

**Detailed Elemental Analysis  
of 1650,s Bronze  
materials found in Illinois  
Utilizing x ray beams from the  
Tracer III V+ and The Artax  
systems**

Comparison of as found surface and cleaned surface  
Artifacts BrNL011, BrNL102, BrNL105

The following 3 slides are typical spectra of samples in a clean area and a natural area. "Cleaning" was done by scraping away the corrosion layer, until bright metal was visible.

**The Tracer measurements without "Clean" in the name were taken through the corrosion layer. Artax scans were set up to cover part of the cleaned area and part of the natural area. This is clearly evident in the photographs and the plots of each element distribution.** It is very important to understand it is impossible for xrf analysis to give quantitative answers when a corrosion layer is present as this material is by its nature very non uniform and x ray physics precludes quantification of these materials. So any quantitative numbers in these situations are just meant to be indicative of the possible greater or lesser presence of an element, and only logical deduction can help one with the knowledge whether the element is in the corrosion or in the base metal ;as you are measuring both in some unknown proportion. It is for this reason that whenever possible both clean and corroded surfaces were measured. Also where possible the front and back of each item was measured as early Cu alloys by their very nature are very non uniform.

The measurements with the Tracer were taken with the Rh X ray tube set at 40 Kv and 3 micro amps, with a .001" Ti - .012" Al beam filter for 500 sec to assure that the trace elements could be detected in the raw spectrum.

***Below are the actual raw spectra of each location "scanned " with the Artax are overlaid so one can easily see the elemental differences for 3 artifacts BrNL011, BrNL102, BrNL105 cleaned and natural.***



BrNL102 a 500 sec/BrNL102 a clean 500 sec

Select Elements

SnLa1 · 50  K  L  M

Clear All Add Z- Z+

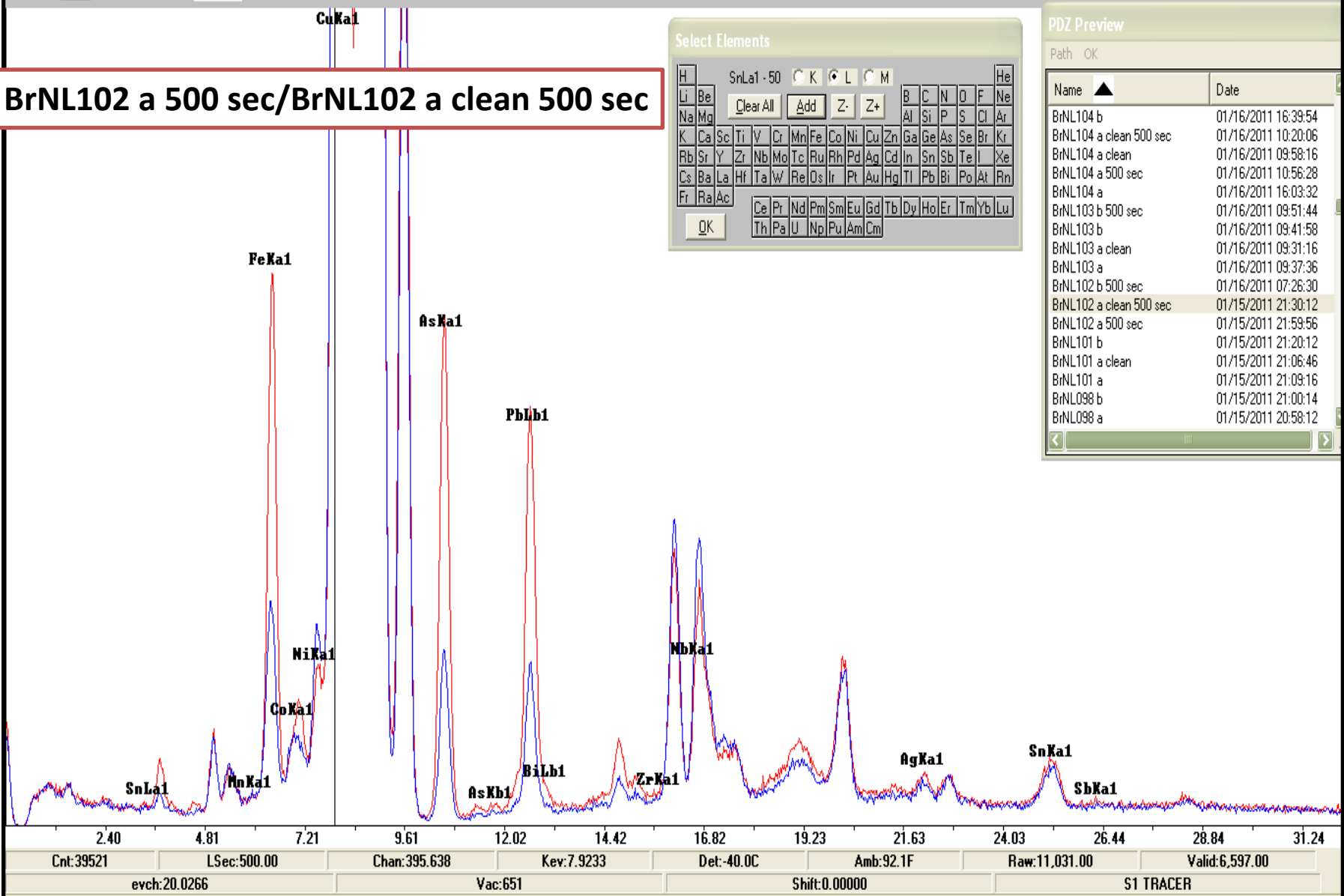
H	He																
Li	Be																
Na	Mg																
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
			Th	Pa	U	Np	Pu	Am	Cm								

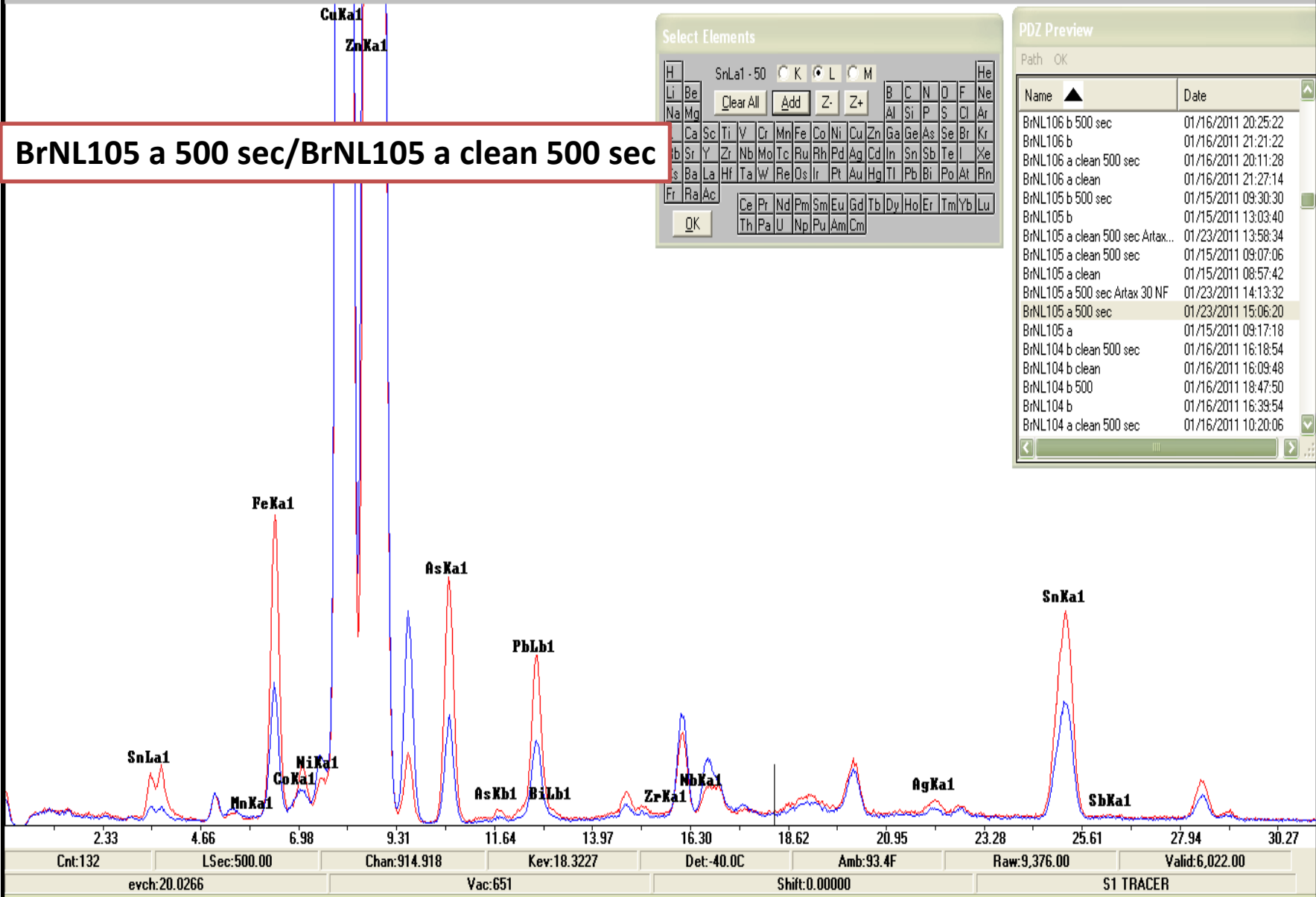
OK

PDZ Preview

Path OK

Name ▲	Date
BrNL104 b	01/16/2011 16:39:54
BrNL104 a clean 500 sec	01/16/2011 10:20:06
BrNL104 a clean	01/16/2011 09:58:18
BrNL104 a 500 sec	01/16/2011 10:56:28
BrNL104 a	01/16/2011 16:03:32
BrNL103 b 500 sec	01/16/2011 09:51:44
BrNL103 b	01/16/2011 09:41:58
BrNL103 a clean	01/16/2011 09:31:16
BrNL103 a	01/16/2011 09:37:36
BrNL102 b 500 sec	01/16/2011 07:26:30
BrNL102 a clean 500 sec	01/15/2011 21:30:12
BrNL102 a 500 sec	01/15/2011 21:59:56
BrNL101 b	01/15/2011 21:20:12
BrNL101 a clean	01/15/2011 21:06:46
BrNL101 a	01/15/2011 21:09:16
BrNL098 b	01/15/2011 21:00:14
BrNL098 a	01/15/2011 20:58:12





