 Magn.: 27.0 x
 Stage X: 6.321 mm
 Stage Y: 1.725 mm
 Stage Z: 62.481 mm
 HV: 5.0 kV

X-ray so...
 Filter: Empty
 Current: 600 nA
 Status: Empty
 HV: 50.0 kV

Substage
 Position X: 0.0 μm
 Position Y: -0.8 μm
 Velocity: 5000.0 μm/s
 Frame time: 02:25 min
 Pixel time: 4.8 ms

Scan
 Dwell time: 16 μs
 Frame time: 0.5 s
 Drift qual.: --- %
 Drift range: --- %

EDS
 40 keV
 60 kcps
 -30.0 °C
 --- s
 --- s

Report
 Report: 1
 Page: 1
 empty

Project: 19/12/2018 09:59 0 kB

Report_0

Loaded: C:\Users\messeds.ber\Desktop\SW test_Nov_2018\map_alignment_tool.bcf

Ch 1 Map Phases

Image extension: 3000 x 600 72.7 x 14.3 mm

Map time
 Manual
 Measurement time [s]: 100
 Cycles: 1

Map area
 Full Fixed Variable

	[μm]	Points
Map width	12833.00	500
Map height	9571.00	375
Point distance	50.00	

SLBSTAGE MOVEMENT

	Current values	New values
Move speed [μm/s]	500	3000
Dwell time [ms]	25.7	4.3
Frame time	12:49min	02:08min

Reference Apply

50 μm Spot size 2870x593 Points

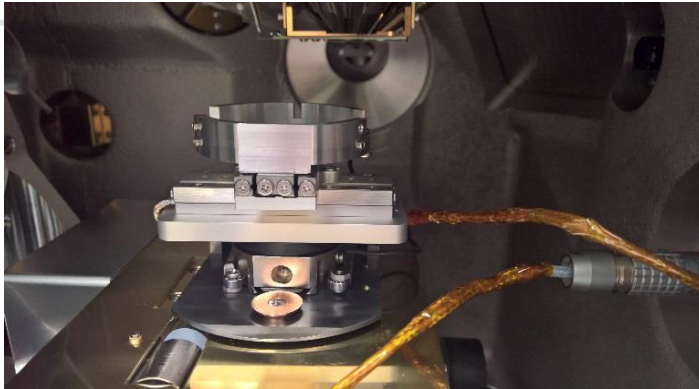
Ch 1 1.00 Cu-Kα 1.00 Si-Kα 1.00 Zn-Kα 1.00 Ni-Kα 1.00 Al-K 1.00 Fe-Kα 1.00

Introduction Video

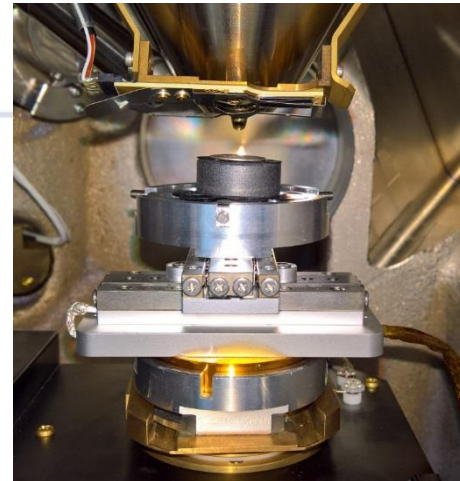
Rapid Stage



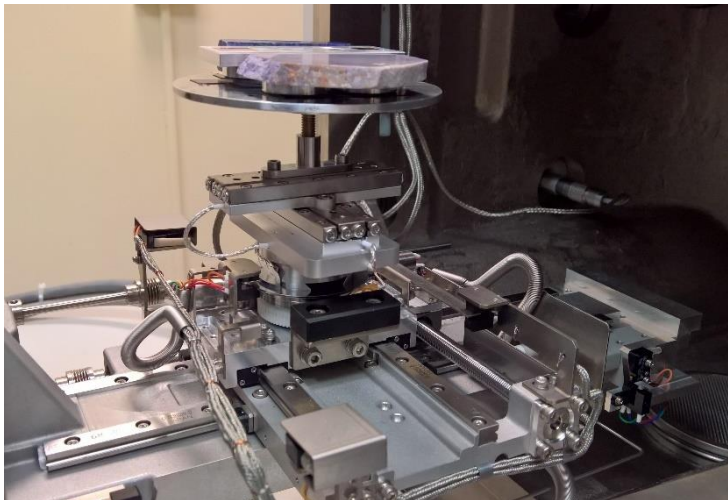
Rapid Stage Installations: Adaptable to various SEMs



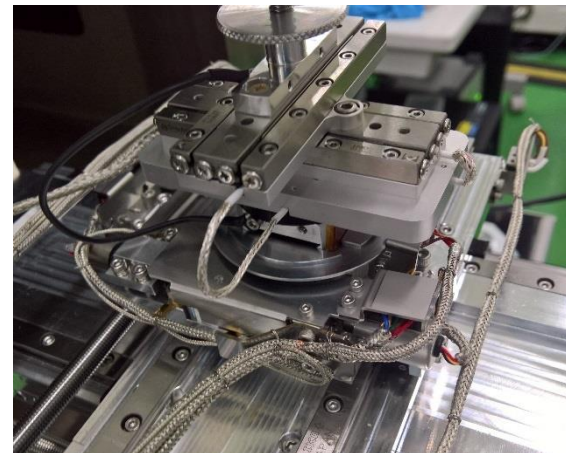
Jeol IT-500



Jeol JSM 6490



Hitachi S 3700N



Hitachi SU 3900

Rapid Stage Specification

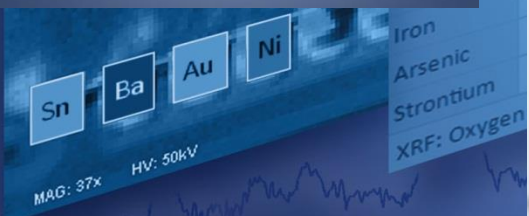
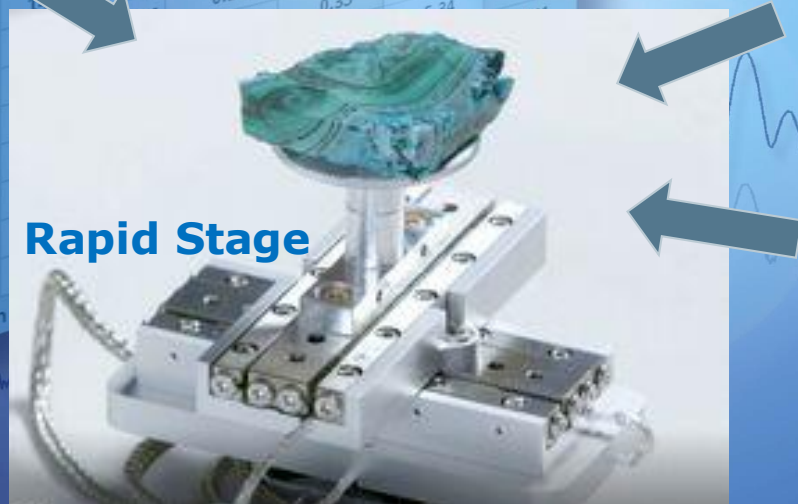


Parameter	Description
Height	27 mm (without sample holder and SEM stage adaption)
Weight	300 g
Sample load	3 kg
Stage travel speed	4 mm /sec
Travel distance	50 mm
Vacuum resistance	10 ⁻⁶ mbar (higher vacuum resistance on request)
Resolution	< 1 nm

Examples



At. No.	Line S.	EDS Mass [%] Norm.	XRF Mass [%] Norm.	Comb. Mass [%] Norm.	Certified Val. /M%
8	K-Series	45.71	45.58	46.03	46.82
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	K-Series	1.34	0.89	0.89	0.95
	K-Series	33.94	34.99	34.18	33.70
	K-Series	0.16	0.12	0.12	0.11
	K-Series		0.35	0.35	0.34
	K-Series		0.35	0.34	5.08



- **Large Area Maps Overview: Mapping Types**

- **Source: Electron Beam (e-beam) and X-ray beam**
- **Detector: EDS and WDS**
- **Stage: SEM-Stage and Rapid Stage**

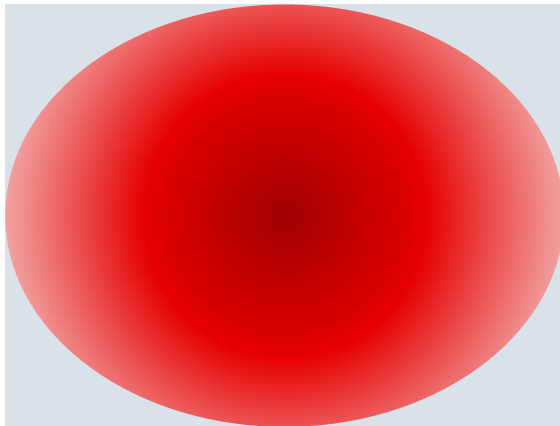
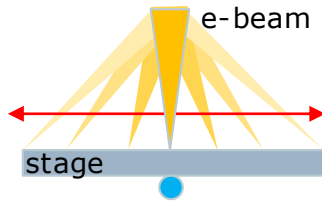
- **Note: Combination (Simultaneous) data-sets**
 - **Rapid Stage with e-beam + X-ray beam + EDS, or**
 - **Rapid Stage with e-beam + EDS and WDS**

Large Area Mapping

3 Different Mapping Modes

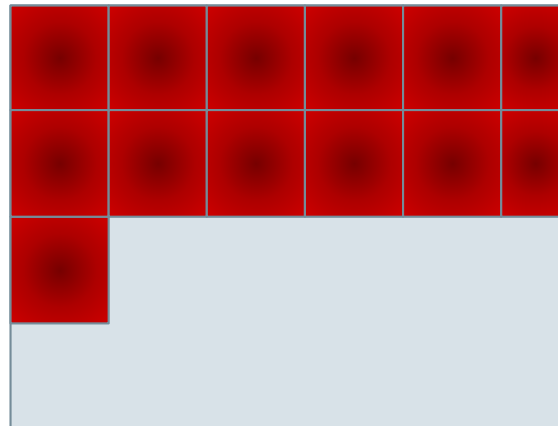
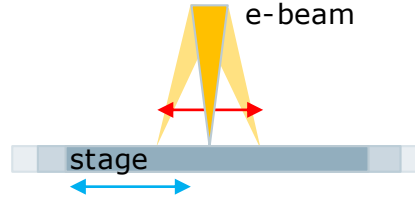


Type I



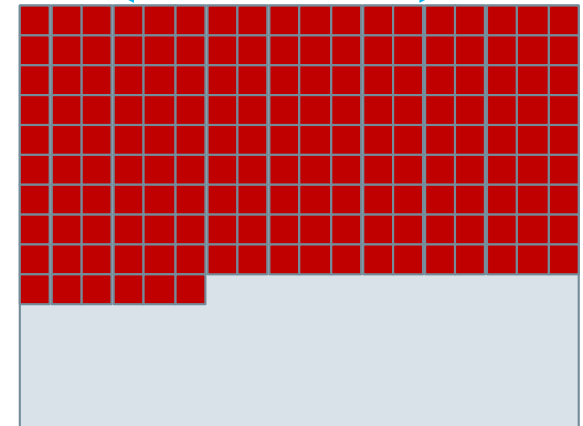
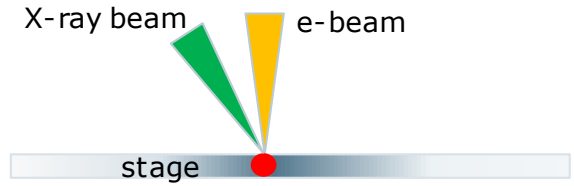
Scan Map Without Limits
(Raster over Full Area)
e.g. Low Mag. 30x

Type II

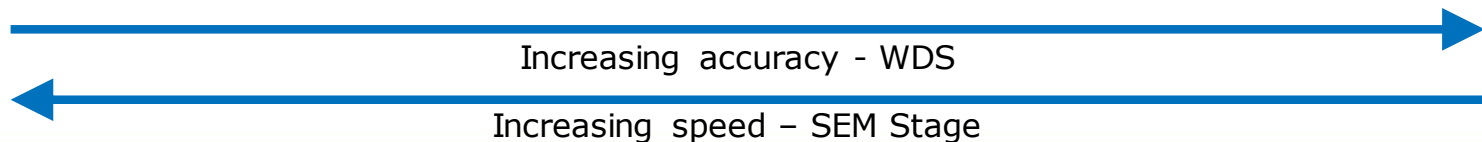


Scan Map With Limits
(Raster over Restricted Area
with Stage Movement)

Type III

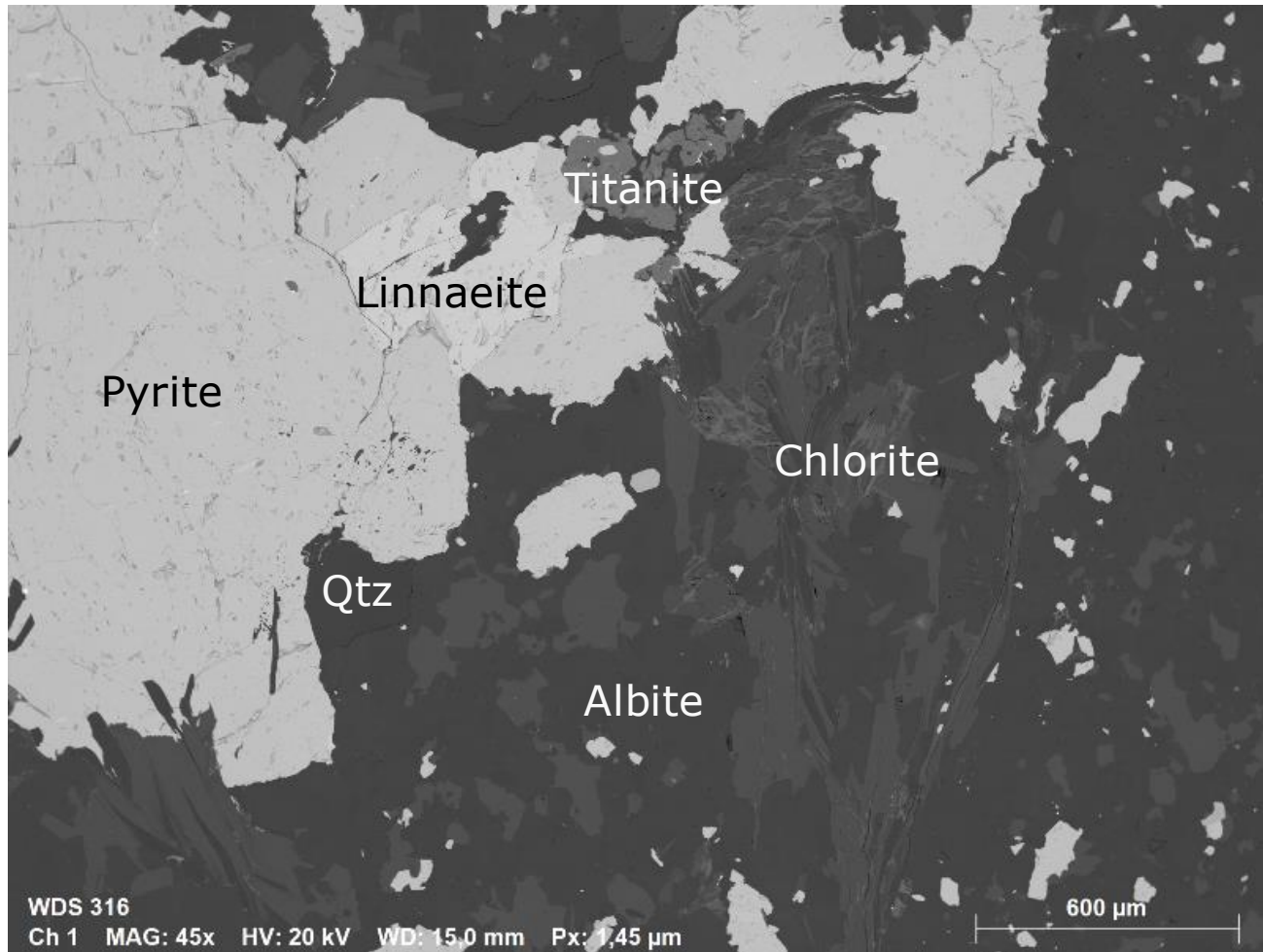


Stage Map
Independent of Magnification



Sample 1

Sulphide bearing rock



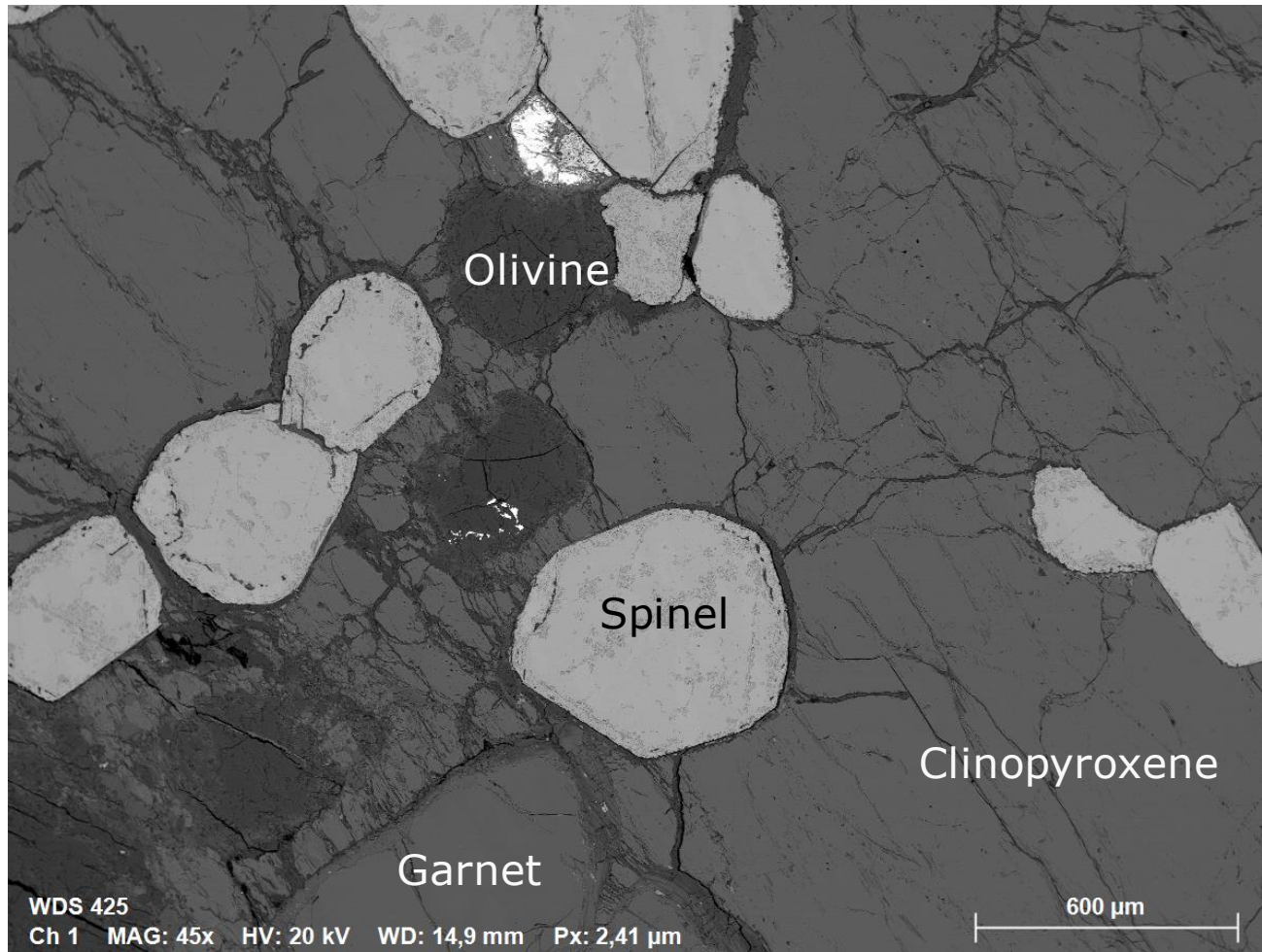
Low
magnification
45x

Image
dimensions:
2.9 x 2.2 mm

Resolution:
2000 x 1500 px
(1.45 µm / px)