# Tracer III V + quantitative analysis of each analysis

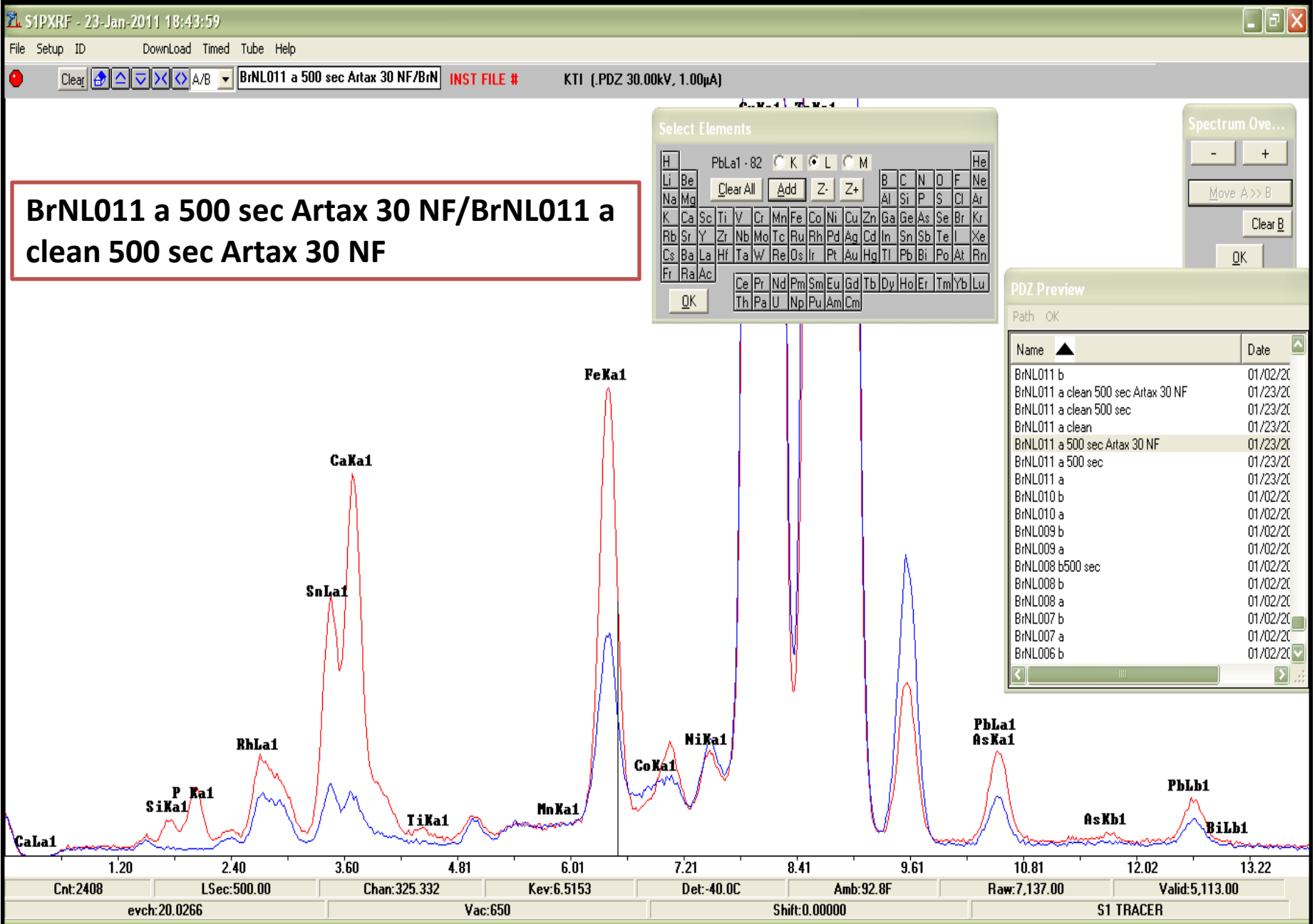
Note that the in all cases for the clean metal analysis the Fe, Cu, As, Pb, Sn, Ag, and Sb are lower and the Zn and Ni are higher. This is also clearly evident in the the Artax scans which follow. **Note only the Clean analysis below is accurate.**

	BrNL011 a 500 sec	BrNL011 a clean 500 sec	BrNL105 a	BrNL105 a clean 500 sec	BrNL102 a 500 sec	BrNL102 a clean 500 sec
FeKa1	0.90	0.39	1.52	0.49	0.76	0.20
NiKa1	0.15	0.19	0.06	0.17	0.08	0.13
CuKa1	75.96	75.94	77.80	77.16	71.56	70.83
ZnKa1	14.79	17.10	10.10	15.89	22.58	25.01
AsKa1	0.17	0.04	0.62	0.06	0.07	0.01
PbLb1	1.79	1.09	3.37	1.39	2.46	0.84
AgKa1	0.05	0.02	0.08	0.02	0.02	0.01
SnKa1	4.60	3.12	5.57	2.71	0.37	0.28
SbKa1	0.06	0.03	0.13	0.04	0.05	0.00
SUM	98.49	97.92	99.27	97.93	97.95	97.32

The slides below depict the same samples as above but the measurement parameters were set to match those used in the area elemental analysis done with the Artax. The Artax is a 0.065 mm micro focus xrf analyzer capable of scanning and object to produce a detailed elemental map. The spacing between the analysis locations was .060 mm. The results of the maps are shown after the Tracer analysis below.

To assure that one clearly understood the detail of the spectra. The Tracer was run at the same setting on the same sample . Thus producing another perspective on what was mapped.

*In detail for the 3 sets of spectra below the presence of Si, P, and increase Sn and Fe, as well as, the increase in the Rh L x rays scattered back to the detector from the samples that have not been “cleaned”. This is because of the significantly higher percent of low mass elements present in the corrosion layer. Note these are not “measured” by xrf because the x rays they emit are too low in energy to detect. For instance H, O, N and C also make up the corrosion layer and are undetected but increase the scatter of the x rays from the surface of the sample.*



**BrNL011 a 500 sec Artax 30 NF/BrNL011 a clean 500 sec Artax 30 NF**

Select Elements

PbLa1 - 82     K     L     M

Clear All    Add    Z-    Z+

H	He
Li	Be
Na	Mg
K	Ca
Rb	Sr
Cs	Ba
Fr	Ra
Ac	
Ce	Pr
Th	Pa
U	Np
Pu	Am
Cm	
B	C
Al	Si
Ga	Ge
In	Sn
Tl	Pb
Bi	Po
At	Rn
As	Se
Br	Kr
Sb	Te
I	Xe
Y	Zr
Nb	Mo
Tc	Ru
Rh	Pd
Ag	Cd
Hg	Tl
Pb	Bi
Po	At
Rn	
V	Cr
Mn	Fe
Co	Ni
Cu	Zn
Ga	Ge
As	Se
Br	Kr
Sb	Te
I	Xe
Y	Zr
Nb	Mo
Tc	Ru
Rh	Pd
Ag	Cd
Hg	Tl
Pb	Bi
Po	At
Rn	
Ti	V
Cr	Mn
Fe	Co
Ni	Cu
Zn	Ga
Ge	As
Se	Br
Kr	
Y	Zr
Nb	Mo
Tc	Ru
Rh	Pd
Ag	Cd
Hg	Tl
Pb	Bi
Po	At
Rn	
Sc	Ti
V	Cr
Mn	Fe
Co	Ni
Cu	Zn
Ga	Ge
As	Se
Br	Kr
Sb	Te
I	Xe
Y	Zr
Nb	Mo
Tc	Ru
Rh	Pd
Ag	Cd
Hg	Tl
Pb	Bi
Po	At
Rn	
La	Hf
Ta	W
Re	Os
Ir	Pt
Au	Hg
Tl	Pb
Bi	Po
At	Rn
La	Hf
Ta	W
Re	Os
Ir	Pt
Au	Hg
Tl	Pb
Bi	Po
At	Rn
Pr	Nd
Pm	Sm
Eu	Gd
Tb	Dy
Ho	Er
Tm	Yb
Lu	

OK

Spectrum Ove...