Sample 2

Garnet-Spinel Peridotite



Low
magnification
45x

Image
dimensions:
2.9 x 2.2 mm

Resolution:
1200 x 900 px
(2.4 μm / px)

Sample 3

Electronics Microchip



Low
magnification
30x

Image
dimensions:
4.3 x 3.2 mm

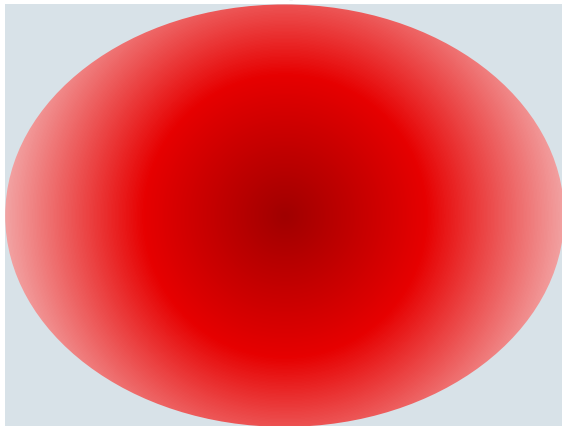
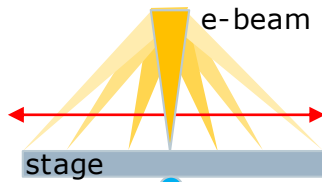
Resolution:
1200 x 900 px
(3.6 μm / px)

Large Area Mapping

Type I

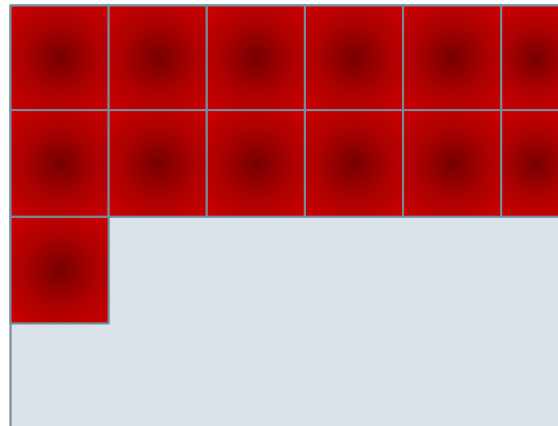
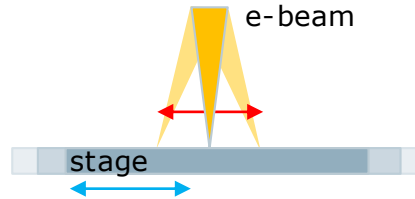


Type I



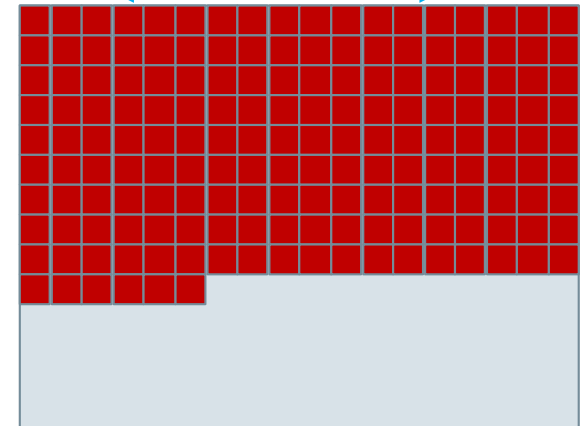
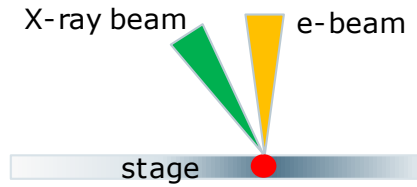
Scan Map Without Limits
(Raster over Full Area)
e.g. Low Mag. 30x

Type II

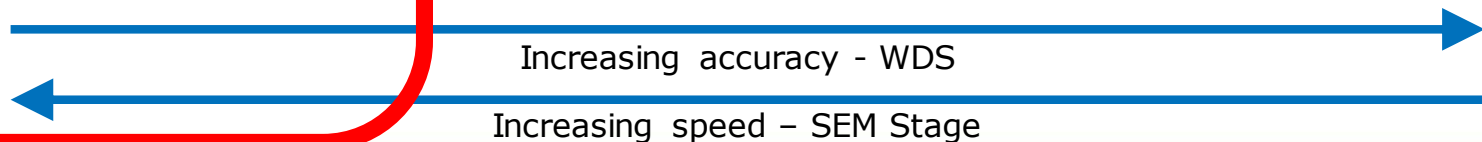


Scan Map With Limits
(Raster over Restricted Area
with Stage Movement)

Type III



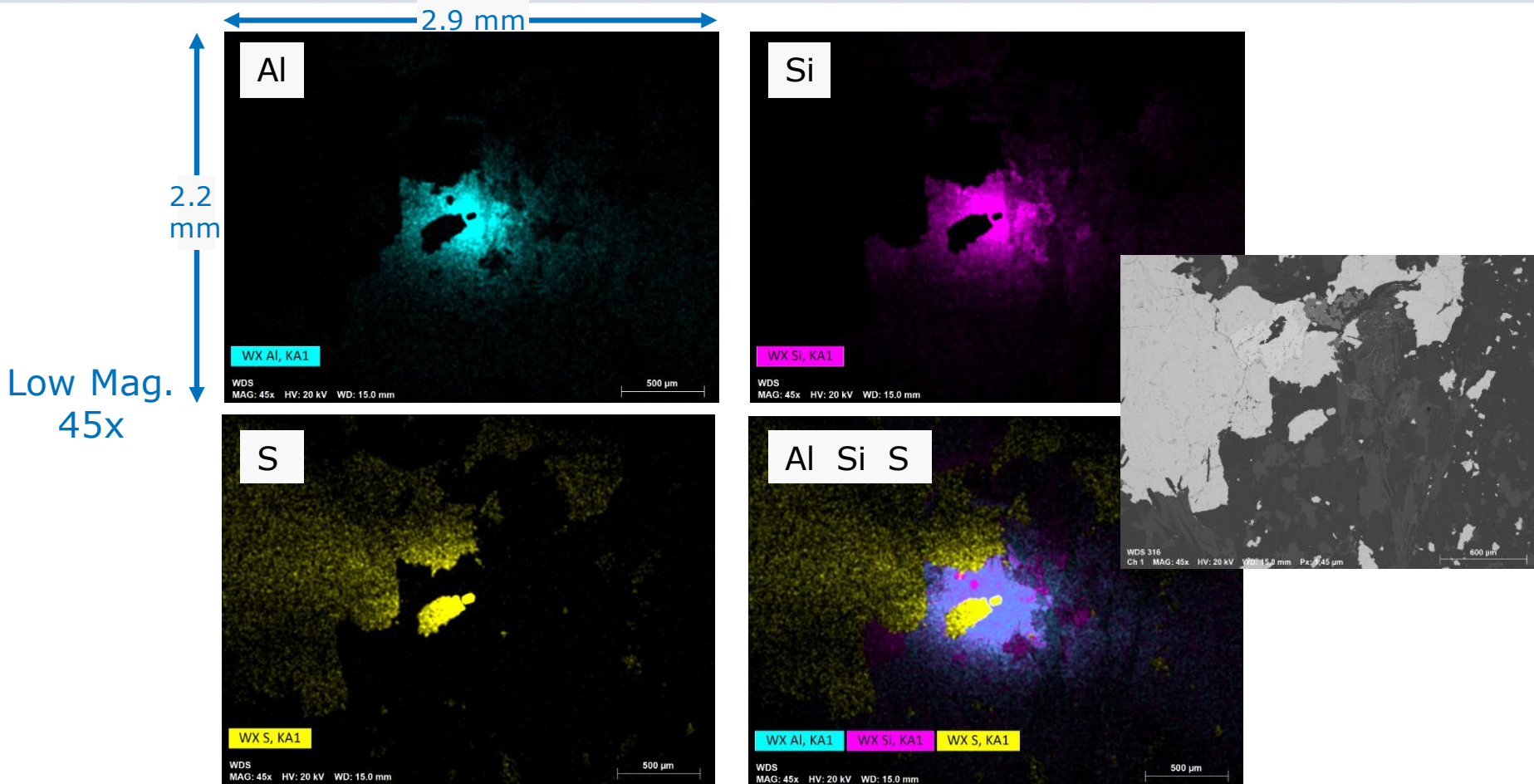
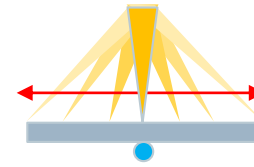
Stage Map
Independent of Magnification



Scan Map Without Range Limits

Sample 1 at low magnification

Single Field

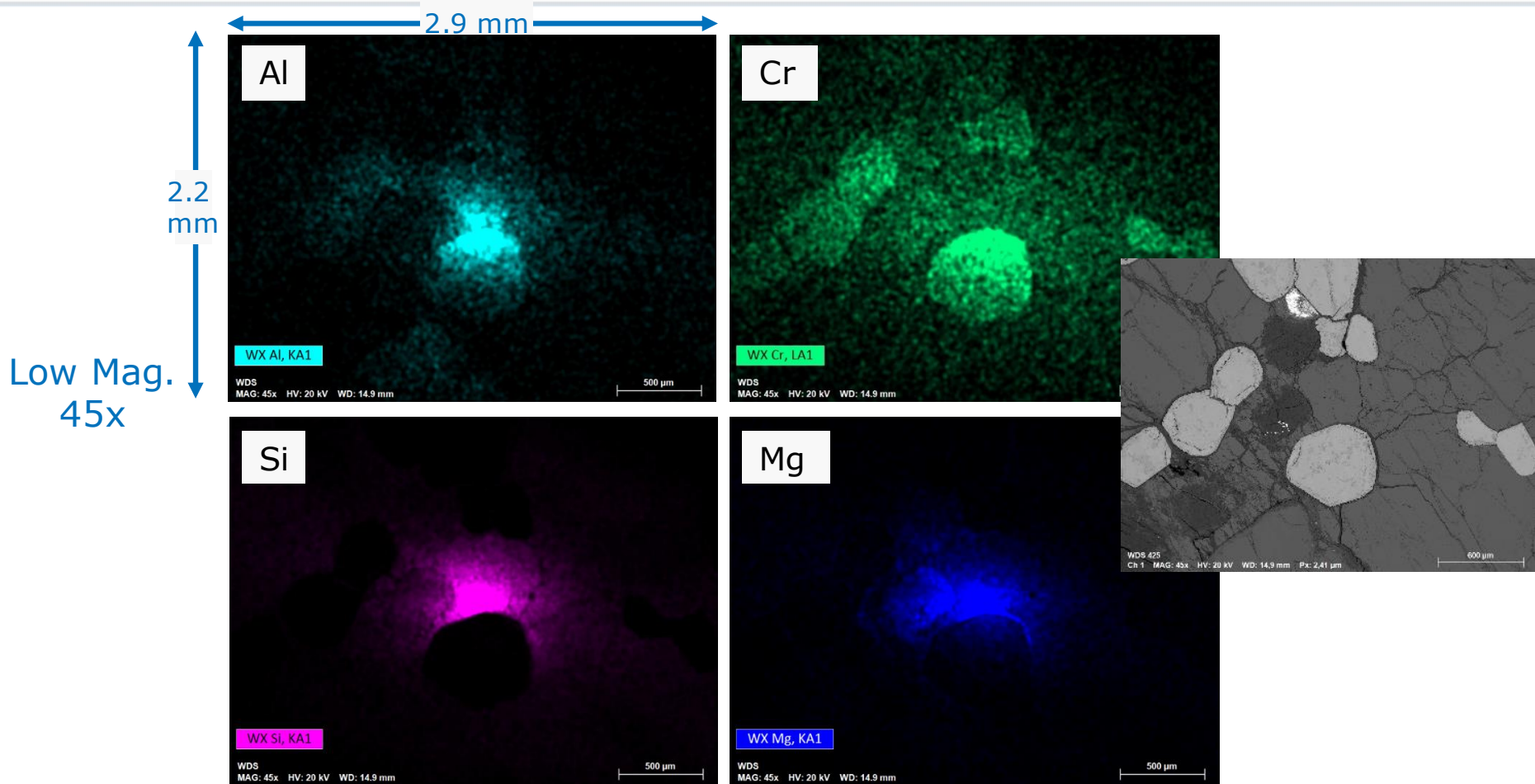
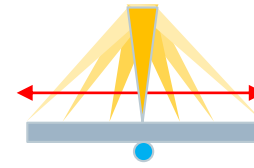


Type I Mapping: Low Magnification – Single Field
Problems for WDS Mapping due to violation of Bragg's Law

Scan Map Without Range Limits

Sample 2 at low magnification

Single Field

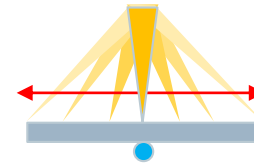


Type I Mapping: Low Magnification – Single Field
Problems for WDS Mapping due to violation of Bragg's Law

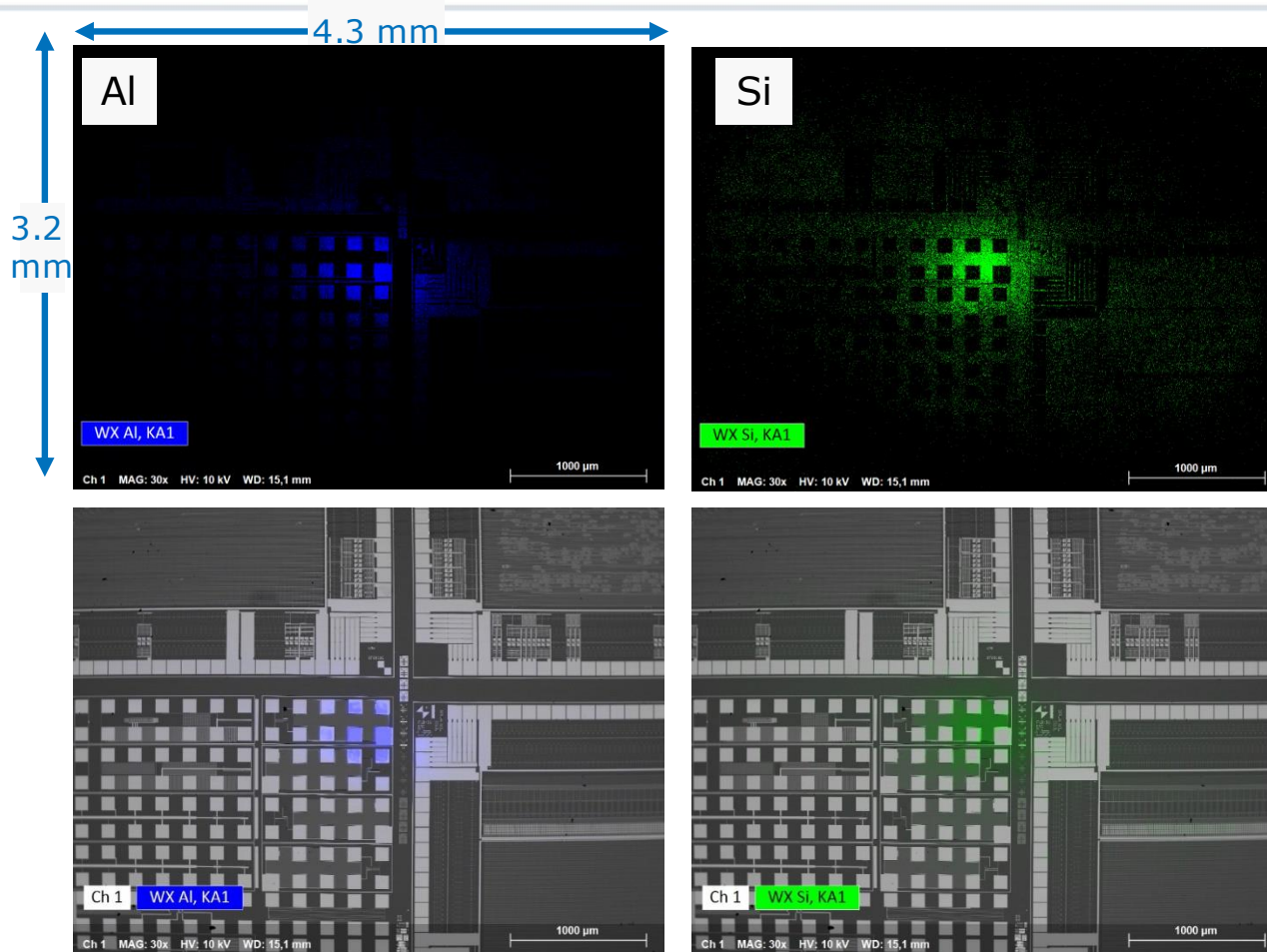
Scan Map Without Range Limits

Sample 3 at low magnification

Single Field



Low Mag.
30x

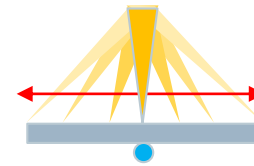


Type I Mapping: Low Magnification – Single Field
Problems for WDS Mapping due to violation of Bragg's Law