-    +

Move A >> B

Clear B

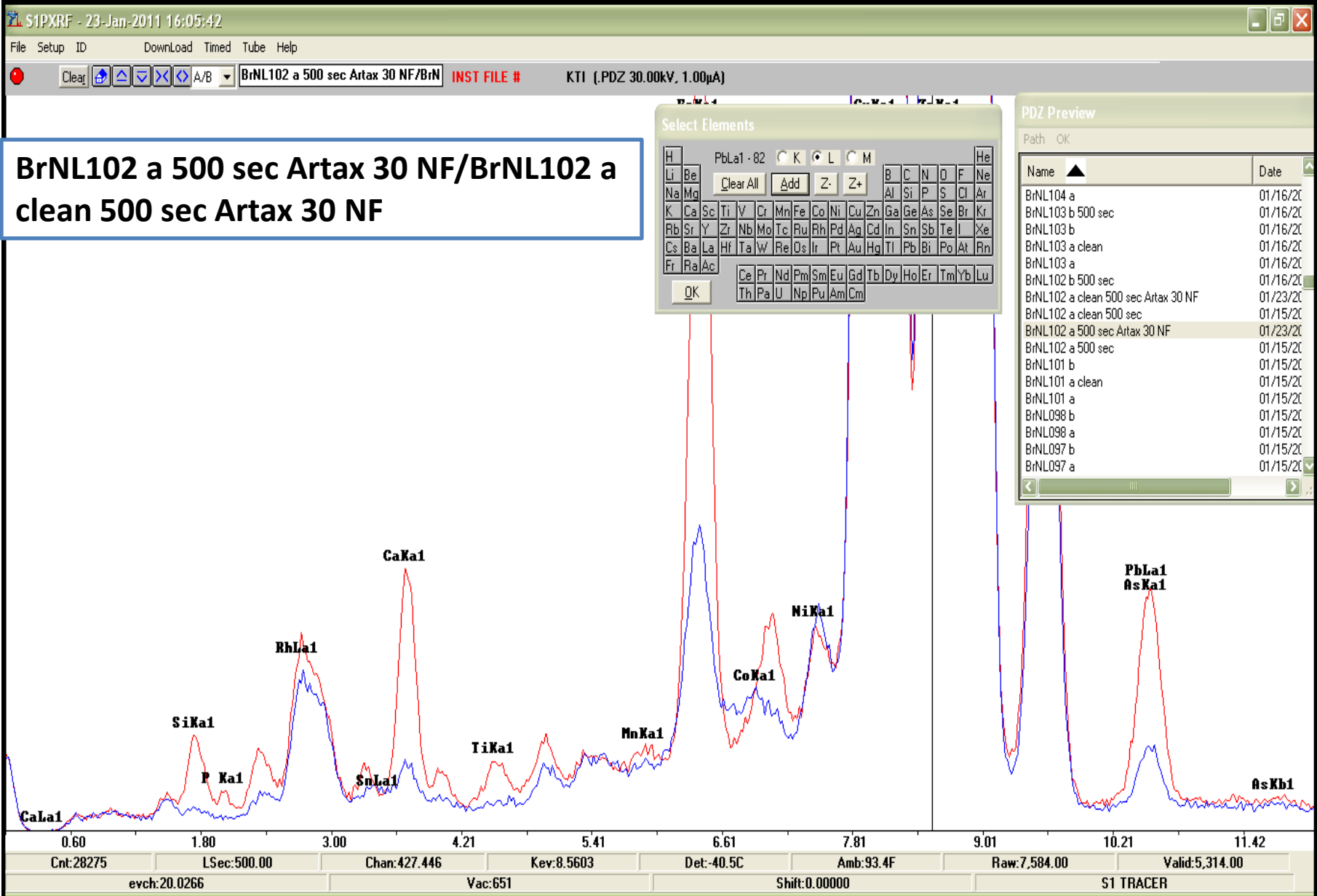
OK

PDZ Preview

Path OK

Name ▲	Date ▼
BrNL011 b	01/02/20
BrNL011 a clean 500 sec Artax 30 NF	01/23/20
BrNL011 a clean 500 sec	01/23/20
BrNL011 a clean	01/23/20
BrNL011 a 500 sec Artax 30 NF	01/23/20
BrNL011 a 500 sec	01/23/20
BrNL011 a	01/23/20
BrNL010 b	01/02/20
BrNL010 a	01/02/20
BrNL009 b	01/02/20
BrNL009 a	01/02/20
BrNL008 b500 sec	01/02/20
BrNL008 b	01/02/20
BrNL008 a	01/02/20
BrNL007 b	01/02/20
BrNL007 a	01/02/20
BrNL006 b	01/02/20





FeKa1 CuKa1

**BrNL105 a 500 sec Artax 30 NF/BrNL105  
a clean 500 sec Artax 30 NF**

Select Elements

PbLa1 - 82  K  L  M

Clear All Add Z- Z+

H	He
Li	Be
Na	Mg
K	Ca
Rb	Sr
Cs	Ba
Fr	Ra
Sc	Ti
Y	Zr
Ba	La
Ra	Ac
Ce	Pr
Th	Pa
U	Np
Pu	Am
Cm	
B	C
Al	Si
Cl	S
Ar	Kr
Br	Xe
Po	At
Rn	
Ga	Ge
In	Sb
Tl	Pb
Hg	Bi
Pt	Au
Ir	Pd
Os	Rh
Re	Mo
Os	Ru
Ir	Rh
Pt	Au
Hg	Tl
Pb	Bi
Po	At
Rn	
Ni	Cu
Zn	Ga
Cd	In
Hg	Tl
Pb	Bi
Po	At
Rn	
Fe	Co
Ni	Cu
Zn	Ga
Cd	In
Hg	Tl
Pb	Bi
Po	At
Rn	
Mn	Fe
Co	Ni
Cu	Zn
Ga	Ge
As	Se
Br	Kr
Sb	Te
I	Xe
Te	I
Xe	
Sm	Eu
Gd	Tb
Dy	Ho
Er	Tm
Yb	Lu

OK

Spectrum Ove...

- +

Move A >> B

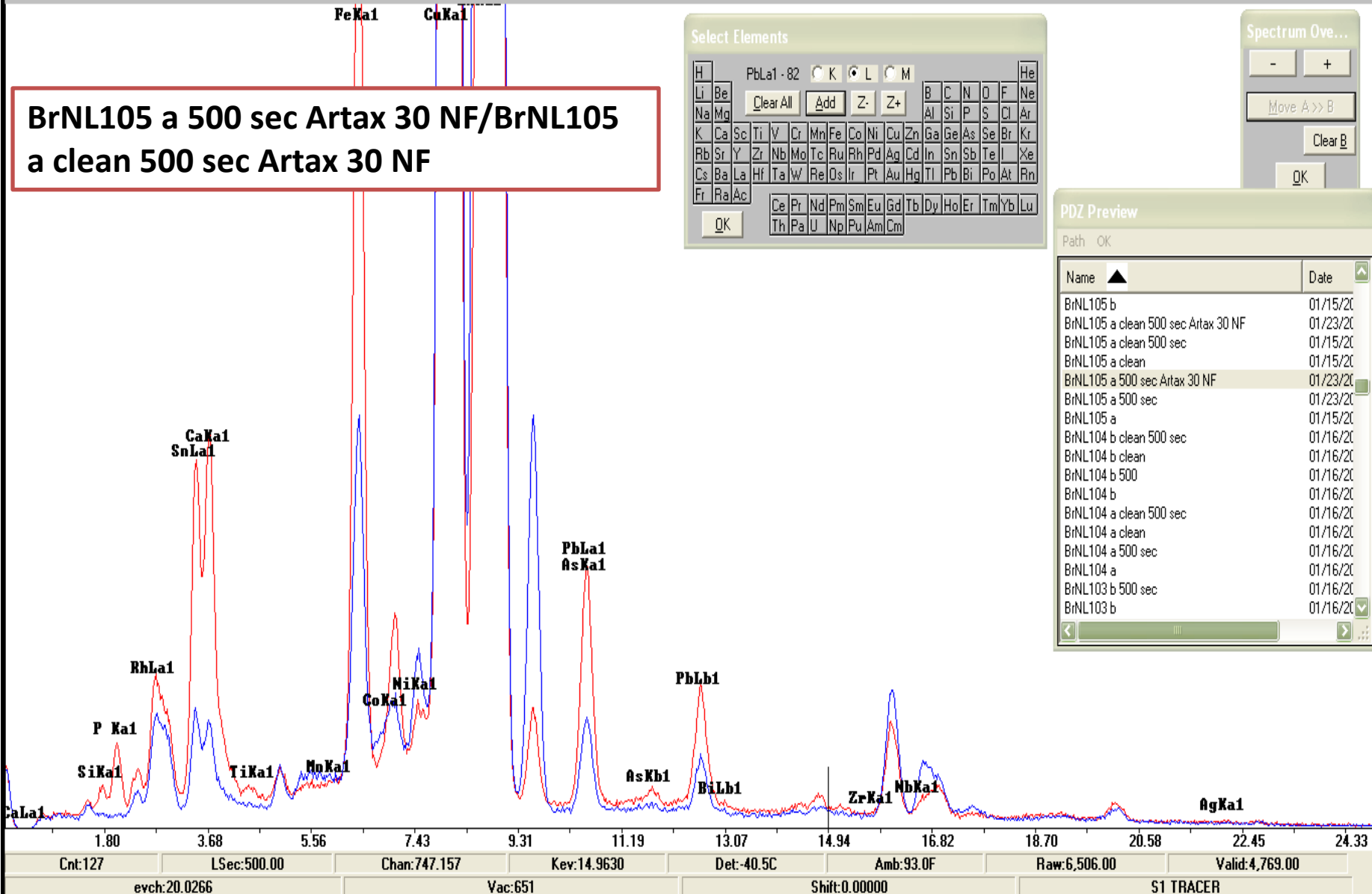
Clear B

OK

PDZ Preview

Path OK

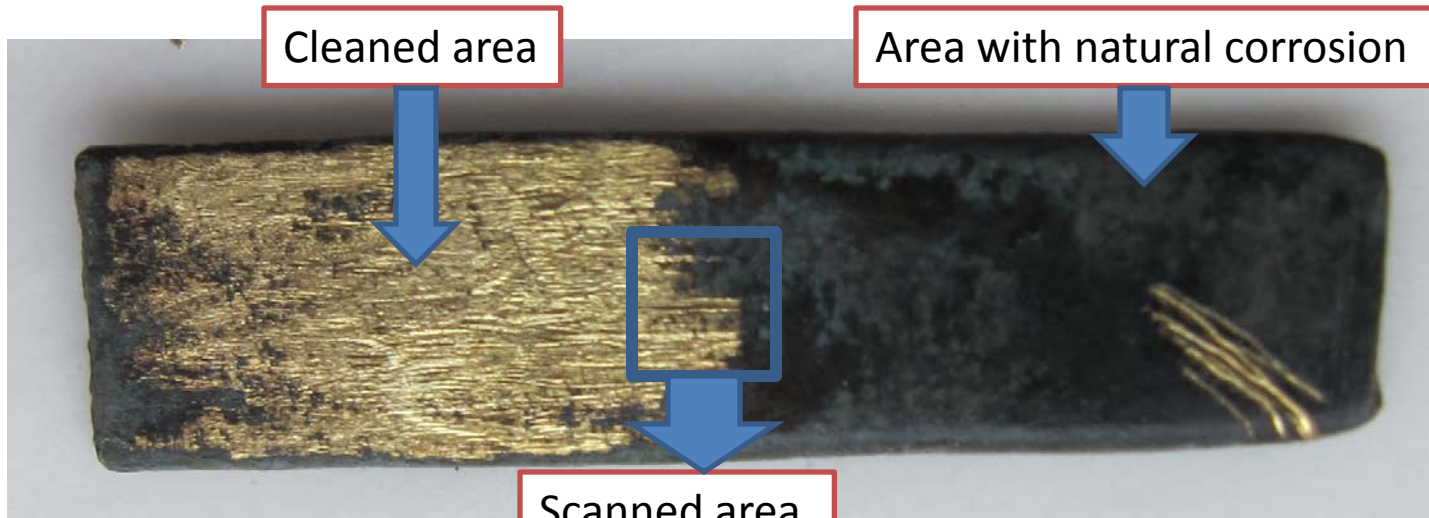
Name ▲	Date ▼
BrNL105 b	01/15/20
BrNL105 a clean 500 sec Artax 30 NF	01/23/20
BrNL105 a clean 500 sec	01/15/20
BrNL105 a clean	01/15/20
BrNL105 a 500 sec Artax 30 NF	01/23/20
BrNL105 a 500 sec	01/23/20
BrNL105 a	01/15/20
BrNL104 b clean 500 sec	01/16/20
BrNL104 b clean	01/16/20
BrNL104 b 500	01/16/20
BrNL104 b	01/16/20
BrNL104 a clean 500 sec	01/16/20
BrNL104 a clean	01/16/20
BrNL104 a 500 sec	01/16/20
BrNL104 a	01/16/20
BrNL103 b 500 sec	01/16/20
BrNL103 b	01/16/20