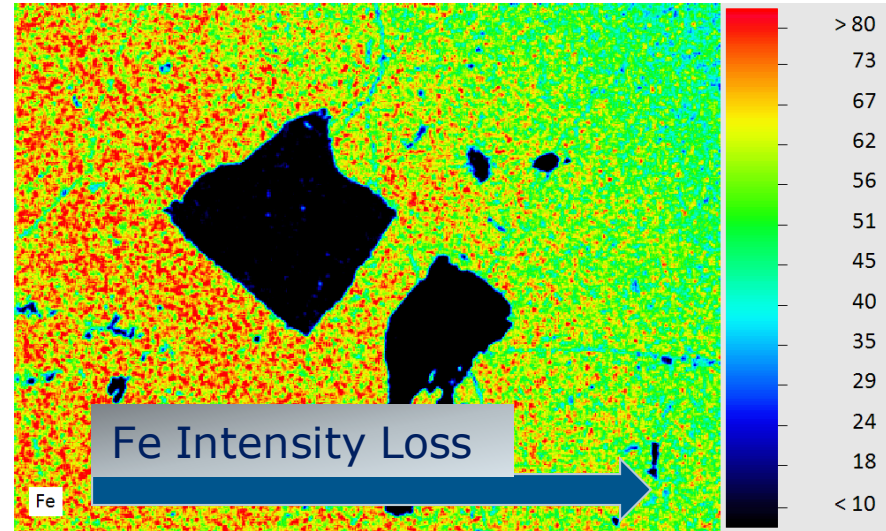
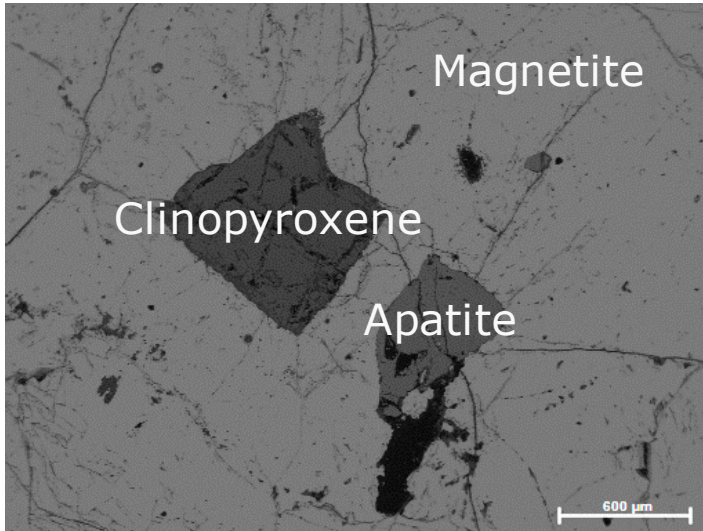
Scan Map Without Range Limits

Sample 3 at low magnification

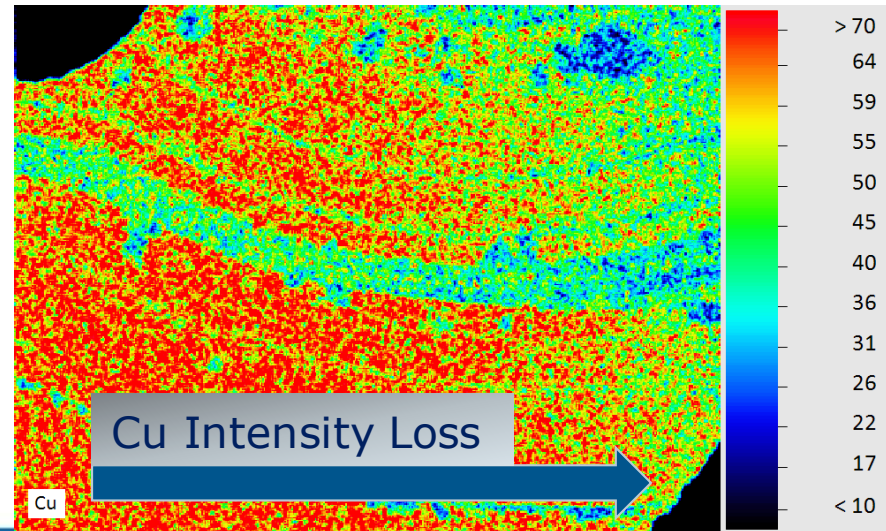
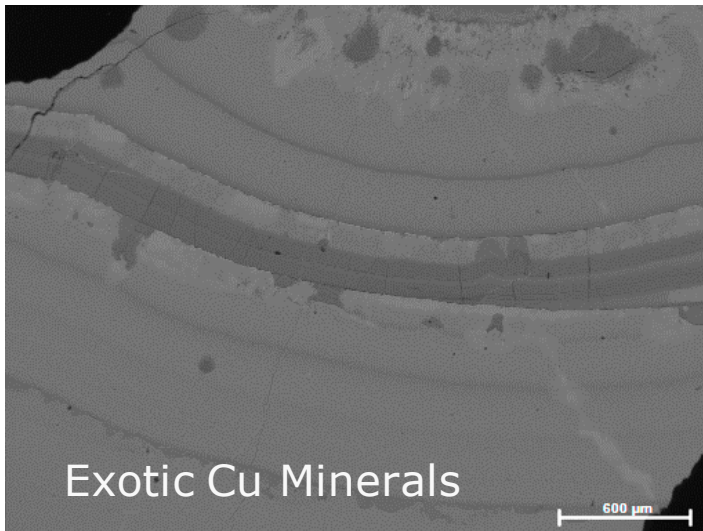
Single Field



El Laco Deposit



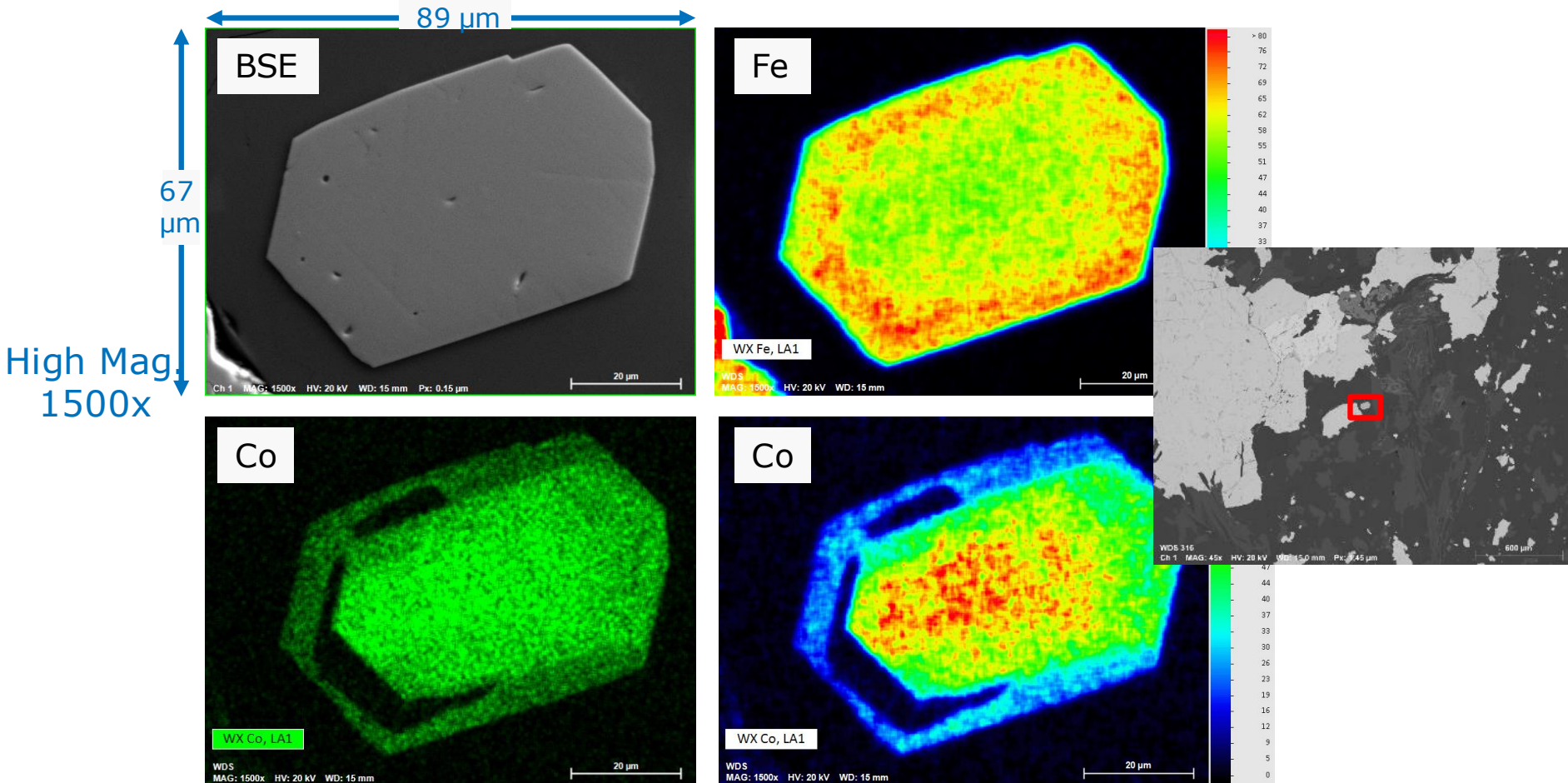
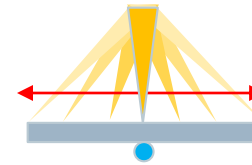
El Tesoro Deposit



Scan Map Without Range Limits

Sample 1 at high magnification

Single Field

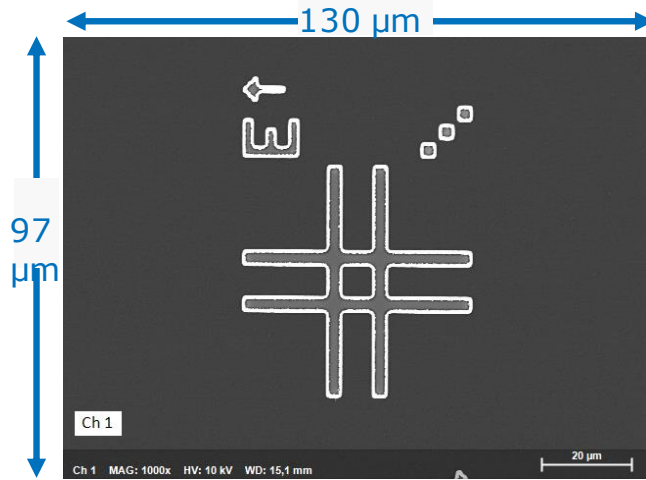
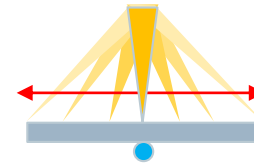


Type I Mapping: High Magnification – Single Field
Suitable method for Small Areas where Bragg Angle Effect is negligible

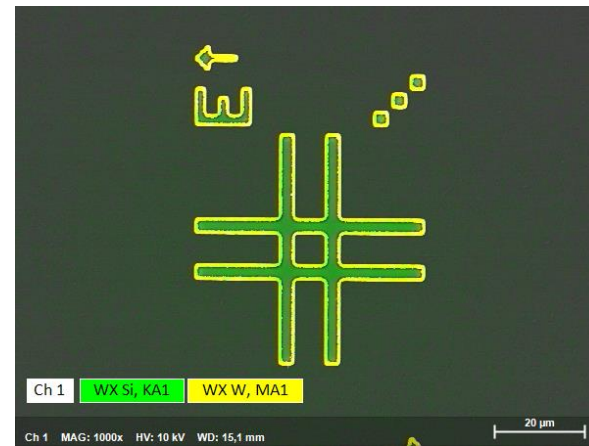
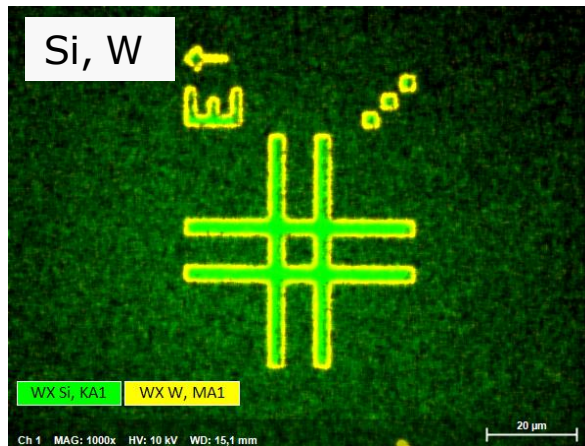
Scan Map Without Range Limits

Sample 3 at high magnification

Single Field



High Mag.
1000x



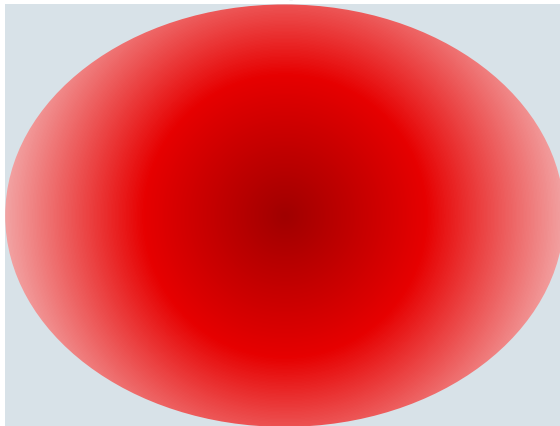
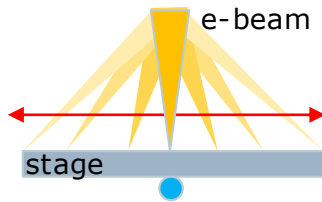
Type I Mapping: High Magnification – Single Field
Suitable method for Small Areas where Bragg Angle Effect is negligible

Large Area Mapping

Type II

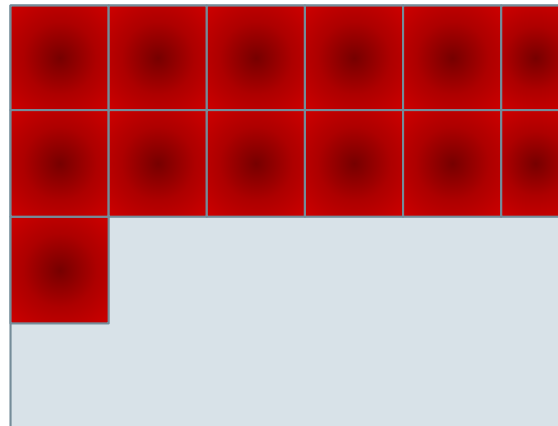
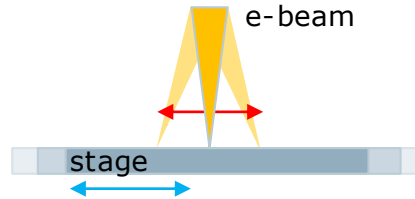


Type I



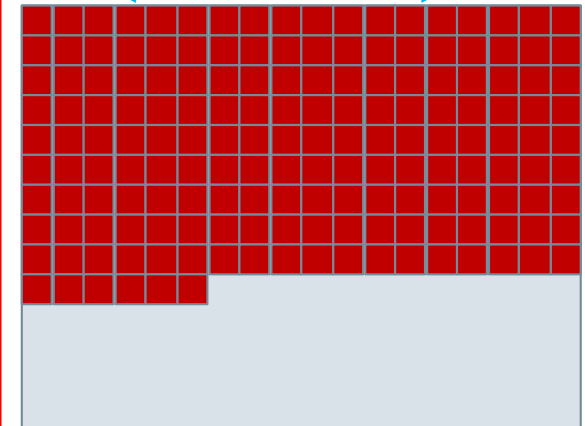
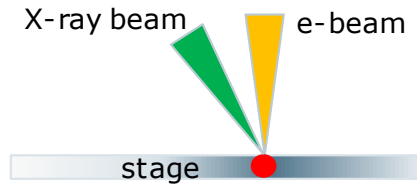
Scan Map Without Limits
(Raster over Full Area)
e.g. Low Mag. 30x

Type II

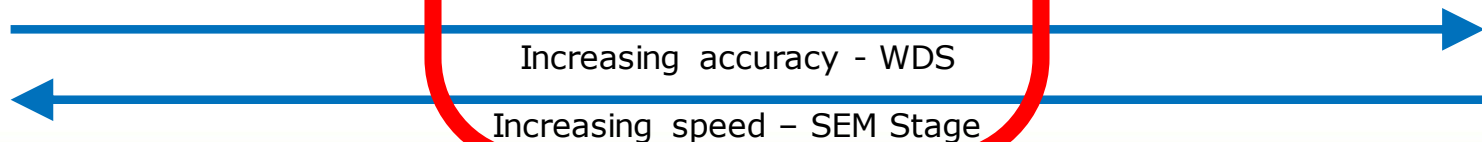


Scan Map With Limits
(Raster over Restricted Area
with Stage Movement)

Type III



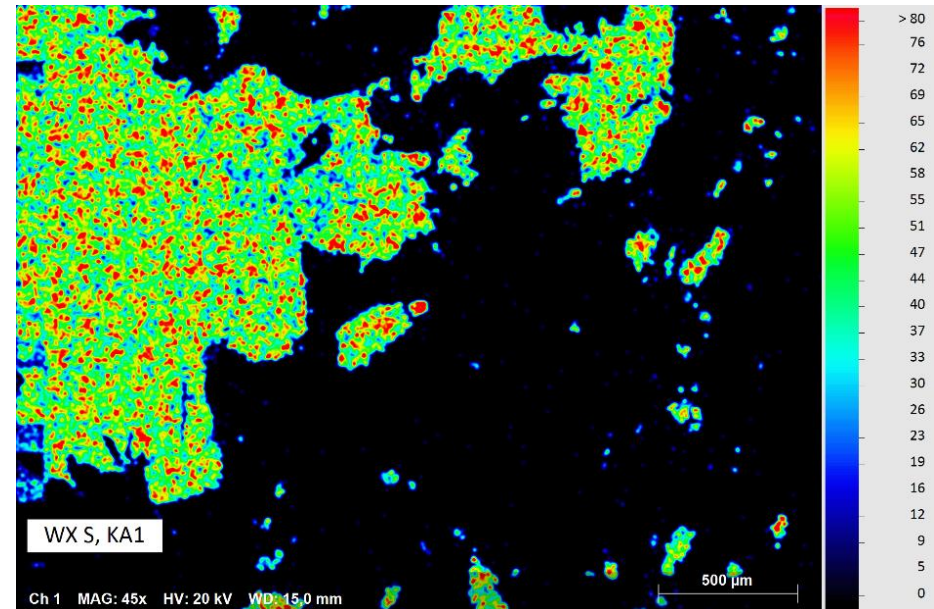
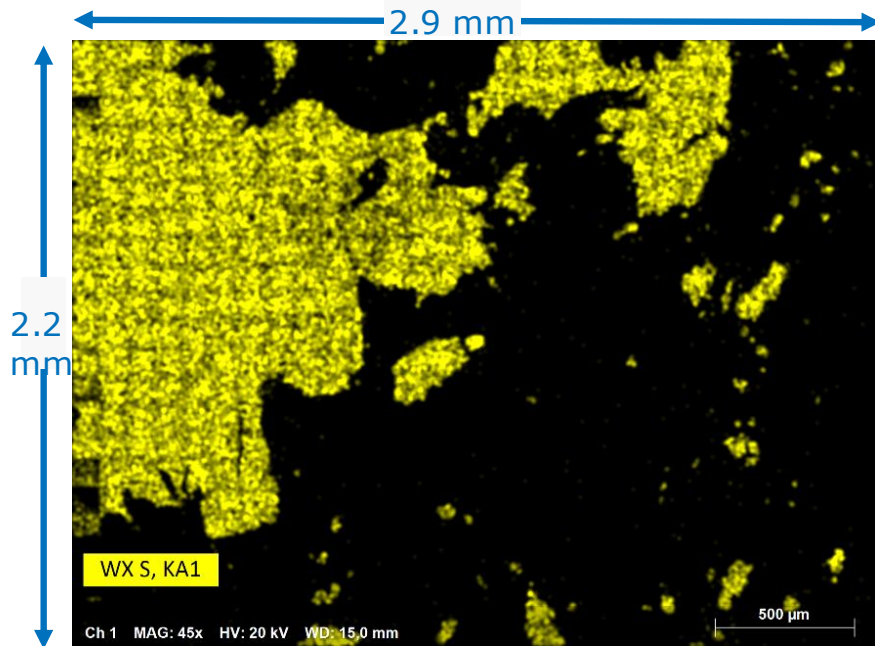
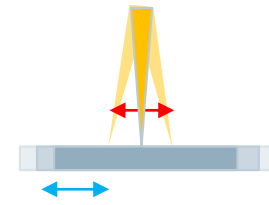
Stage Map
Independent of Magnification



Scan Mapping with Range Limits

Sample 1 at low magnification

Segmented Map: 29 x 22 Tiles



- ✓ Faster than stage map
- ✓ Intensity fading reduced

- Slower than scan map without limits
- Tiling may be visible

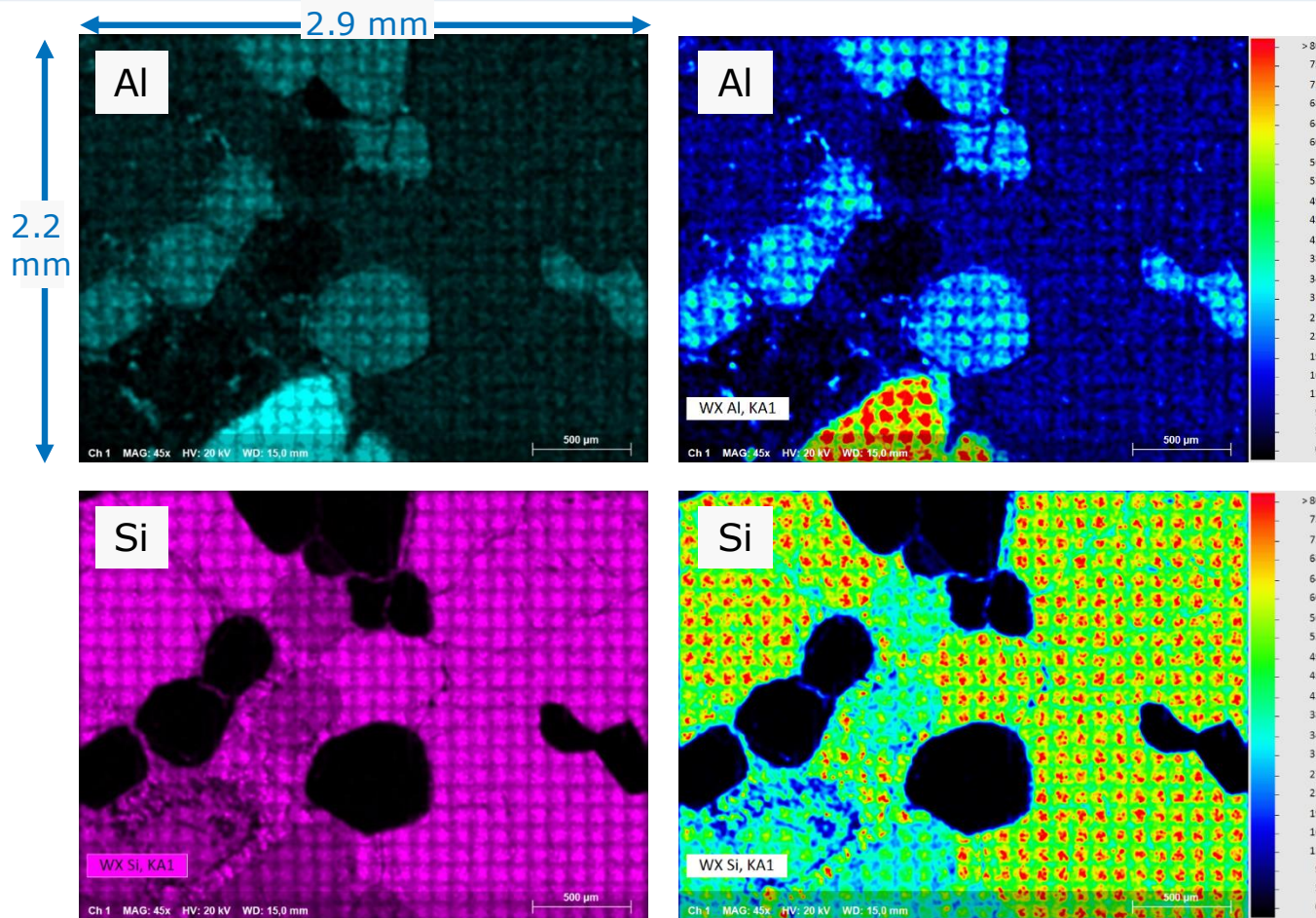
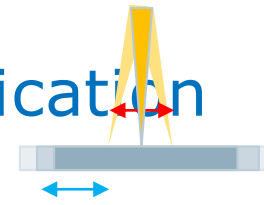
Type II Mapping: Low Magnification – Multiple Tiles 29 x 22

Bragg Angle Effect is lowered but may still be visible in mosaics

Scan Mapping with Range Limits

Sample 2 with Tiling at low magnification

Extended Map: 29 x 22 Tiles



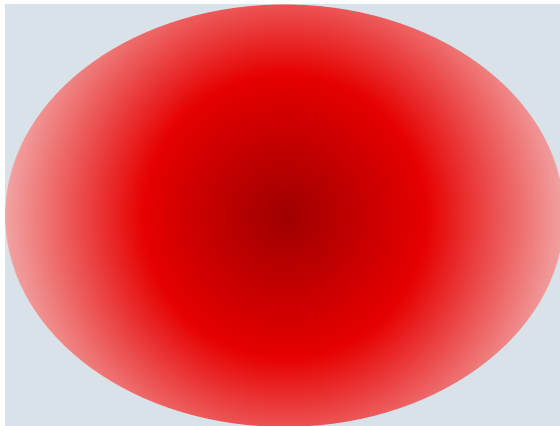
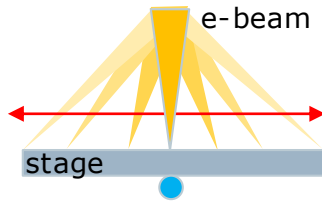
Type II Mapping: Low Magnification – Multiple Tiles 29 x 22
Bragg Angle Effect is lowered but may still be visible in mosaics

Large Area Mapping

Type IIIa: SEM Stage

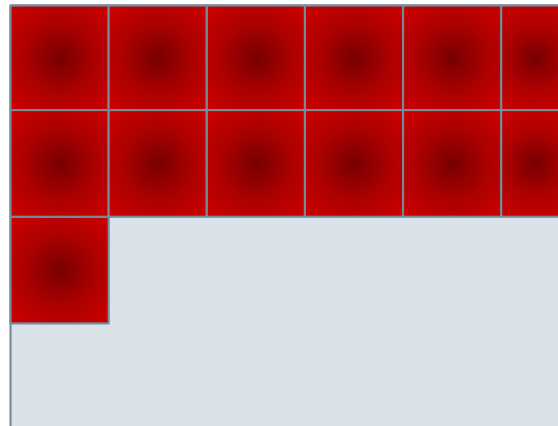
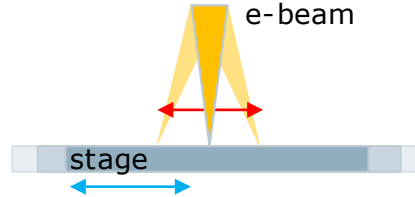


Type I



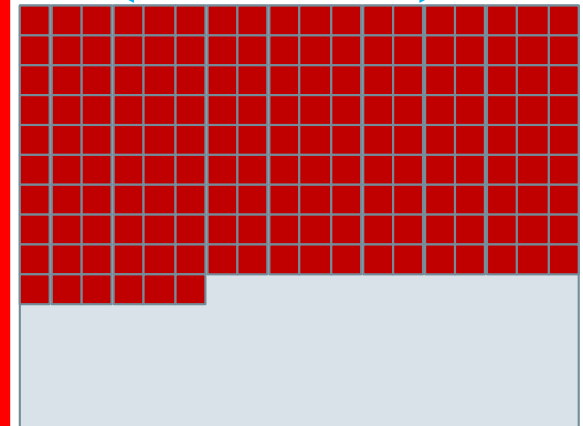
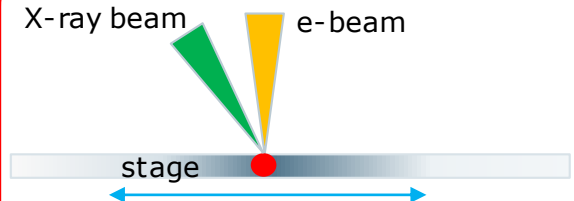
Scan Map Without Limits
(Raster over Full Area)
e.g. Low Mag. 30x

Type II

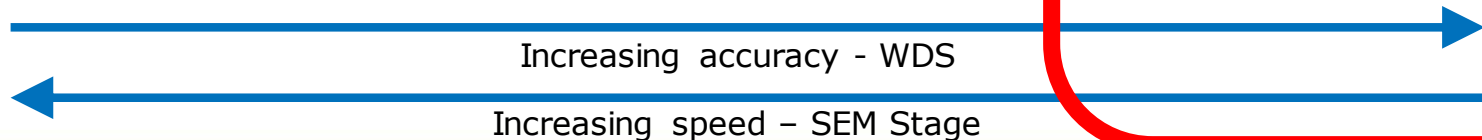


Scan Map With Limits
(Raster over Restricted Area
with Stage Movement)

Type III



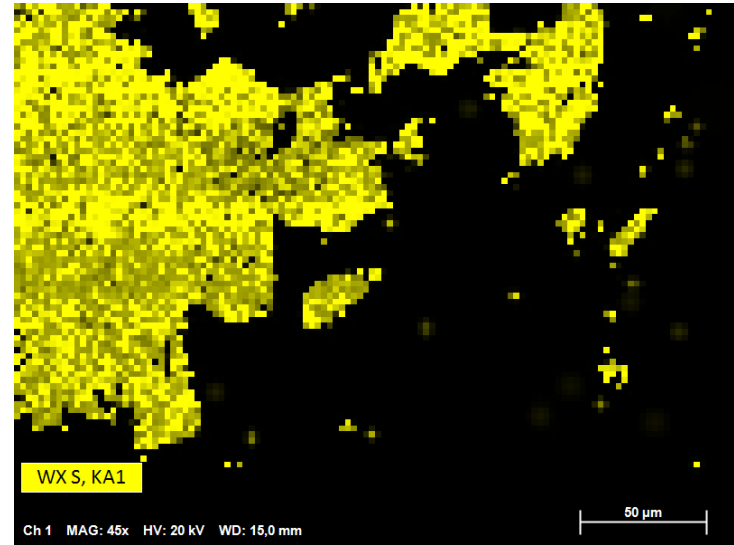
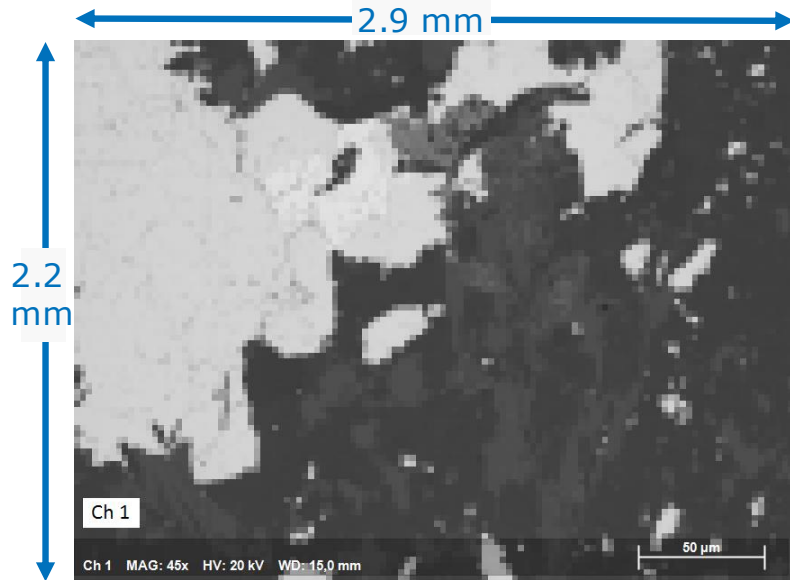
Stage Map
Independent of Magnification



Stage Mapping using SEM Stage

Sample 1 at low magnification

SEM-EDS/WDS



$120 \times 90 = 10,800 \text{ px}$ → 10 h

$1200 \times 900 = 1,080,000 \text{ px}$ → 42.5 d

Type IIIa Mapping: Low Magnification – Single Field Equivalent
High Analytical Time due to slow SEM Stage Movement

For SEM-EDS/WDS:

Not Practical or Realistic use of Analytical Equipment.

For SEM-XRF (Micro-XRF)

This is standard method, but slow. Fixed X-ray beam.

Stage Mapping using SEM Stage

Sample 2 at low magnification

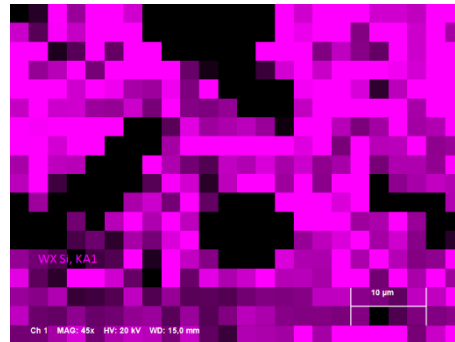
SEM-EDS/WDS



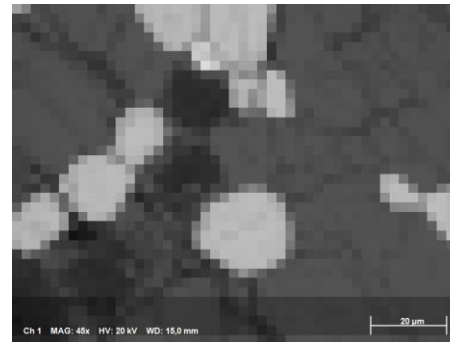
Effective time: 3.4 s / per pixel



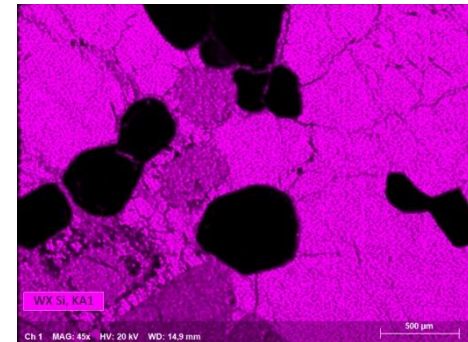
6x4 px = 82 s



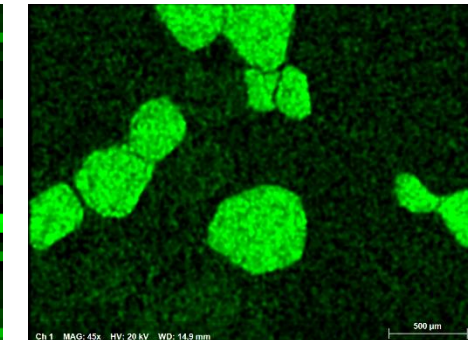
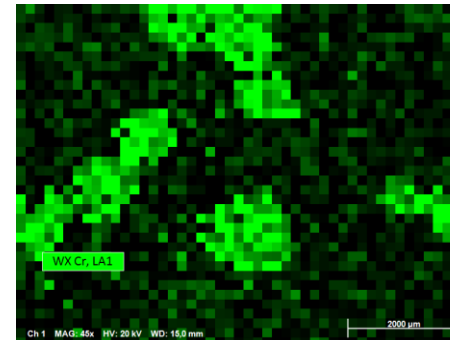
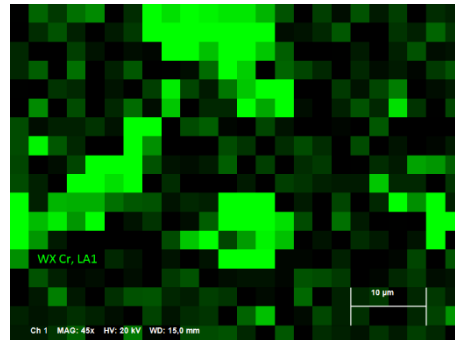
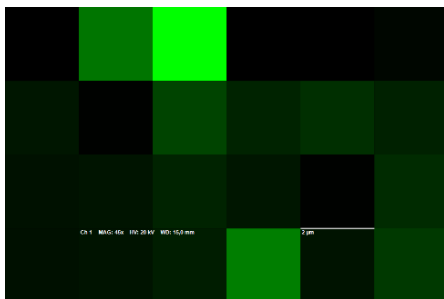
24x18 px = 25 min



48x36 px = 97 min



1200x900 px = 42 d



Type IIIa Mapping: Low Magnification – Single Field Equivalent
High Analytical Time due to slow SEM Stage Movement

Stage Mapping using SEM Stage

Sample 2 at low magnification

SEM-XRF



Large Area Map

Sample Size: Polished Section: 45 x 30 mm

Sample from El Tesoro, Chile.