# Tracer III V + quantitative analysis of each analysis

Note that the in all cases for the clean metal analysis the Fe, Cu, As, Pb, Sn, Ag, and Sb are lower and the Zn and Ni are higher. This is also clearly evident in the the Artax scans which follow. **Note only the Clean analysis below is accurate.**

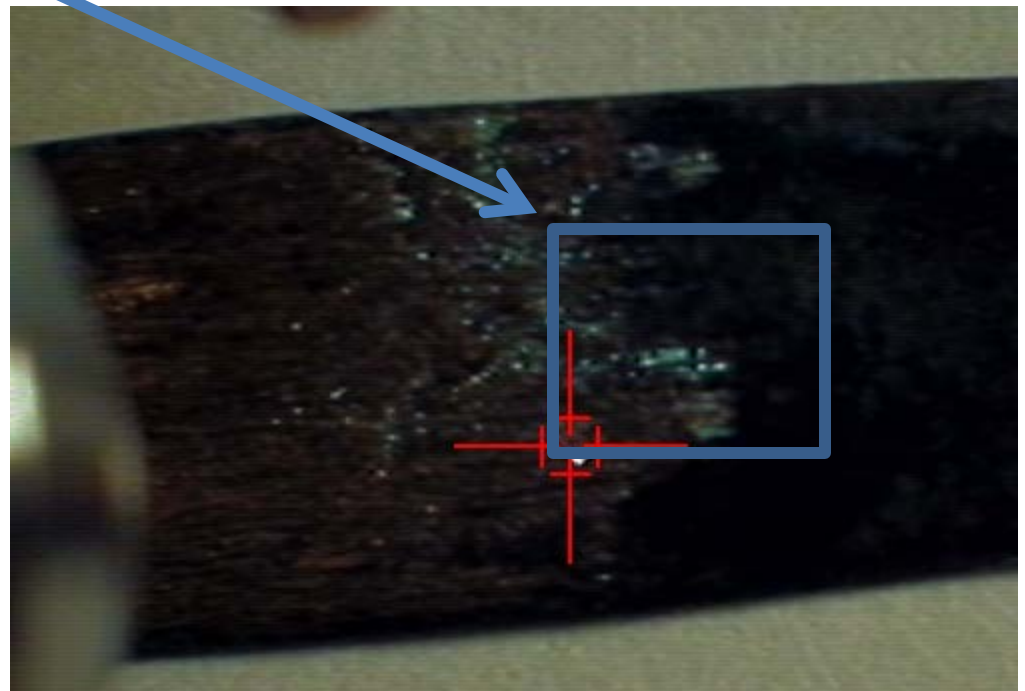
	BrNL011 a 500 sec	BrNL011 a clean 500 sec	BrNL105 a	BrNL105 a clean 500 sec	BrNL102 a 500 sec	BrNL102 a clean 500 sec
FeKa1	0.90	0.39	1.52	0.49	0.76	0.20
NiKa1	0.15	0.19	0.06	0.17	0.08	0.13
CuKa1	75.96	75.94	77.80	77.16	71.56	70.83
ZnKa1	14.79	17.10	10.10	15.89	22.58	25.01
AsKa1	0.17	0.04	0.62	0.06	0.07	0.01
PbLb1	1.79	1.09	3.37	1.39	2.46	0.84
AgKa1	0.05	0.02	0.08	0.02	0.02	0.01
SnKa1	4.60	3.12	5.57	2.71	0.37	0.28
SbKa1	0.06	0.03	0.13	0.04	0.05	0.00
SUM	98.49	97.92	99.27	97.93	97.95	97.32



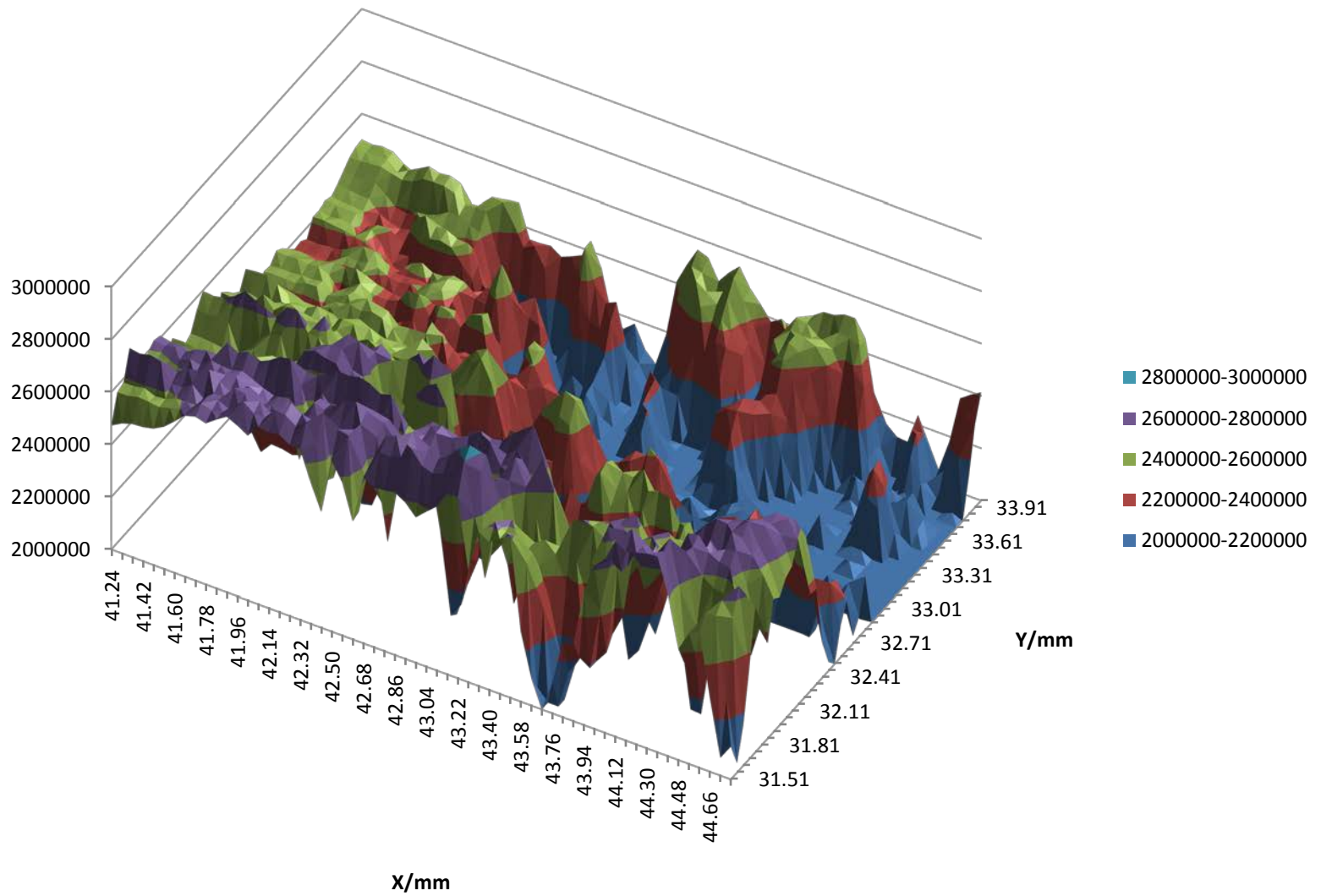
## Sample BrNL011

### Xrf elemental scan

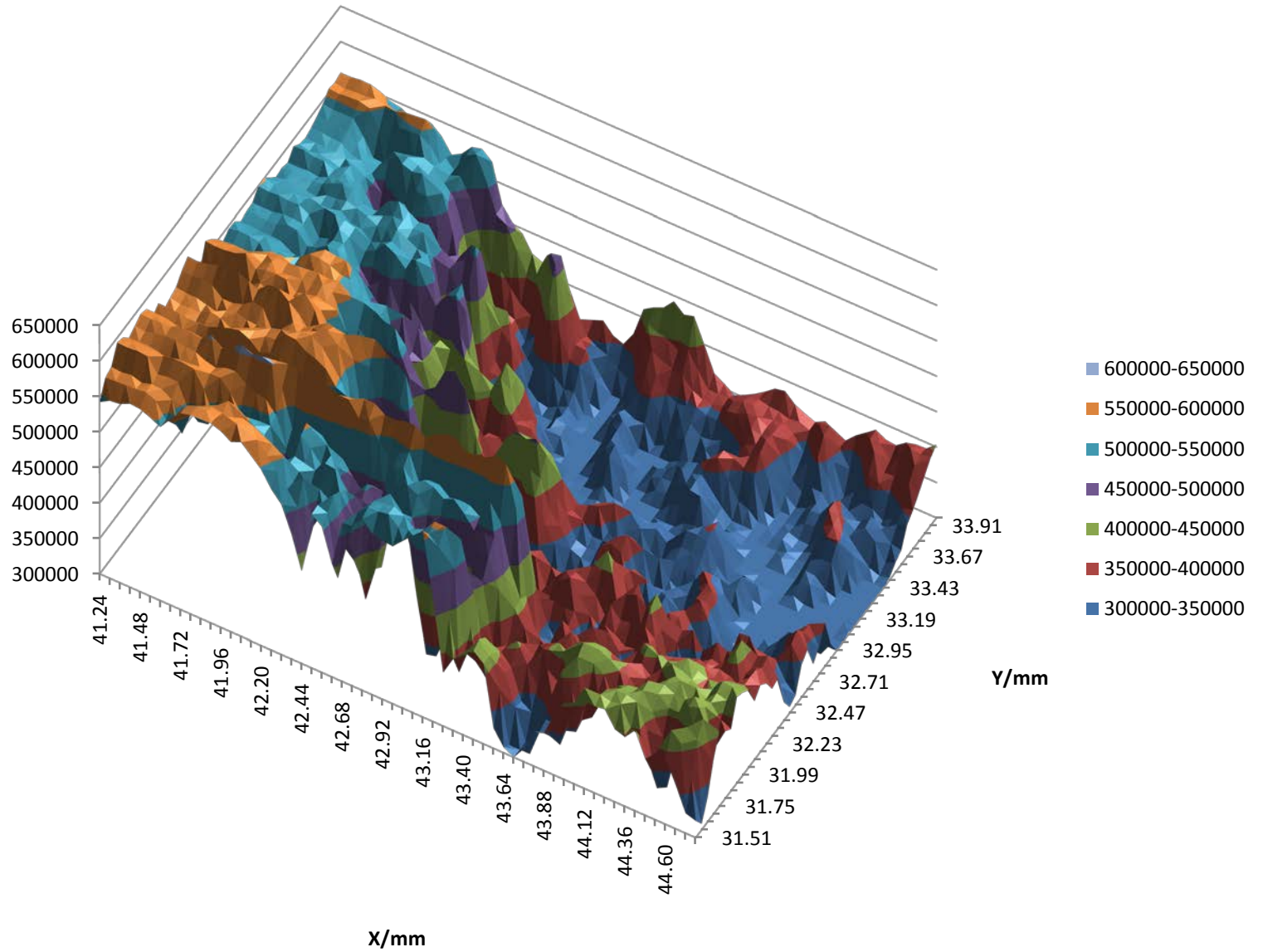
1. 2520 points
2. .065 mm spot size
3. .060 mm spacing
4. 2.5 mm by 3.5 mm area
5. 21 hours
6. 30 sec per analysis



# Cu K12

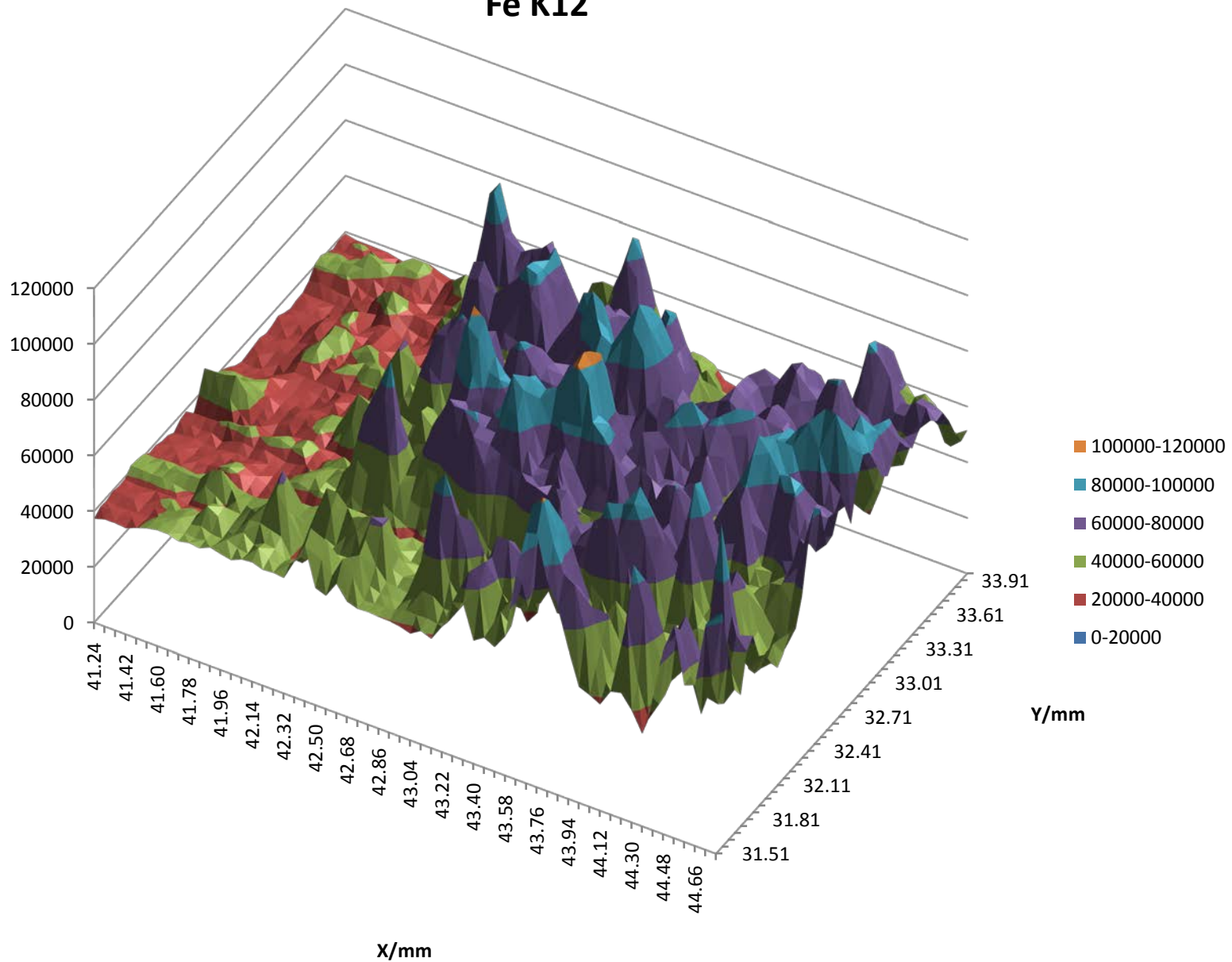


# Zn K12

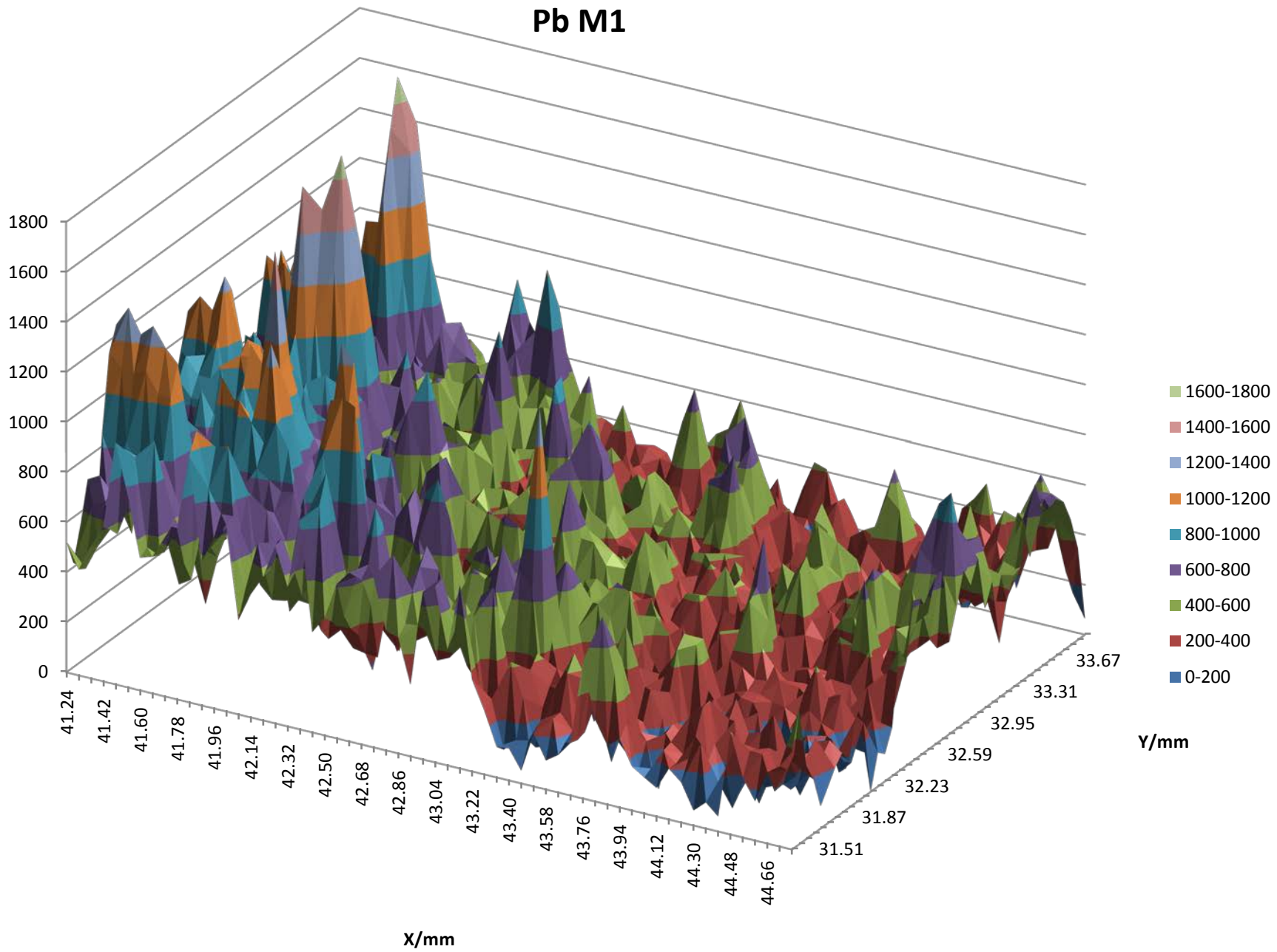




# Fe K12

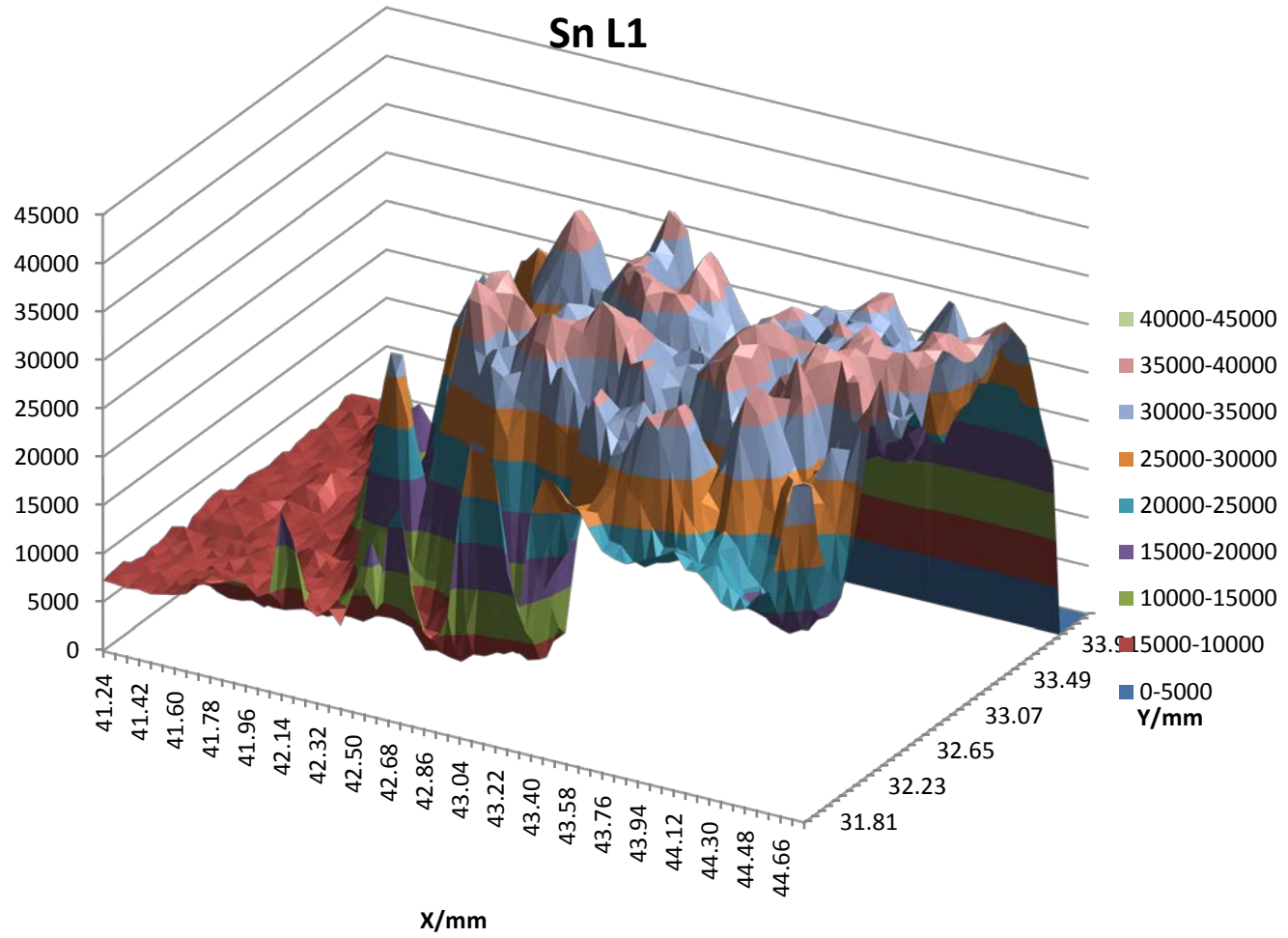