Clearly Defined Elemental and Mineralogical Phases
Can identify the presence of trace elements, in this case, Cobalt (Co), Manganese (Mn), Strontium (Sr)

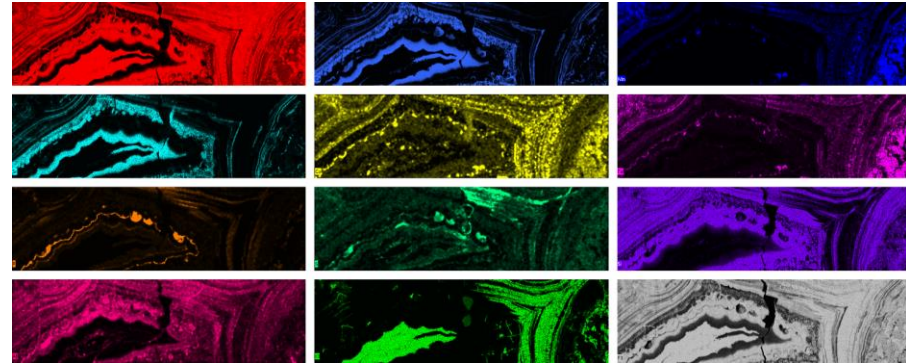
Analytical Parameters:

Tube Voltage: Rh at 50 kV

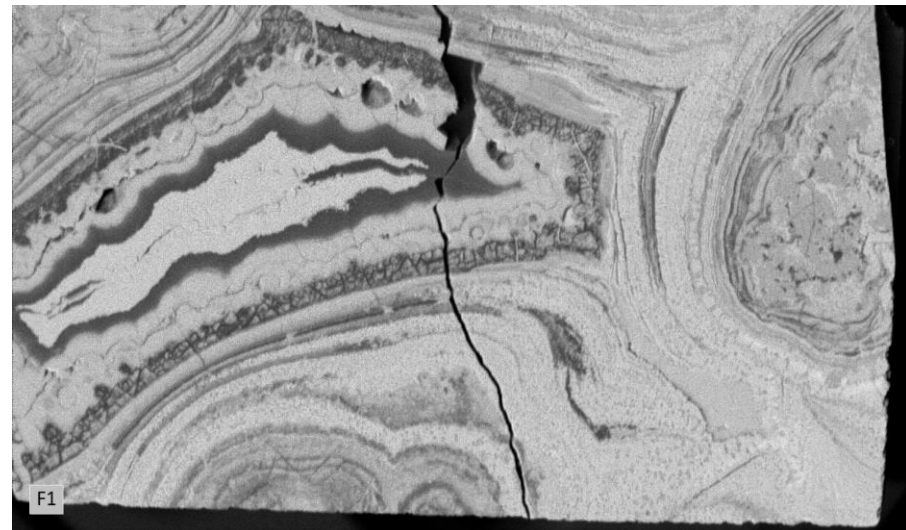
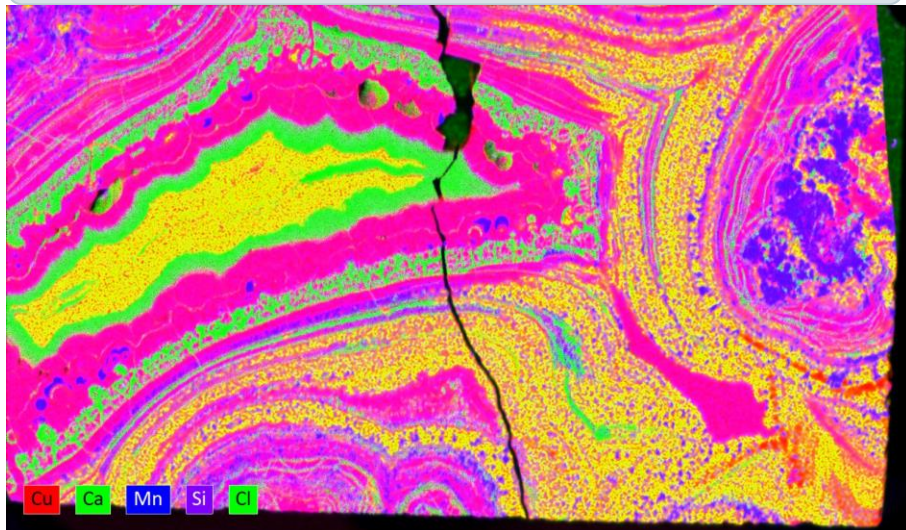
Anode Current: 600 μ A

Pixel Spacing: 25 μ m

Analytical Time: Rapid Stage 101 mins
SEM Stage >800 mins



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

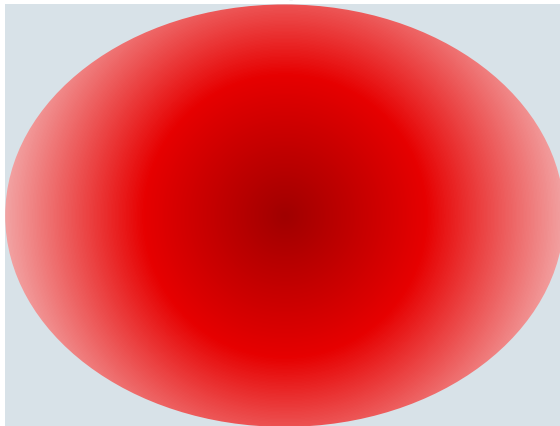
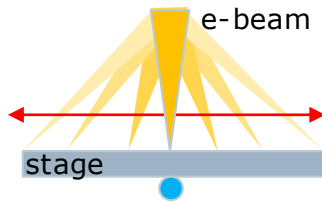


Large Area Mapping

Type IIIb: Rapid Stage

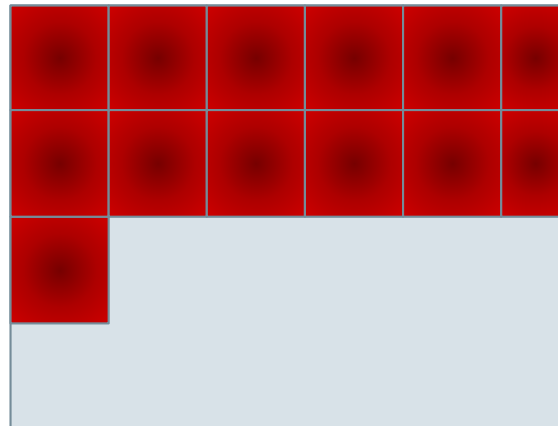
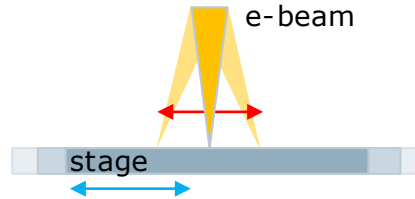


Type I



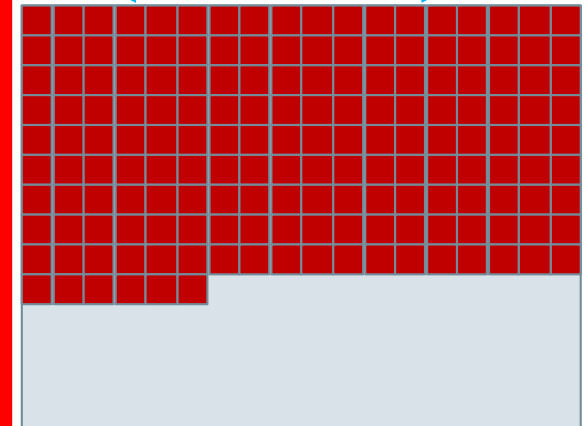
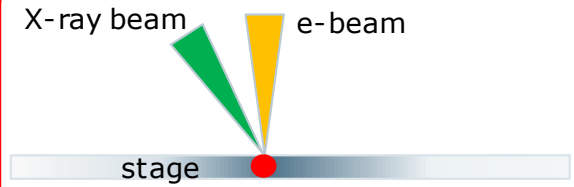
Scan Map Without Limits
(Raster over Full Area)
e.g. Low Mag. 30x

Type II

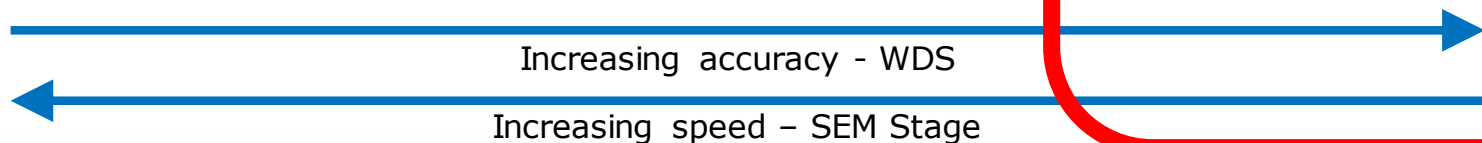


Scan Map With Limits
(Raster over Restricted Area
with Stage Movement)

Type III

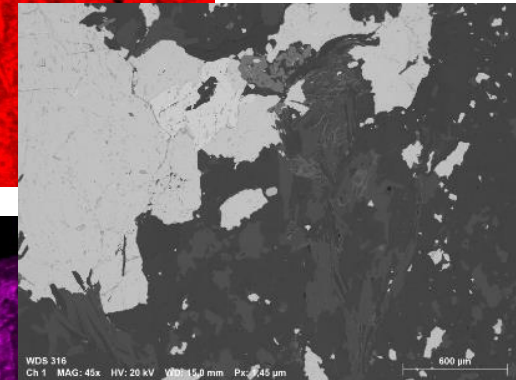
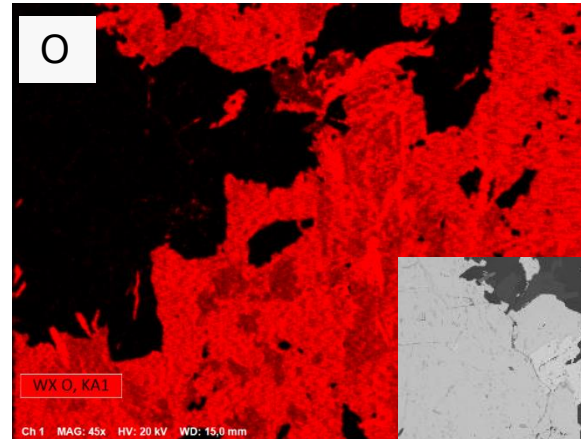
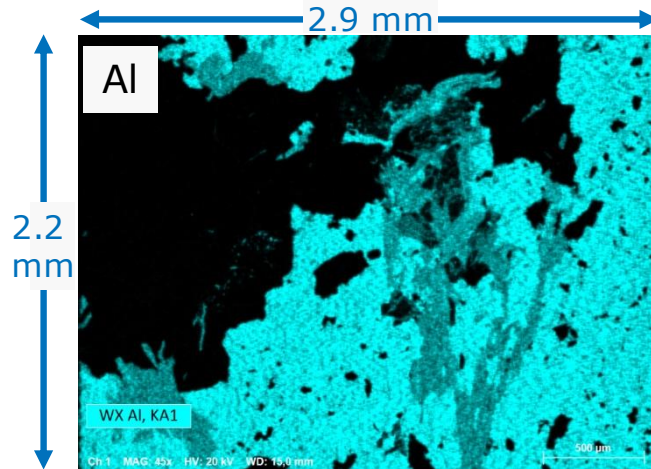


Stage Map
Independent of Magnification



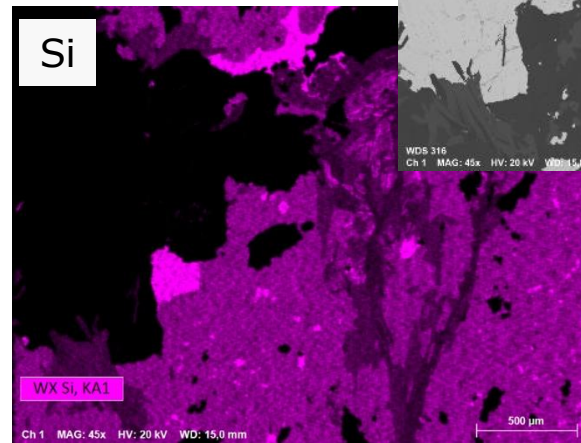
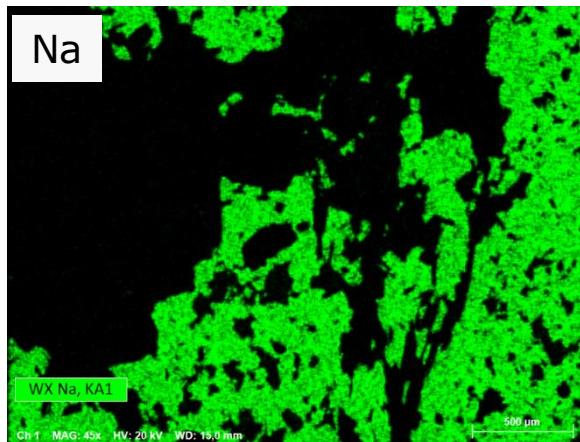
Stage Mapping using Rapid Stage

Sample 1 at low magnification



Dwell time:
4 ms / px

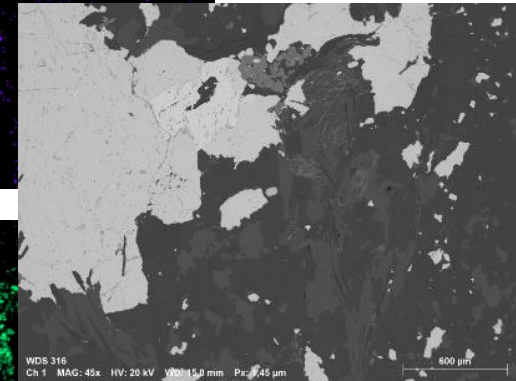
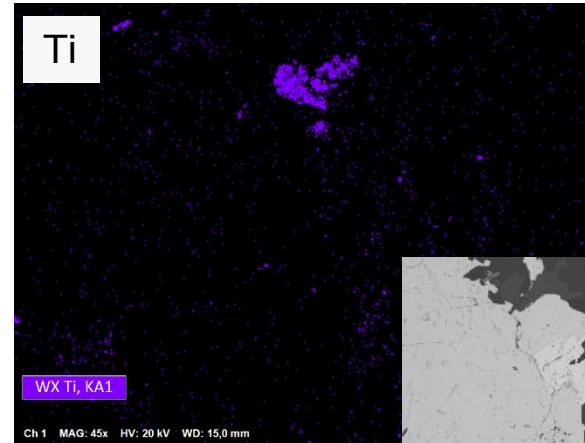
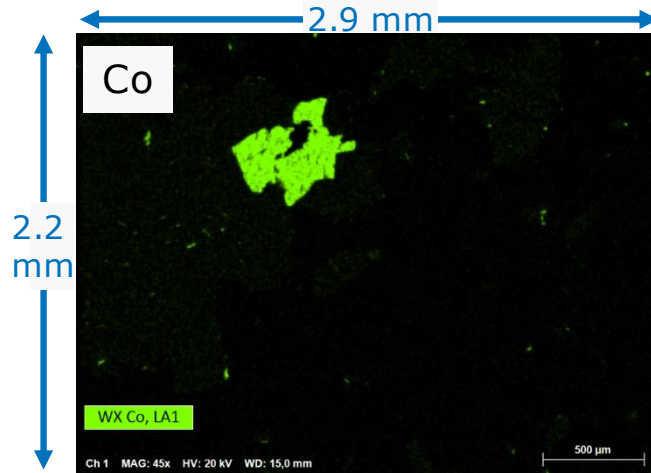
Analytical
time: 1 h /
frame



Type IIIb Mapping: Low Magnification – Single Field Equivalent
High speed mapping with no artifacts

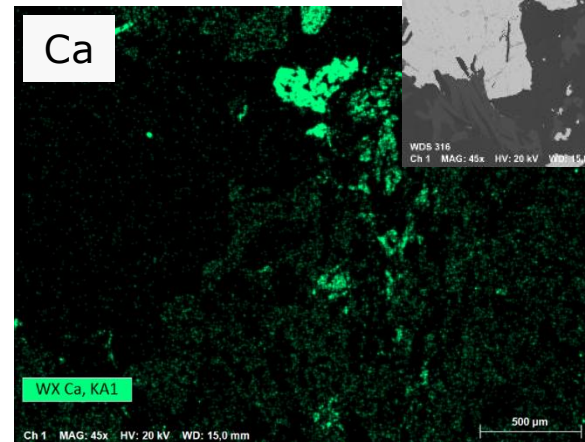
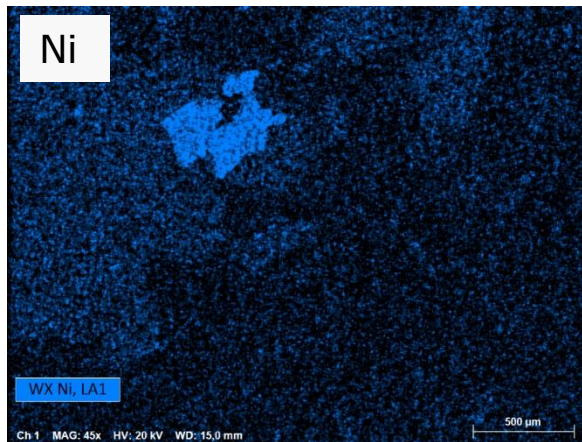
Stage Mapping using Rapid Stage

Sample 1 at low magnification



Dwell time:
4 ms / px

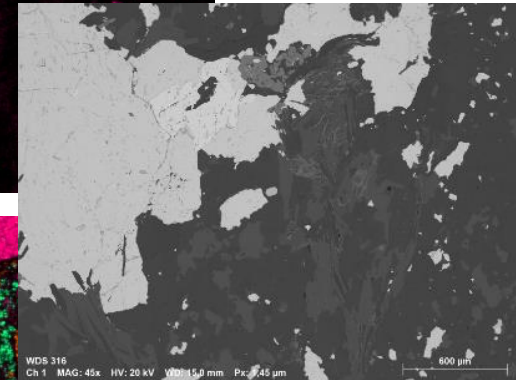
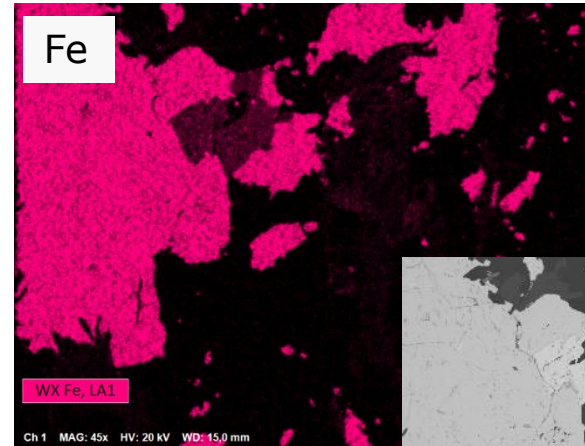
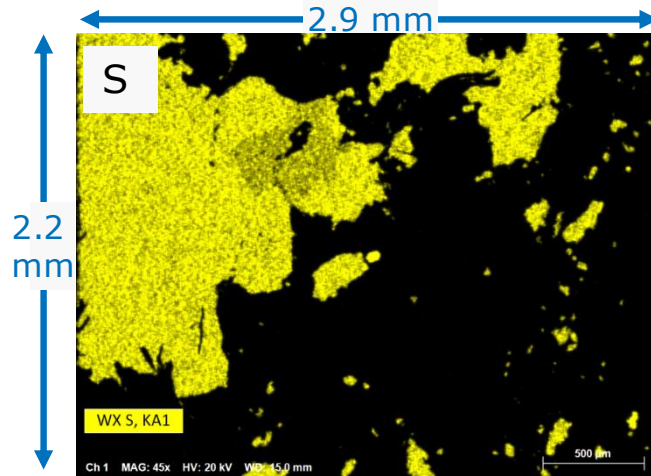
Analytical
time: 1 h /
frame



Type IIIb Mapping: Low Magnification – Single Field Equivalent
High speed mapping with no artifacts