# Pb M1

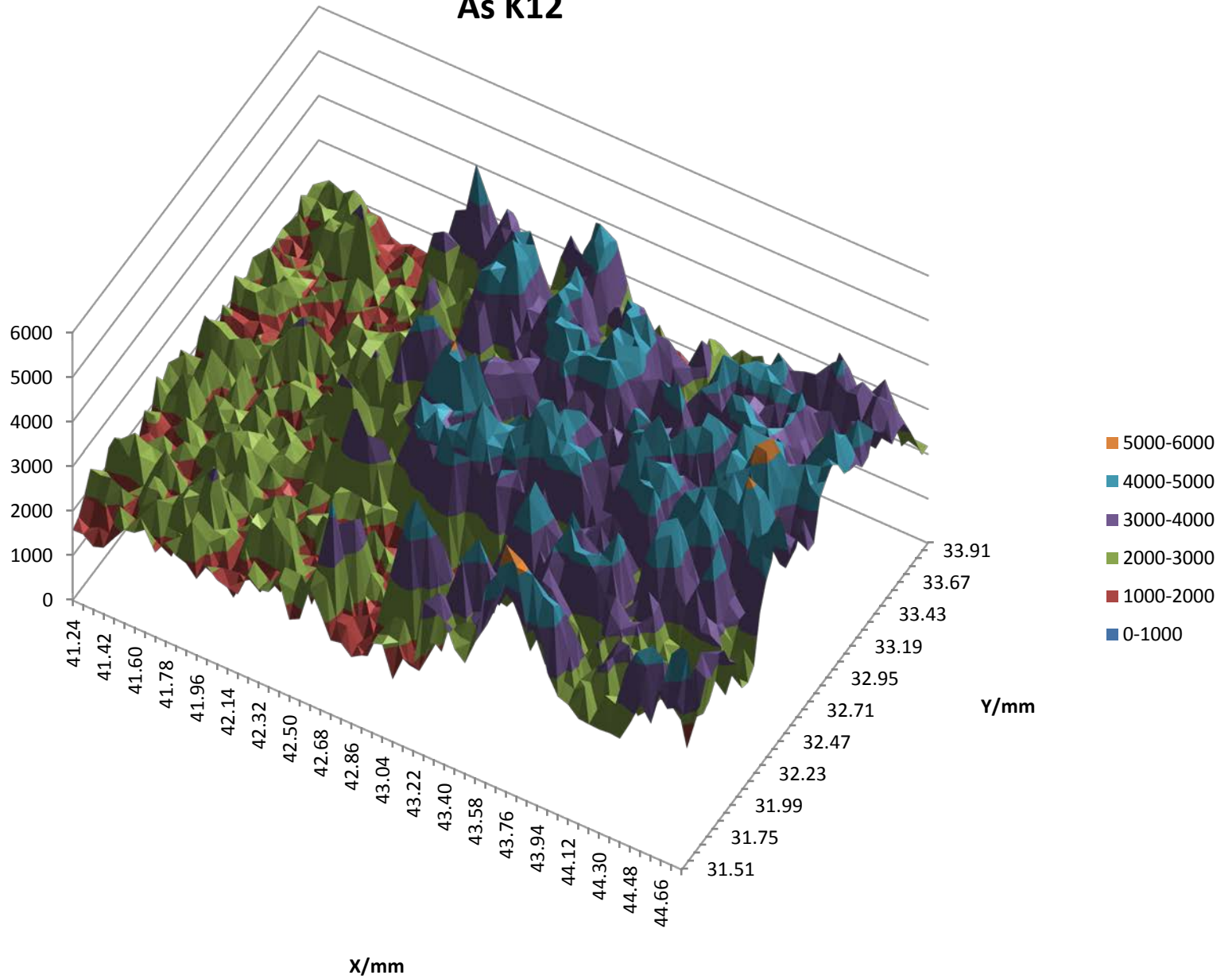




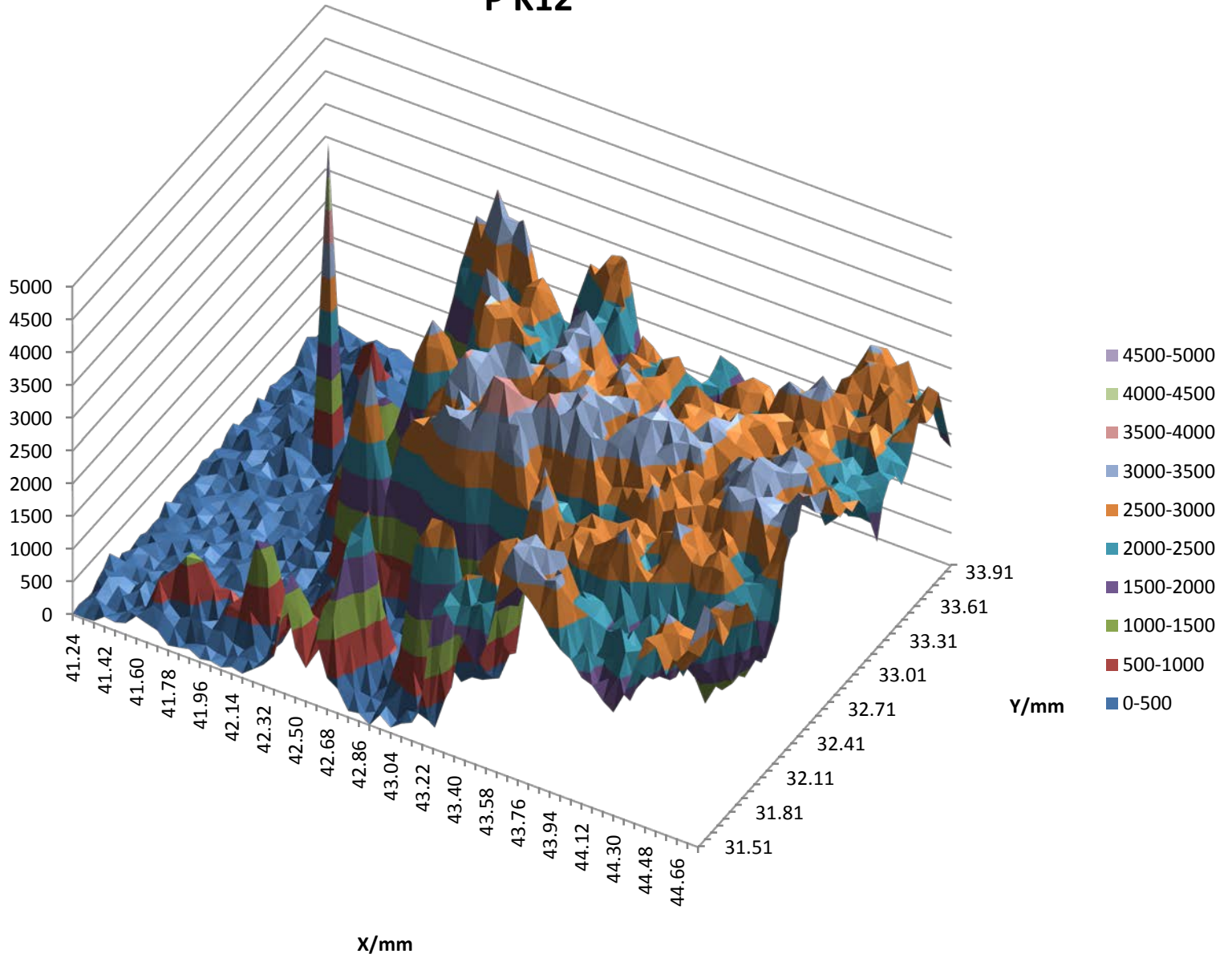
# Sn L1



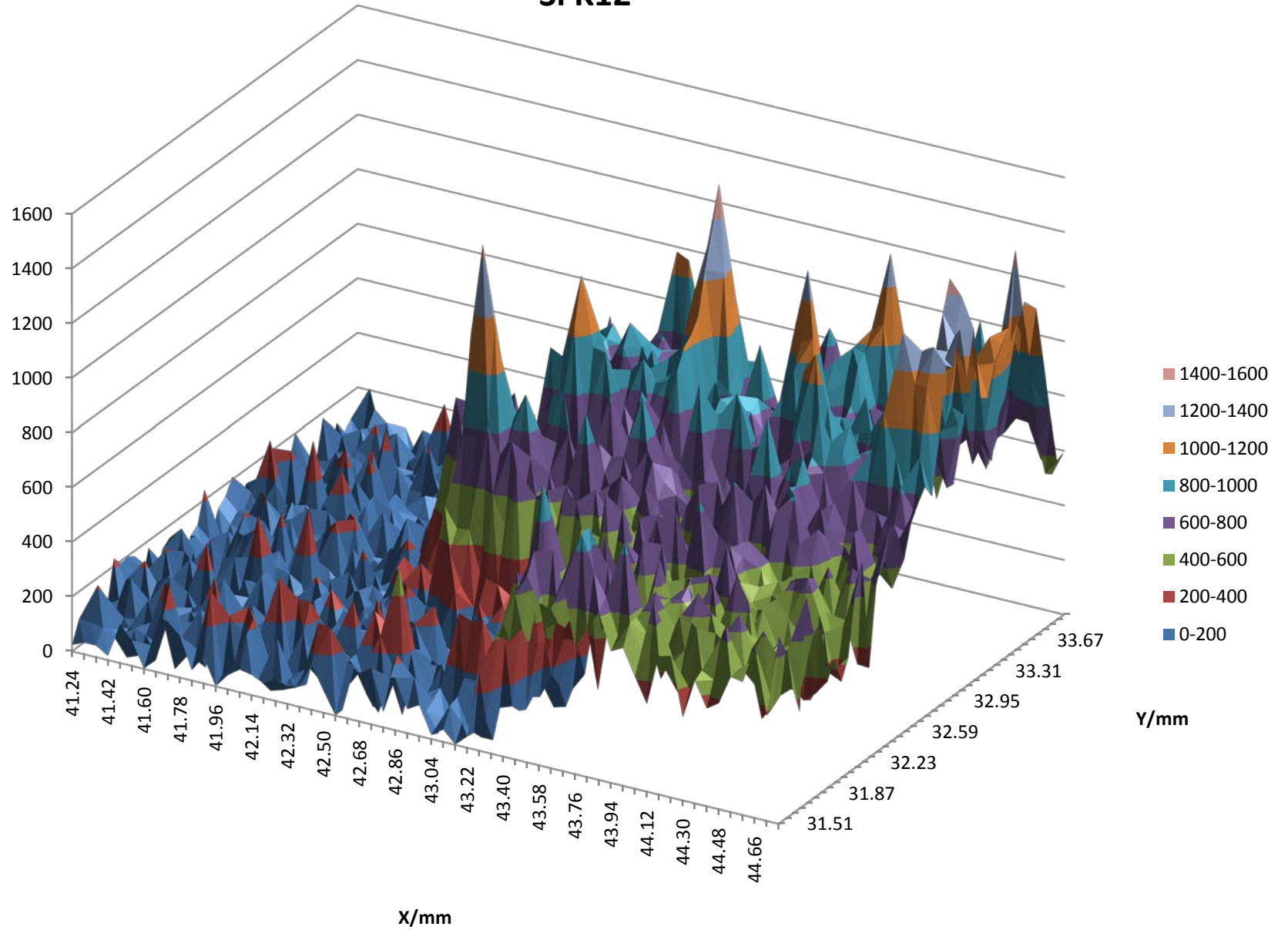
# As K12



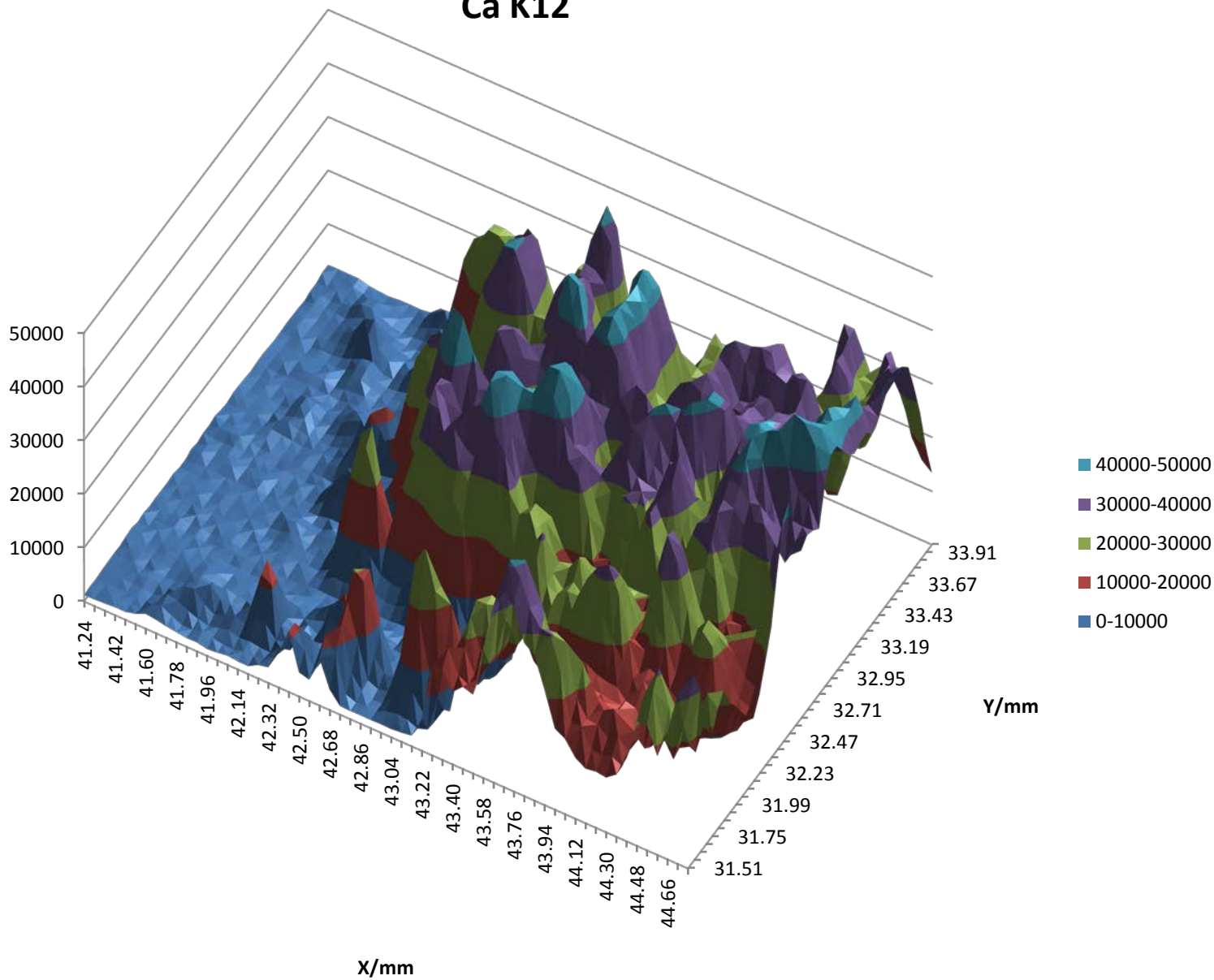