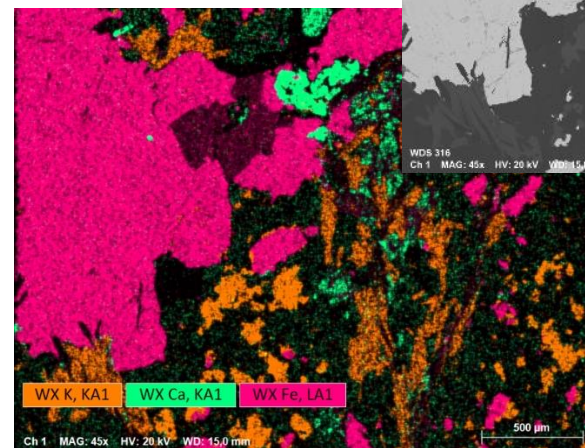
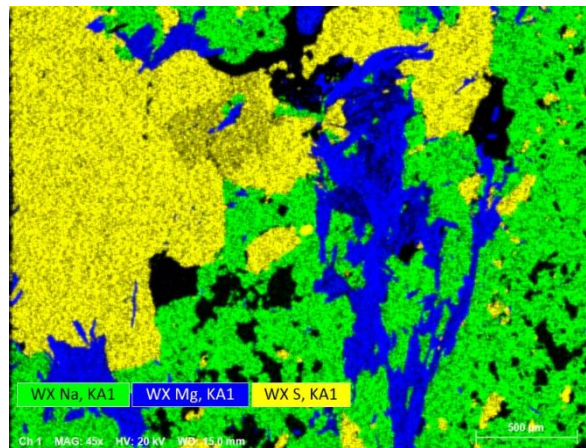
Stage Mapping using Rapid Stage

Sample 1 at low magnification



Dwell time:
4 ms / px

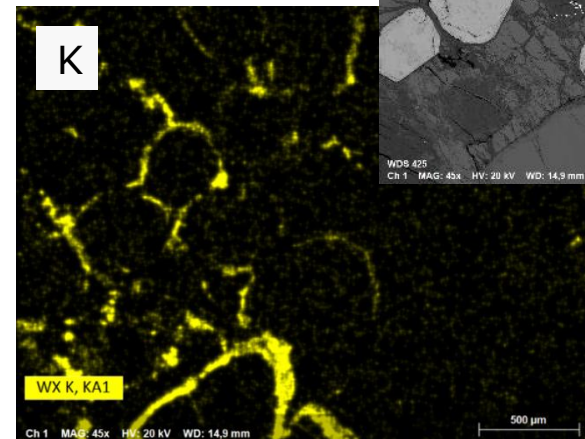
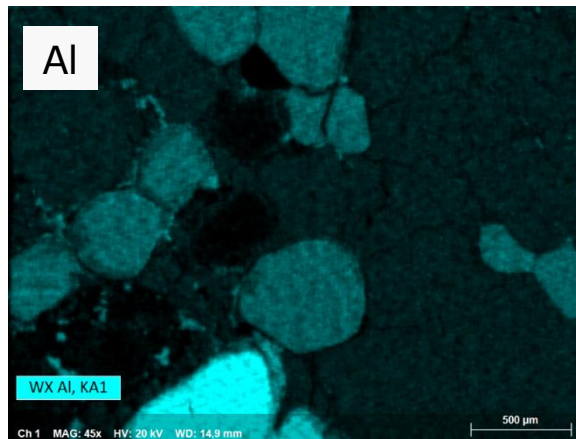
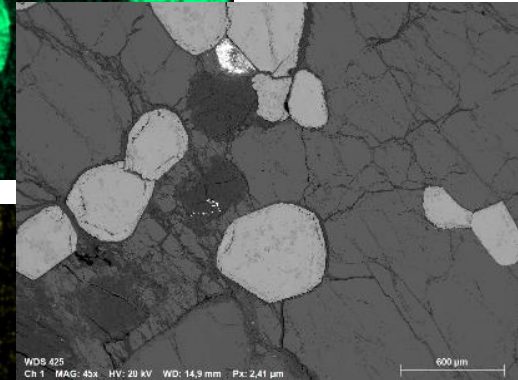
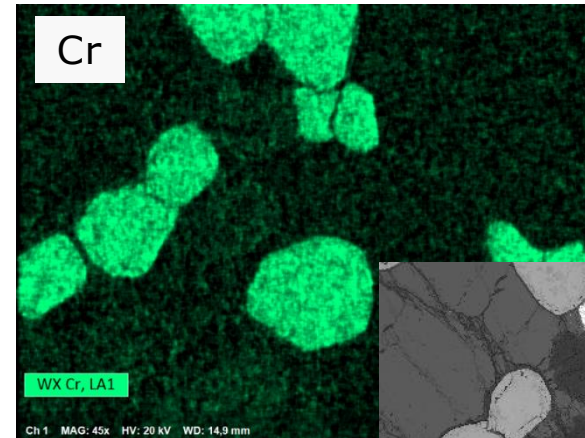
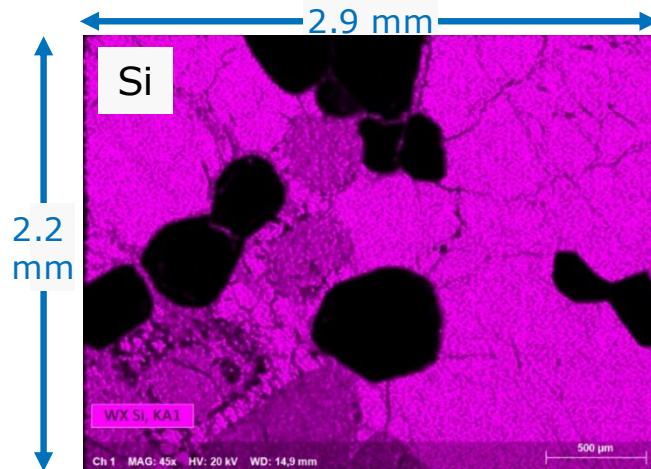
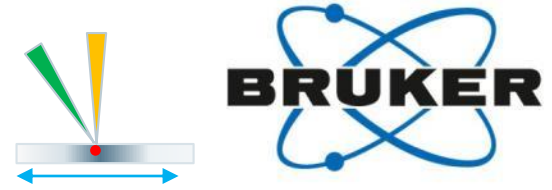
Analytical
time: 1 h /
frame



Type IIIb Mapping: Low Magnification - Single Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage

Sample 2 at low magnification

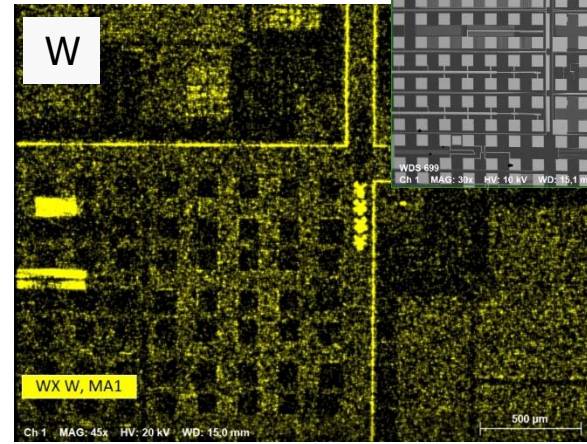
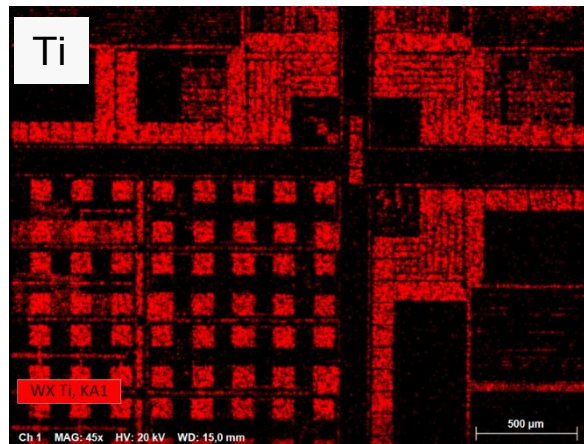
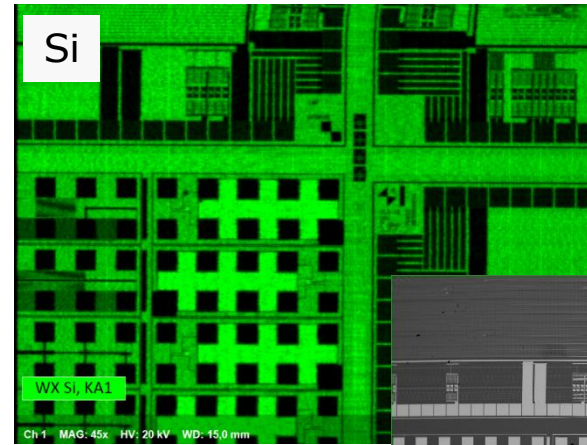
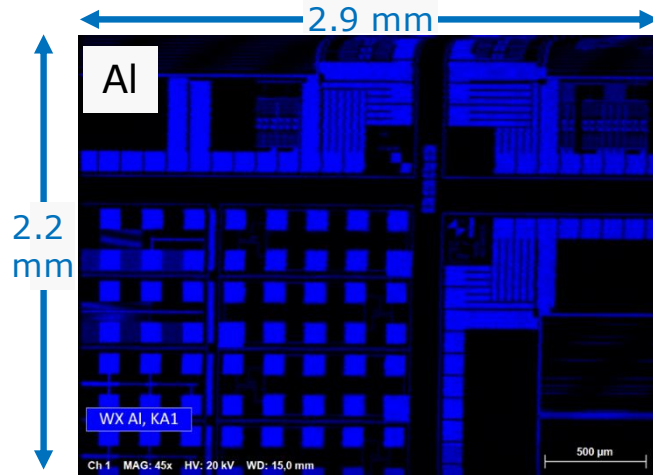


Dwell time:
4 ms / px

Analytical
time: 72
min / frame

Type IIIb Mapping: Low Magnification – Single Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage Sample 3 at low magnification



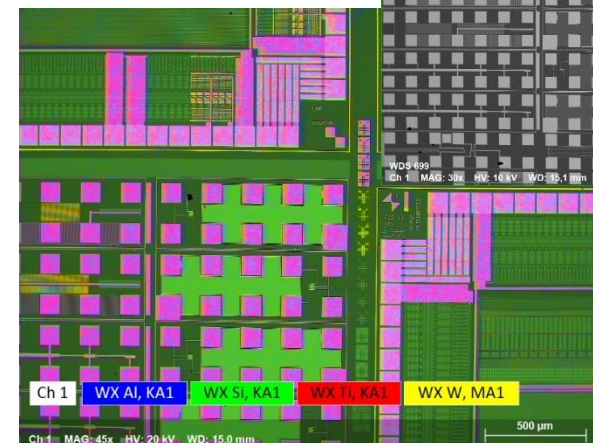
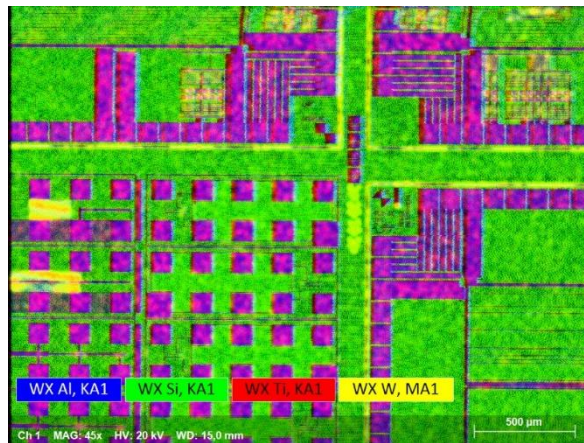
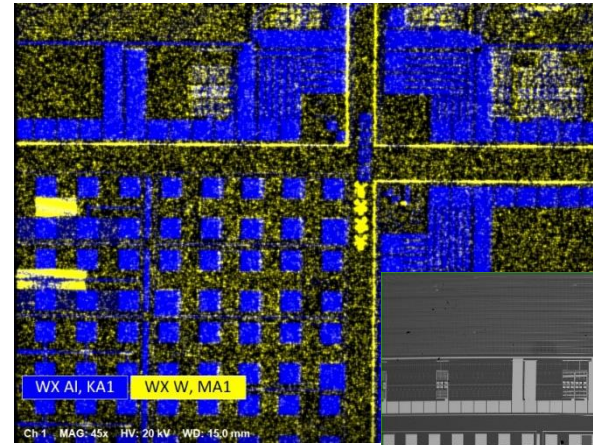
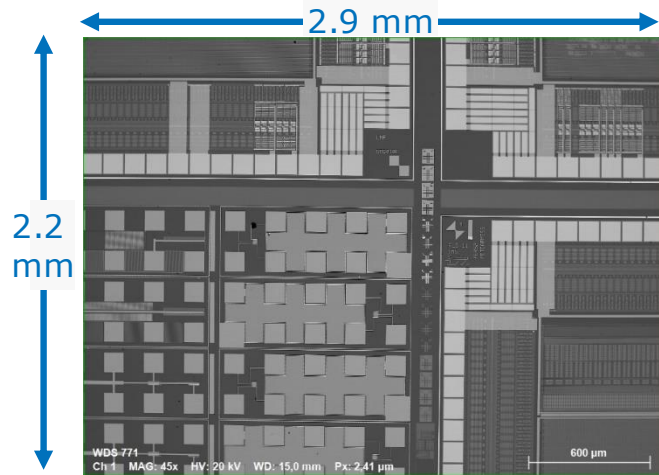
Dwell time:
6.9 ms / px

Analytical
time: 2 h /
frame

Type IIIb Mapping: Low Magnification – Single Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage

Sample 3 at low magnification



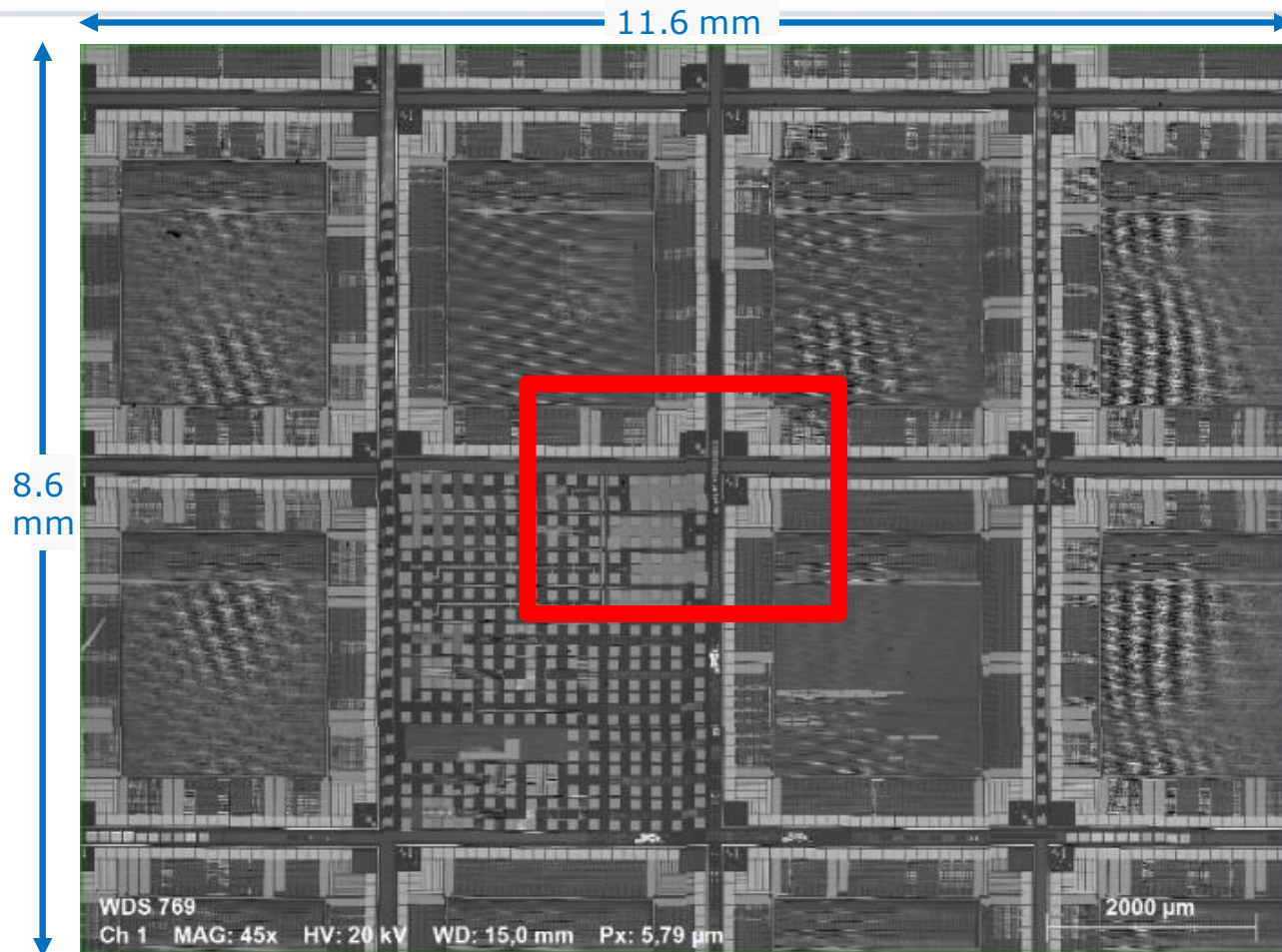
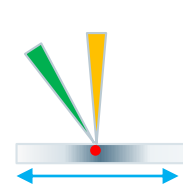
Dwell time:
6.9 ms / px

Analytical
time: 2 h /
frame

Type IIIb Mapping: Low Magnification – Single Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage

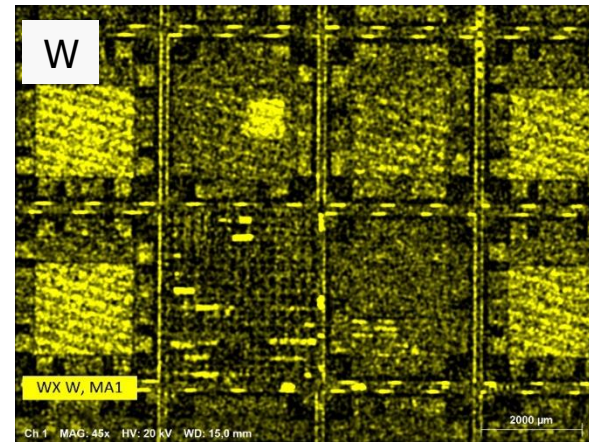
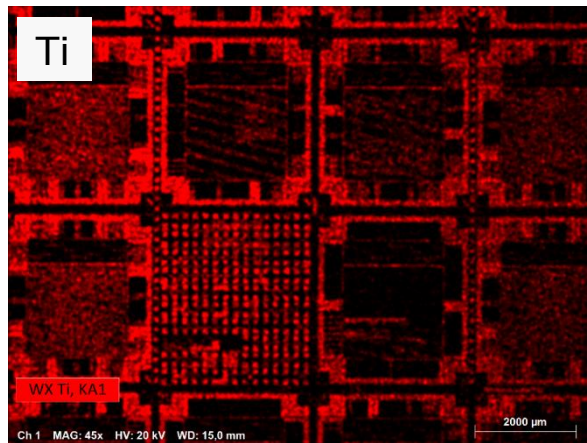
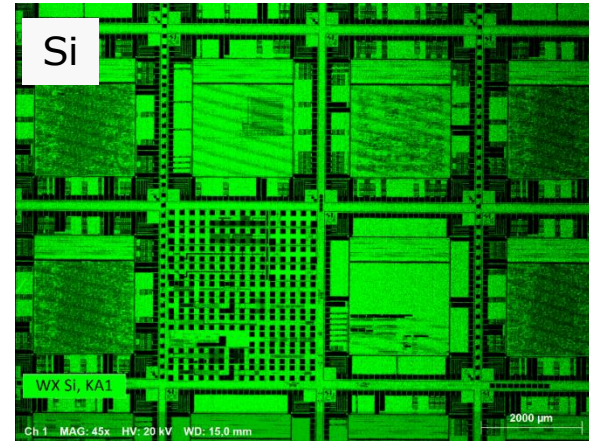
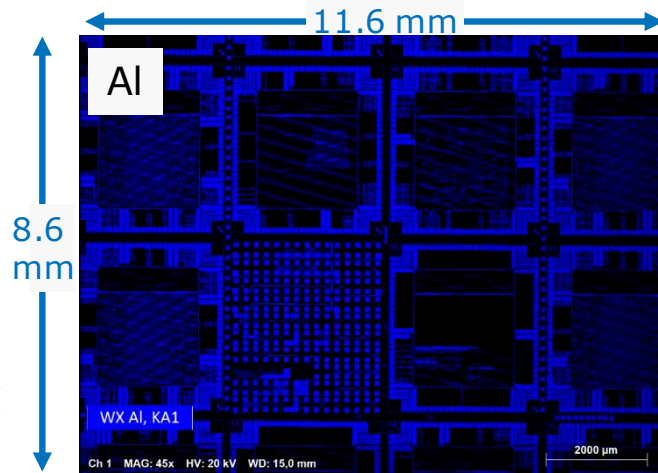
Sample 3 extended area: 4x4



Type IIIb Mapping: Low Magnification – Multiple Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage

Sample 3 extended area



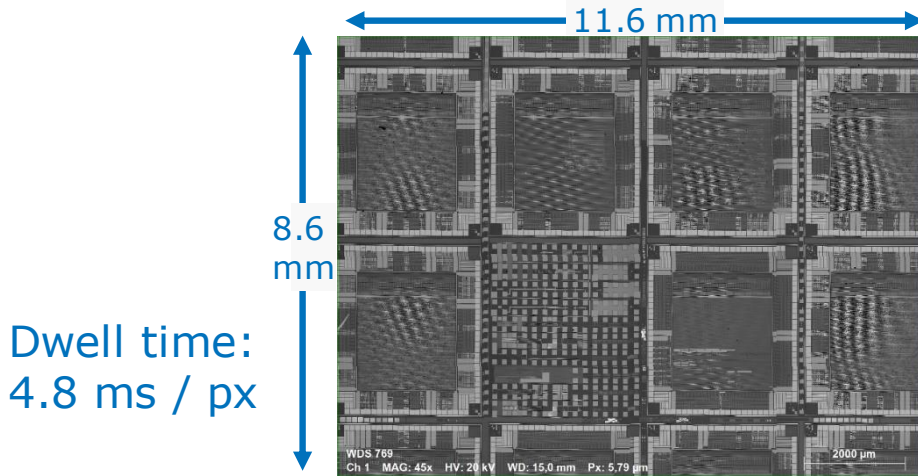
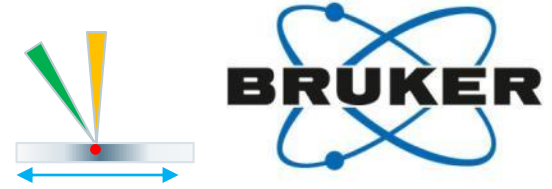
Dwell time:
4.8 ms / px

Analytical
time: 4 h /
frame

Type IIIb Mapping: Low Magnification – Multiple Field Equivalent
High speed mapping with no artifacts

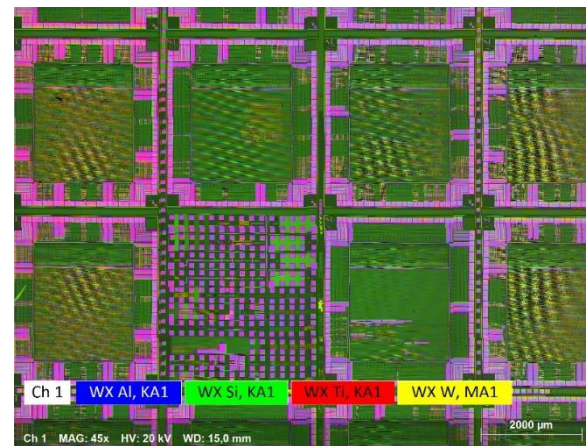
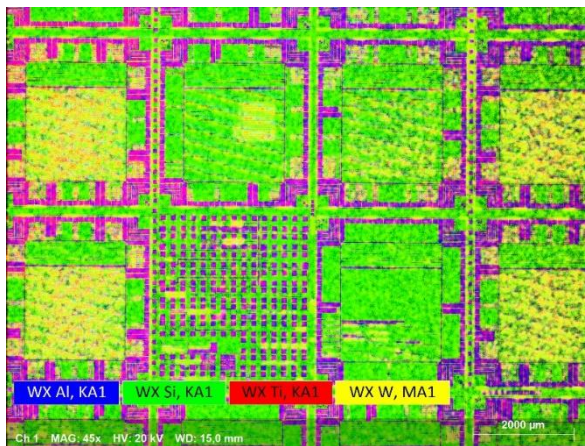
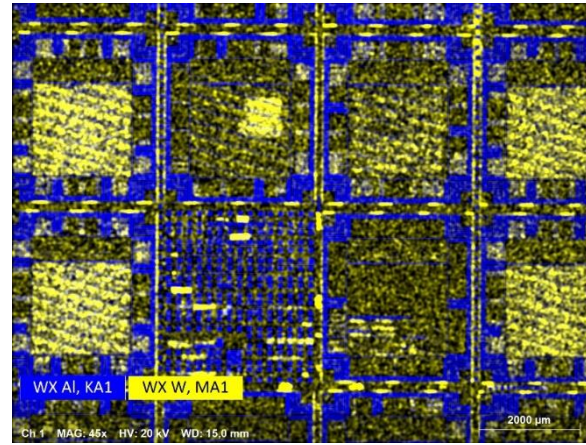
Stage Mapping using Rapid Stage

Sample 3 extended area



Dwell time:
4.8 ms / px

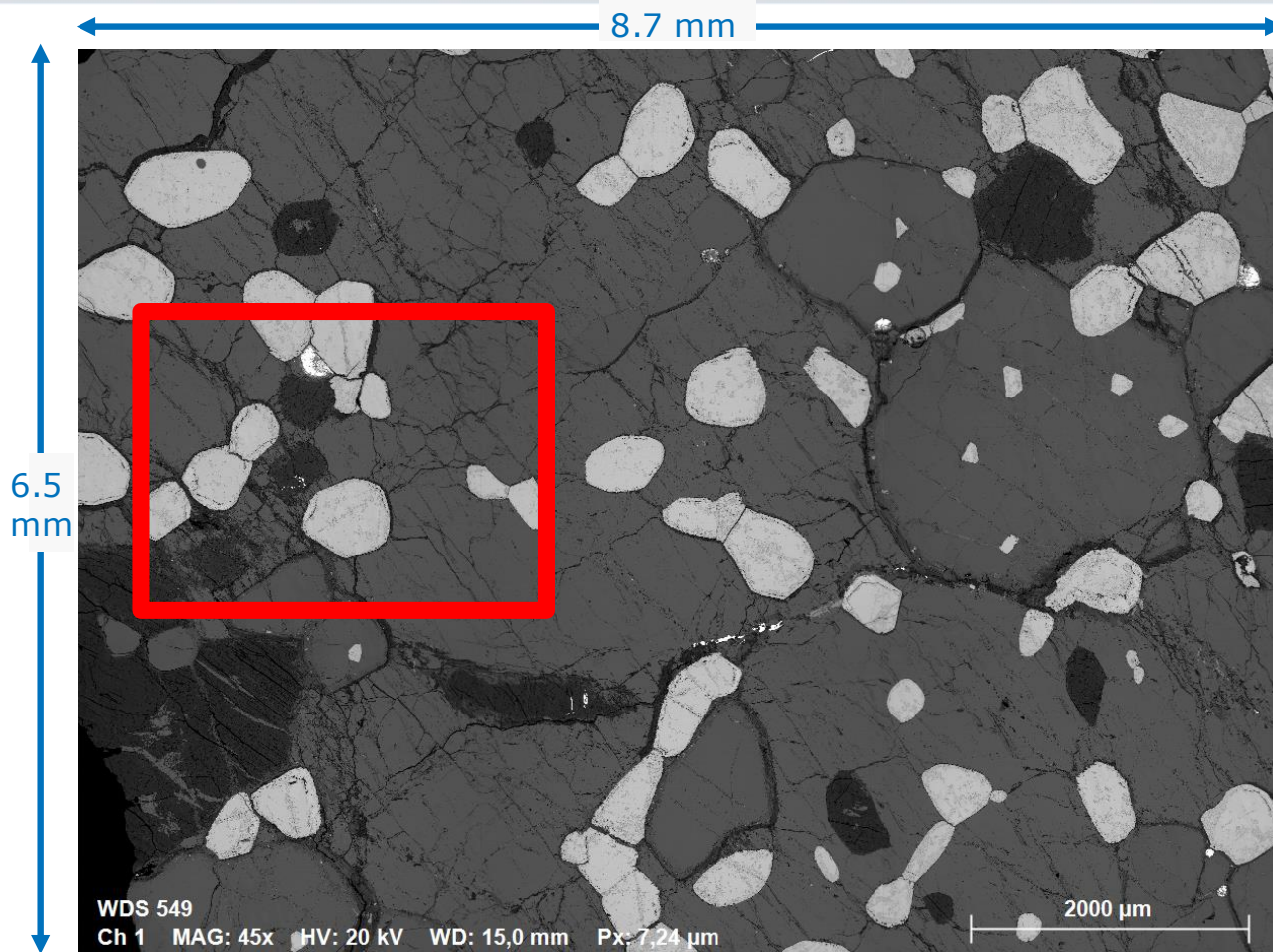
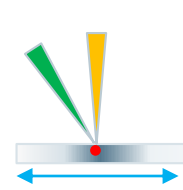
Analytical
time: 4 h /
frame



Type IIIb Mapping: Low Magnification – Multiple Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage

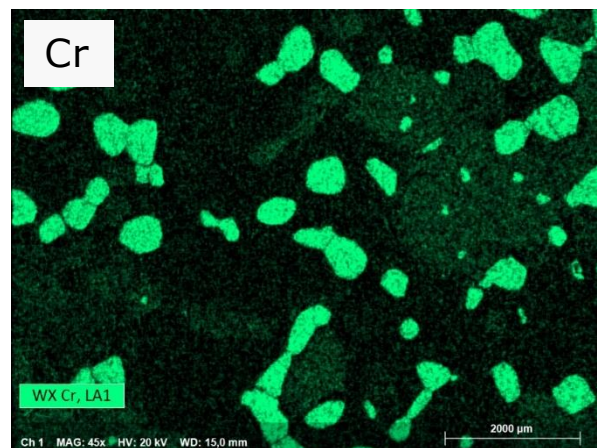
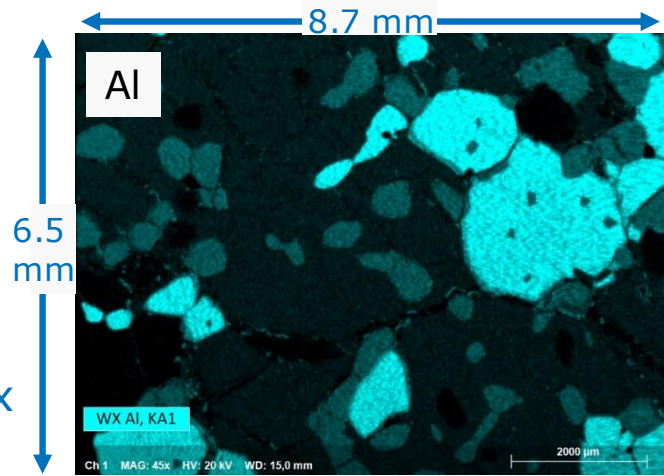
Sample 2 extended area: 3x3



Type IIIb Mapping: Low Magnification – Multiple Field Equivalent
High speed mapping with no artifacts

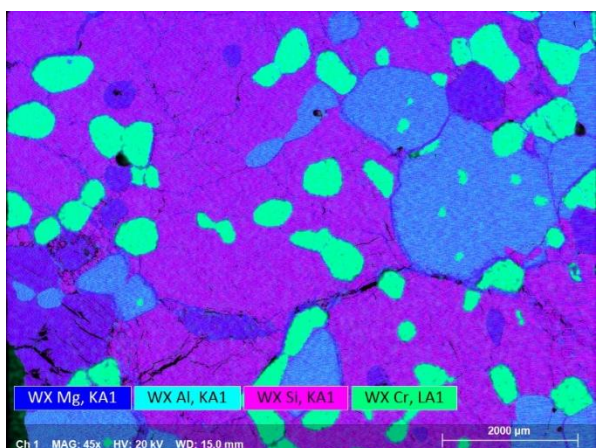
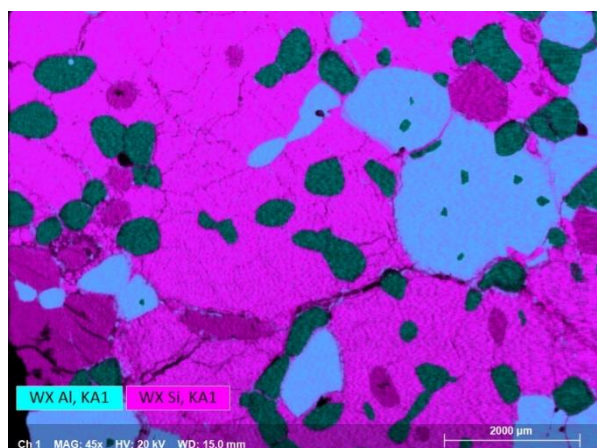
Stage map using Rapid Stage

Sample 2 extended area



Dwell time:
15.4 ms / px

Analytical
time: 4.5 h /
frame



Type IIIb Mapping: Low Magnification – Multiple Field Equivalent
High speed mapping with no artifacts

Stage Mapping using Rapid Stage Sample 2 extended area



MAPPING

Sample Test sample Standards ESL-506-1! Micro... HV ---kV X-ray... HV 0.0 kV Scan 1000 px EDS ICR 60 kcps WDS ---eV EBSD Size 80 px Report Report_0 Project (mod.) 18/09/2019 14:00 3 kB Map result table

Preview Capture Acquire QMap EDS Linemarker + PB-ZAF XRF XRF Loaded: C:\Data\Bruker - XTrace\Data\Applications - Geology\SouthAfrica-Mantle\AHM710_Speed0200_Pixel100.bcf

Ch1 Ch2 Map Phases

Map Phases Charts Line scan Spectrum

MAP INFORMATION

Mapping parameter

- Width: 600 pixel
- Height: 450 pixel
- Pixel size: 27000 μm

Acquisition parameter

- Pixel time: 128 ms
- Overall time: 577 min

Tube parameter

- High voltage: 50 kV
- Anode current: 600 μA
- Filter: Empty
- Optic: Lens
- Chamber at: Vacuum

Sample information

Close

Loaded image 600 x 450 15.4 x 11.5 mm

Table of elements Finder

H	He	F1	F2	F3	F4	F5	F6	F7	F8	He
Li	Be	Inputs	I1	I2	I3	I4	I5	I6	I7	I8
Na	Mg	Al	Si	P	S	Cl	Ar			
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
Zn	Ga	Ge	As	Se	Br	Kr				
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag
Cd	In	Sn	Sb	Te	I	Xe				
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au
Hg	Tl	Pb	Bi	Po	At	Rn				
Fr	Ra	Ac	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb
Dy	Ho	Er	Tm	Yb	Lu					
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm
Md	Nd	Lr								

Map display settings

Image filter: None Smooth Sharpen

Map filter: None Average Smooth Automatic

Result types: Counts

Color control: * 0.00, 1.00

Palette mode: Color count: 256, Minimum: 0.0, Maximum: 0.0

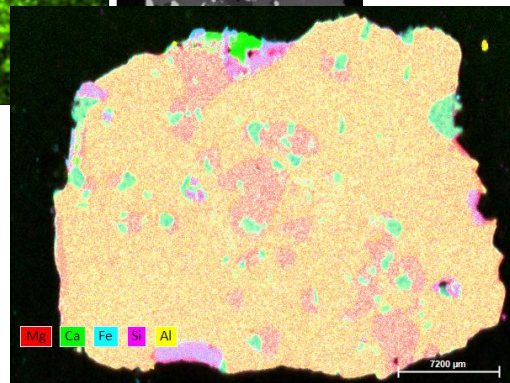
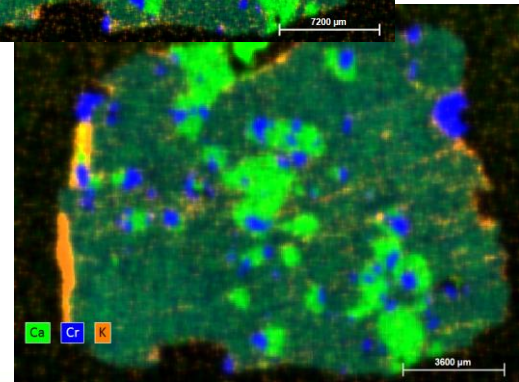
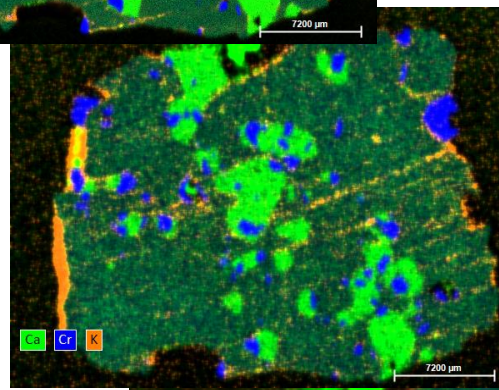
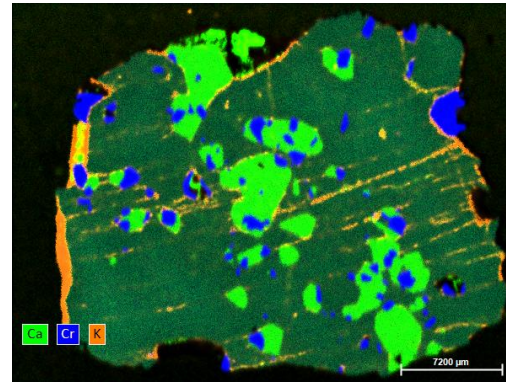
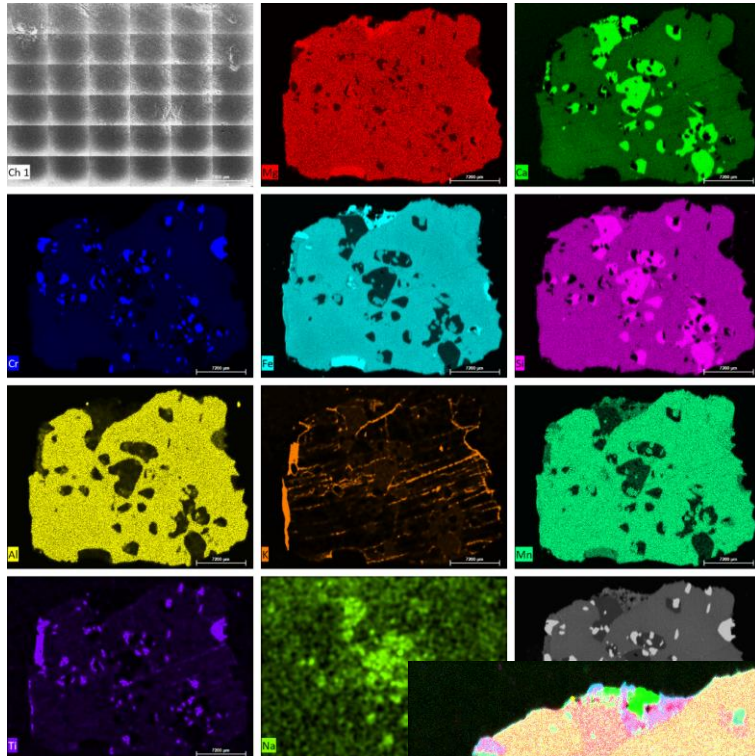
Map result list