# P K12



# Si K12

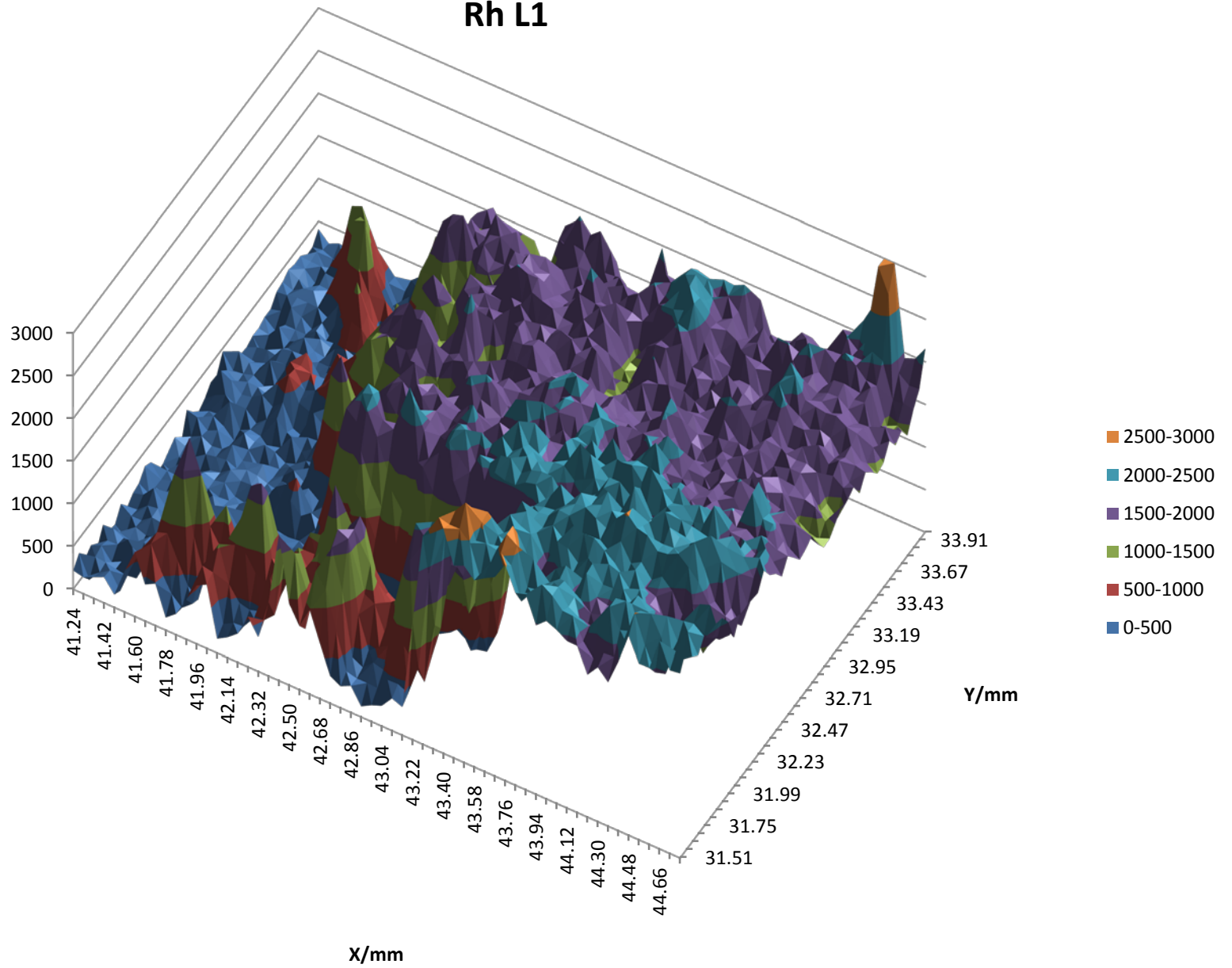


# Ca K12





# Rh L1

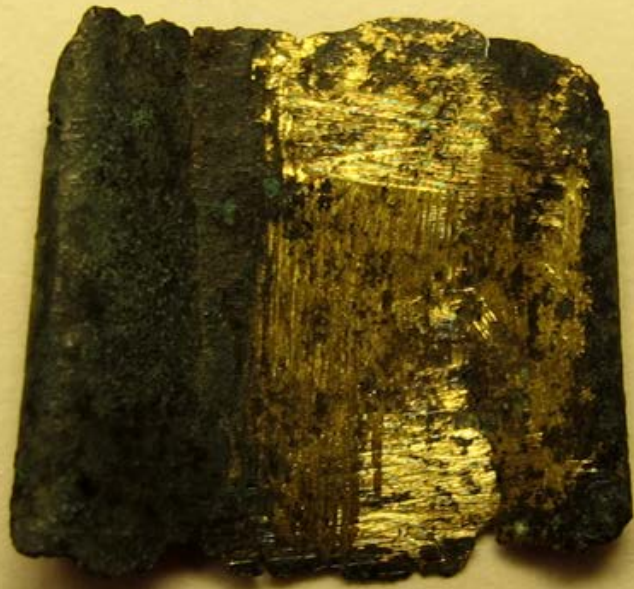


XRF

3/13/07