Counts/Pixel Area Ch1 Mg-K Ca-Ka Cr-Ka Fe-Ka Si-K Al-K K-Ka Mn-Ka Ti-Ka Na-Ka F1

Ch1 1.00 Mg-K 1.00 Ca-Ka 1.00 Cr-Ka 1.00 Fe-Ka 1.00 Si-K 1.00 Al-K 1.00 K-Ka 1.00 Mn-Ka 1.00 Ti-Ka 1.00 Na-Ka 1.00 F1 1.00

Stage Mapping using Rapid Stage

Sample 2 extended area



Mantle Peridotite:
 Garnet
 Chromite
 Clinopyroxene
 Olivine

Decreased Analytical Time :
 (minutes)
 577
 23
 11
Decreased Information per pixel

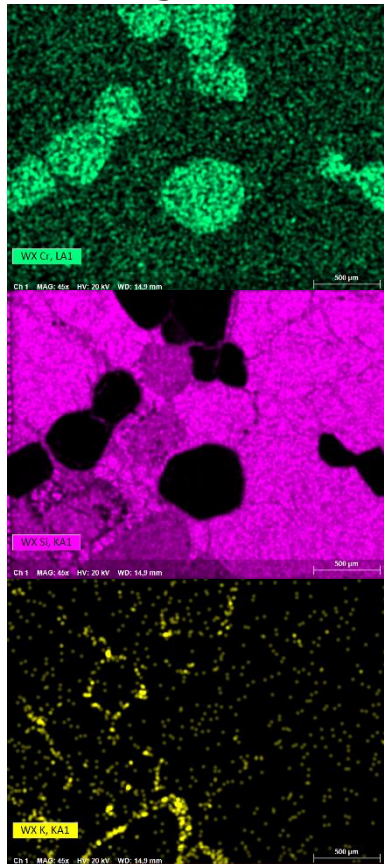


Stage Mapping using Rapid Stage

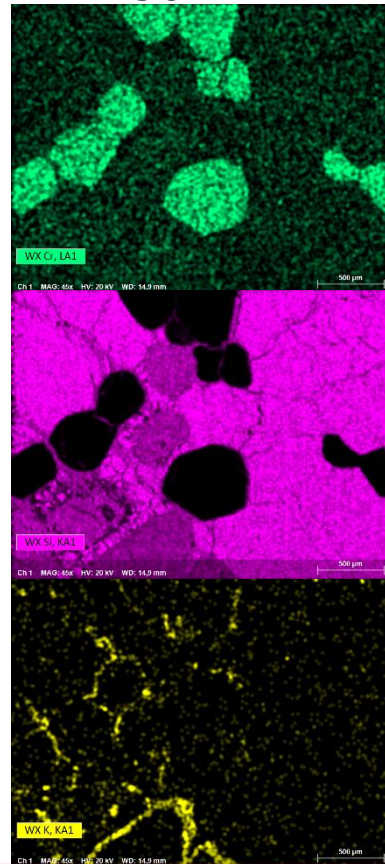
Effect of acquisition time



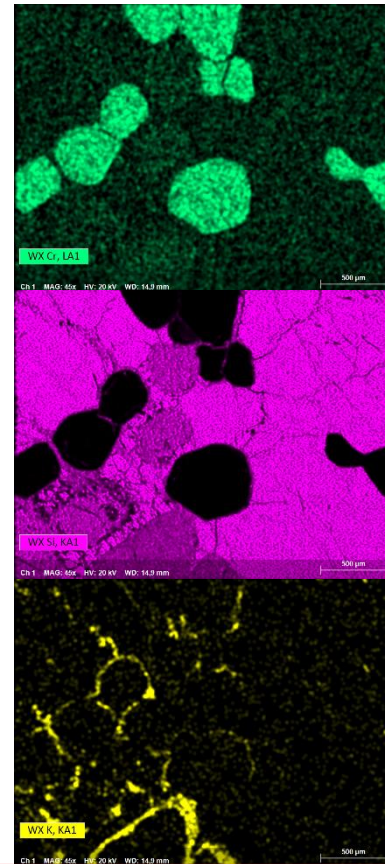
0.9 ms/px
15 min



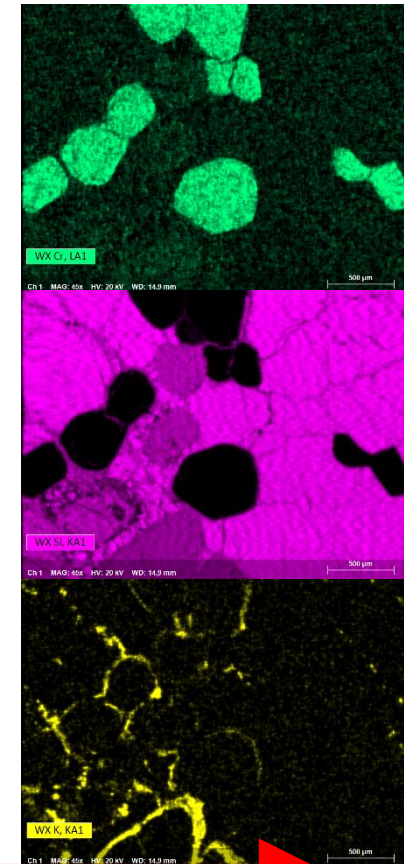
2 ms/px
36 min



4 ms/px
72 min



8 ms/px
144 min

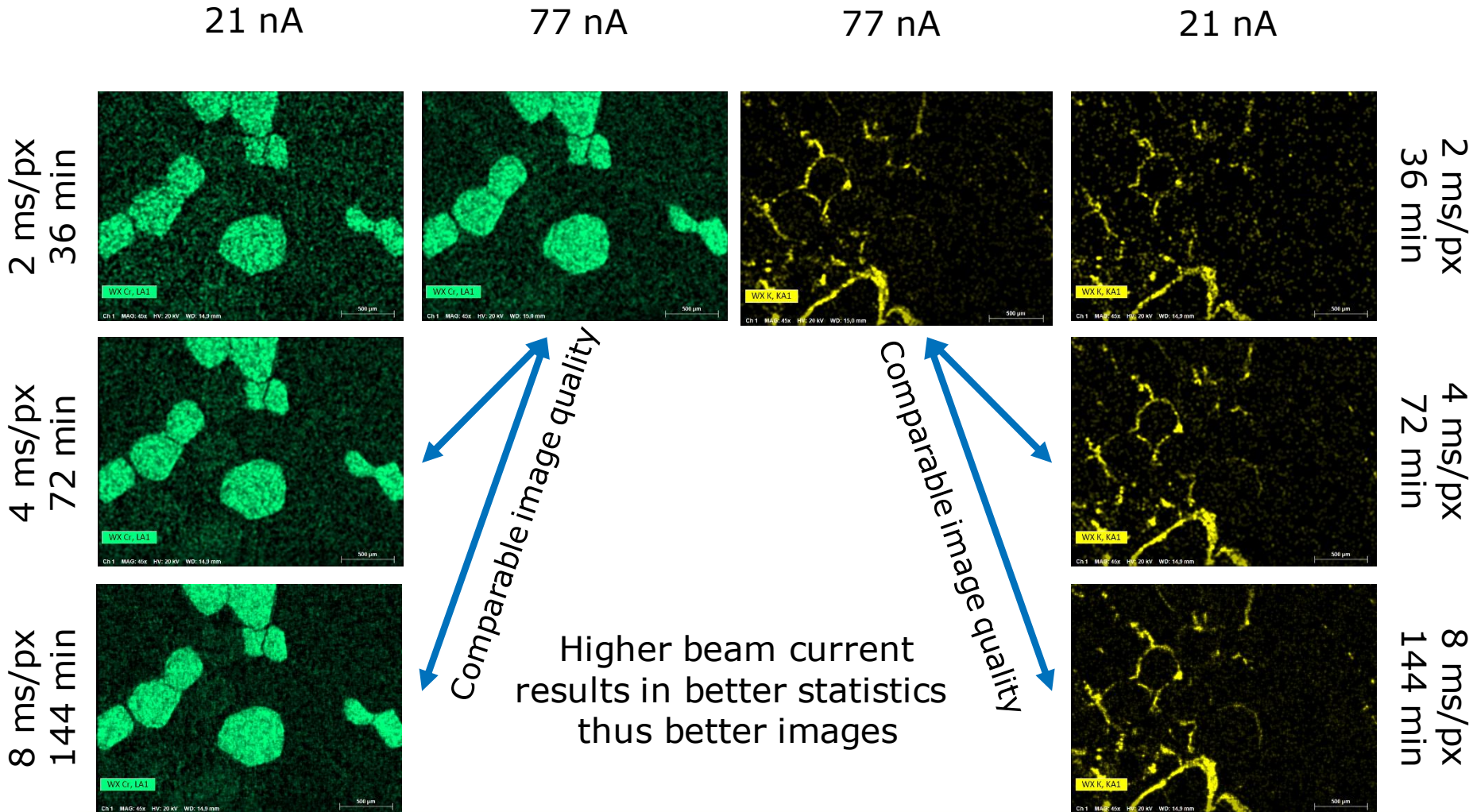


Increasing Information

Increasing Analytical Speed

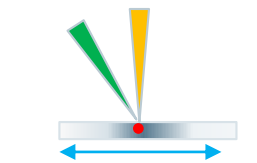
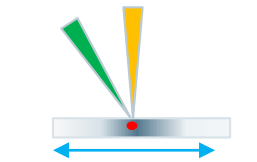
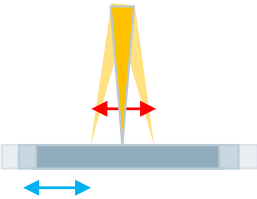
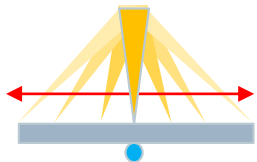
Stage Mapping using Rapid Stage

Effect of beam current



Large Area Mapping Summary

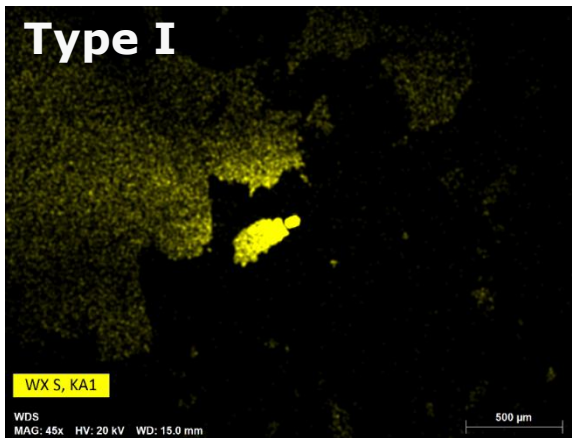
Mapping Types I, II, IIIa and IIIb



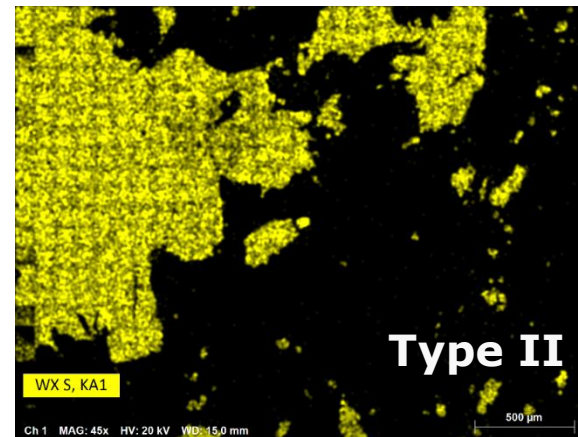
	FOV (mm)	FOV (px)	WDS Dwell time (ms/px)	Time /image (min)	Remarks
Type I: Raster Map	2.9 x 2.2	1200 x 900	8	60	Lateral intensity loss
Type II: Raster Map with Tiles	2.9 x 2.2	1200 x 900	8	360	Tiling may be visible
Type IIIa: SEM Stage Map	2.9 x 2.2	1200 x 900	8	60,480	Extremely slow
Type IIIb: Rapid Stage Map	2.9 x 2.2	1200 x 900	8	144	Fast and correct

Comparing mapping types

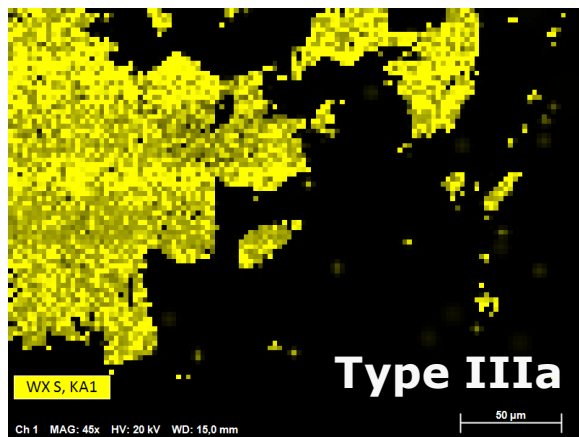
Sample 1 at low magnification



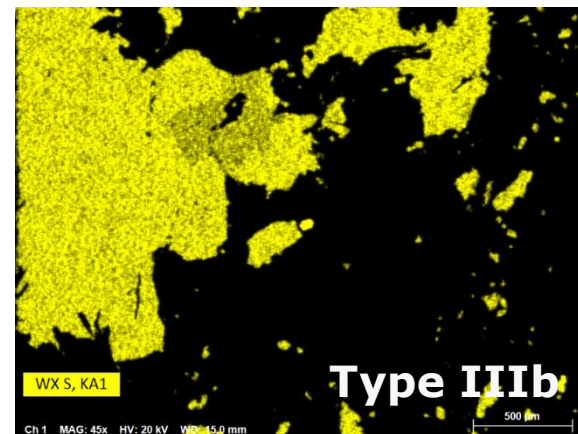
- ✓ Extremely fast
- Inaccurate at low magnification



- ✓ Relatively fast
- Tiling may be visible



- ✓ Accurate
- ✓ Extremely slow



- ✓ Very fast
- ✓ Accurate

Summary and Conclusions: Rapid Stage Benefits



Fast mapping

- Increase in speed by significant factor:
 - Especially for WDS and SEM-XRF use
- Enhancing WDS and SEM-XRF usability
- SEM Stage communication not designed for on-the-fly measurement

Accurate results

- Mapping with a vertical beam
- Avoiding violation of Bragg conditions
- Avoiding lateral intensity loss
- Supports simultaneous analysis with e-beam and X-ray beam or EDS and WDS.

Summary and Conclusions: Rapid Stage and Micro-XRF



- Can work in combination with SEM e-beam
 - Commonly Low-KV due to charging and sample interaction

- The analysis of samples in micrometers (μm) scale on a standard SEM.
- Able to perform large area maps on a variety of samples.

- Sample Preparation Minimal for Micro-XRF
 - No carbon-coating
 - No polishing
 - Directly into the SEM

- Able to detect and resolve minor and trace elements
- Identification of high energy X-Ray lines

Are There Any Questions?

Please type in the questions you might have
in the Q&A box and press *Send*.



For more information, please contact us:

Bruker Nano GmbH

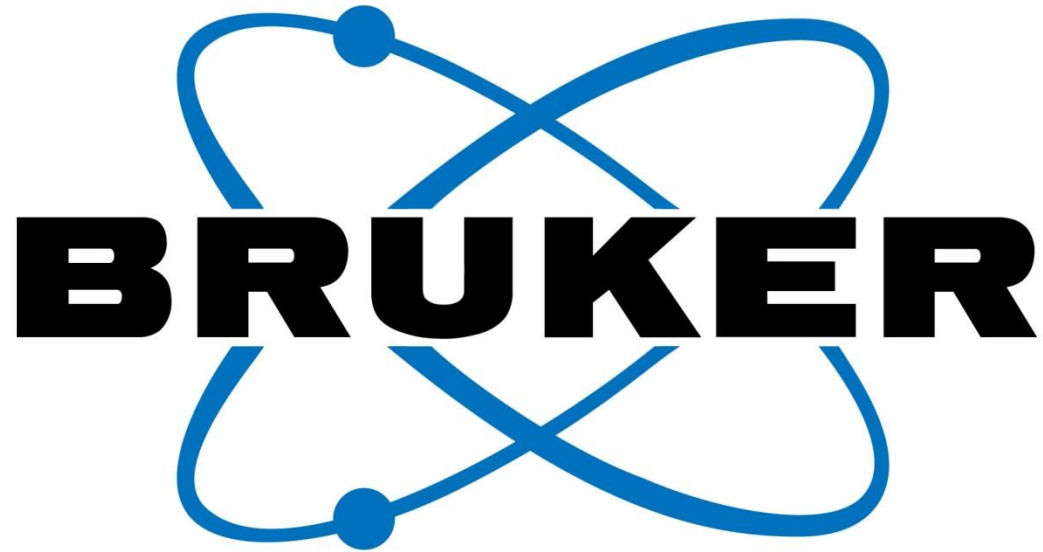
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Andrew.Menzies@bruker.com



Innovation with Integrity