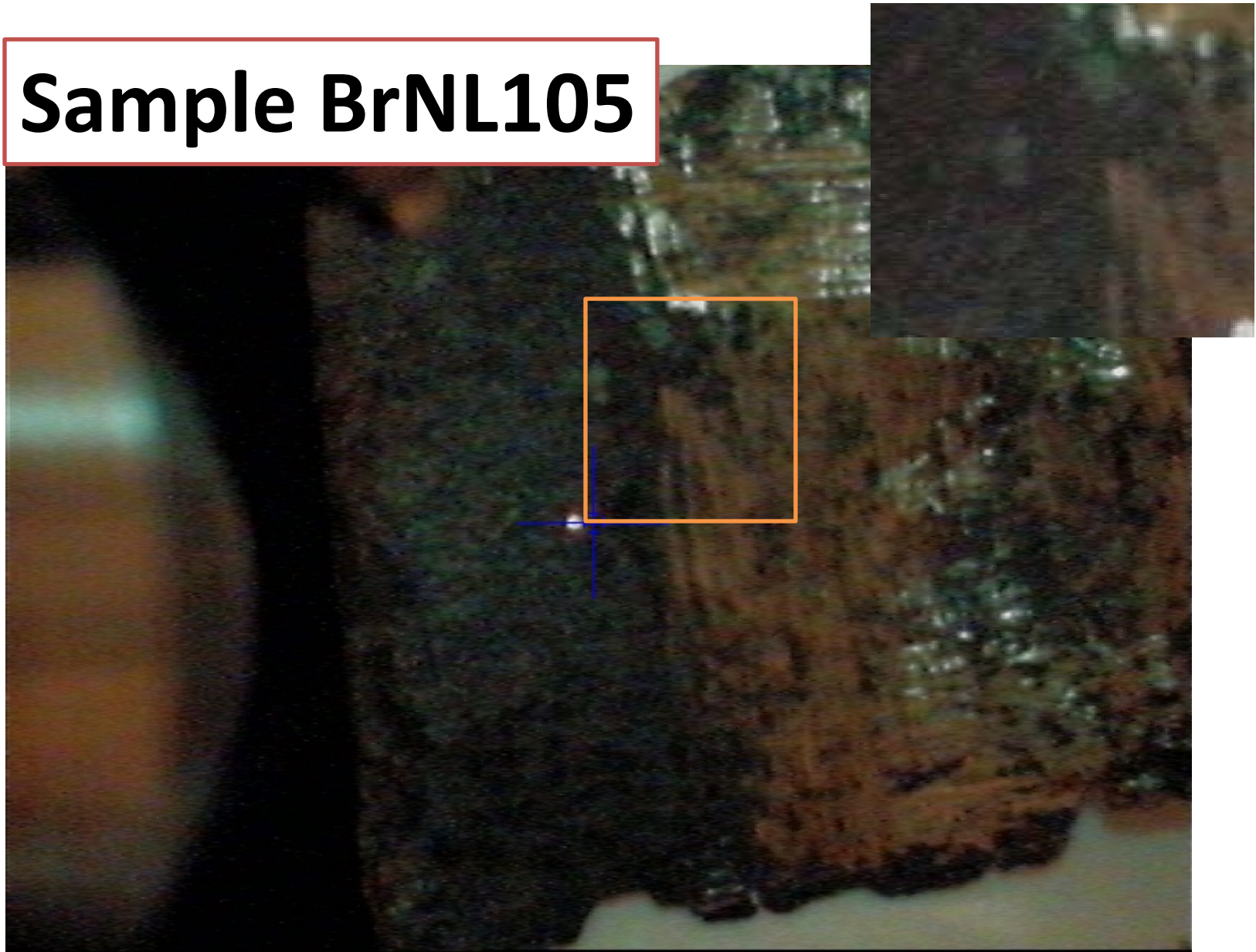
NL6

NL 66



Bv NL105

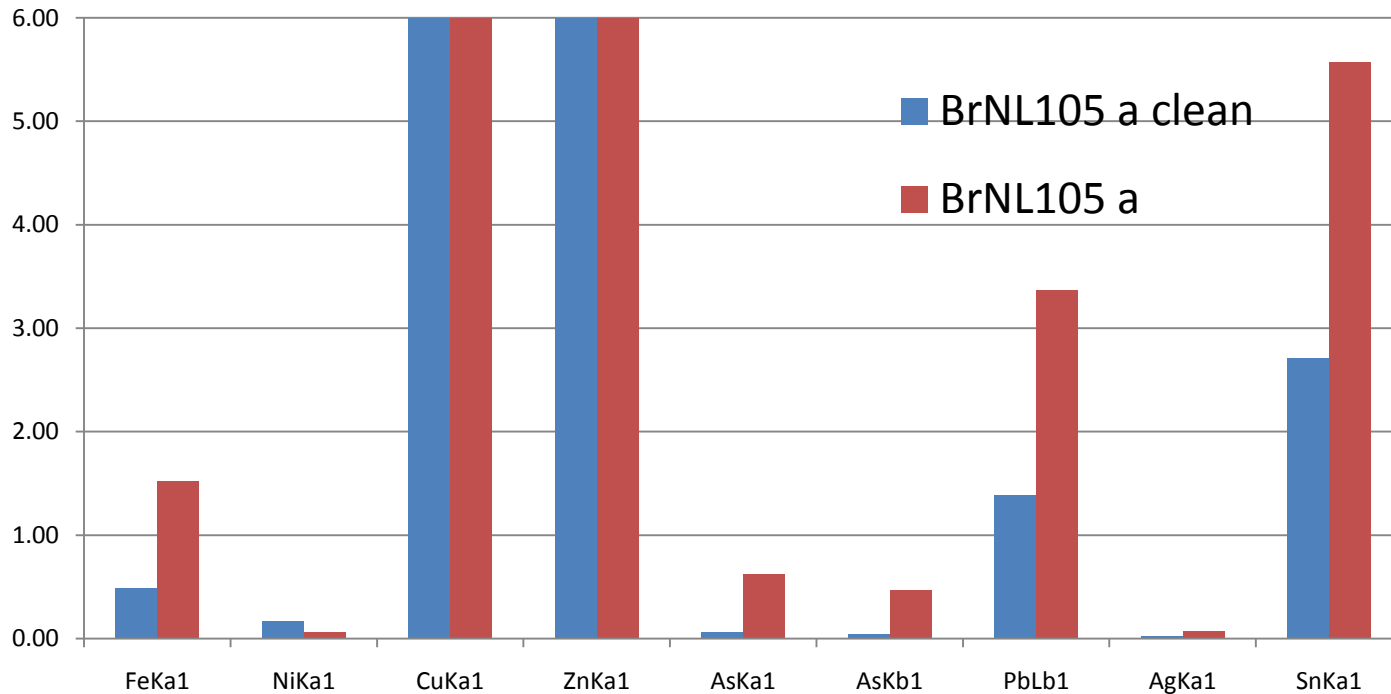
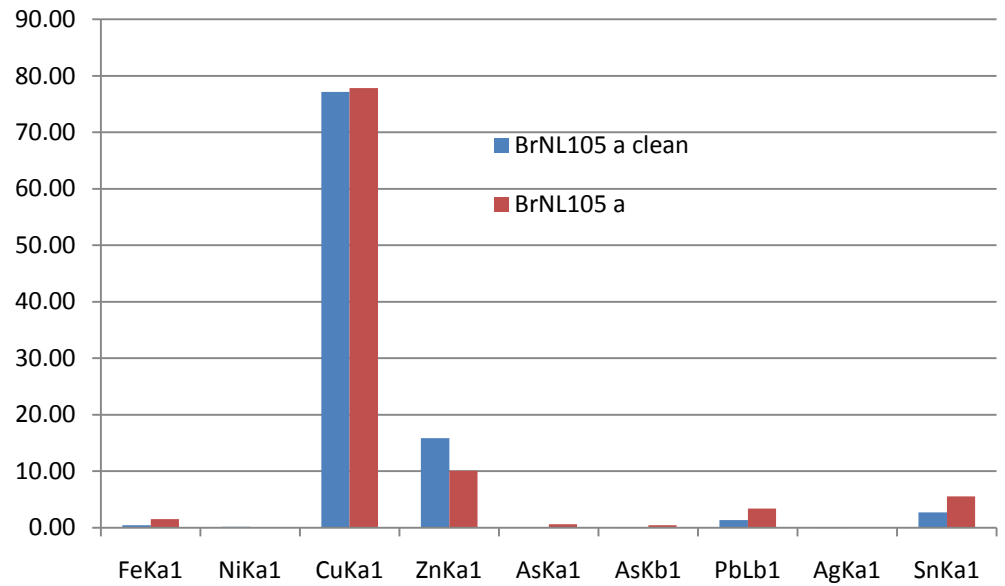
# Sample BrNL105



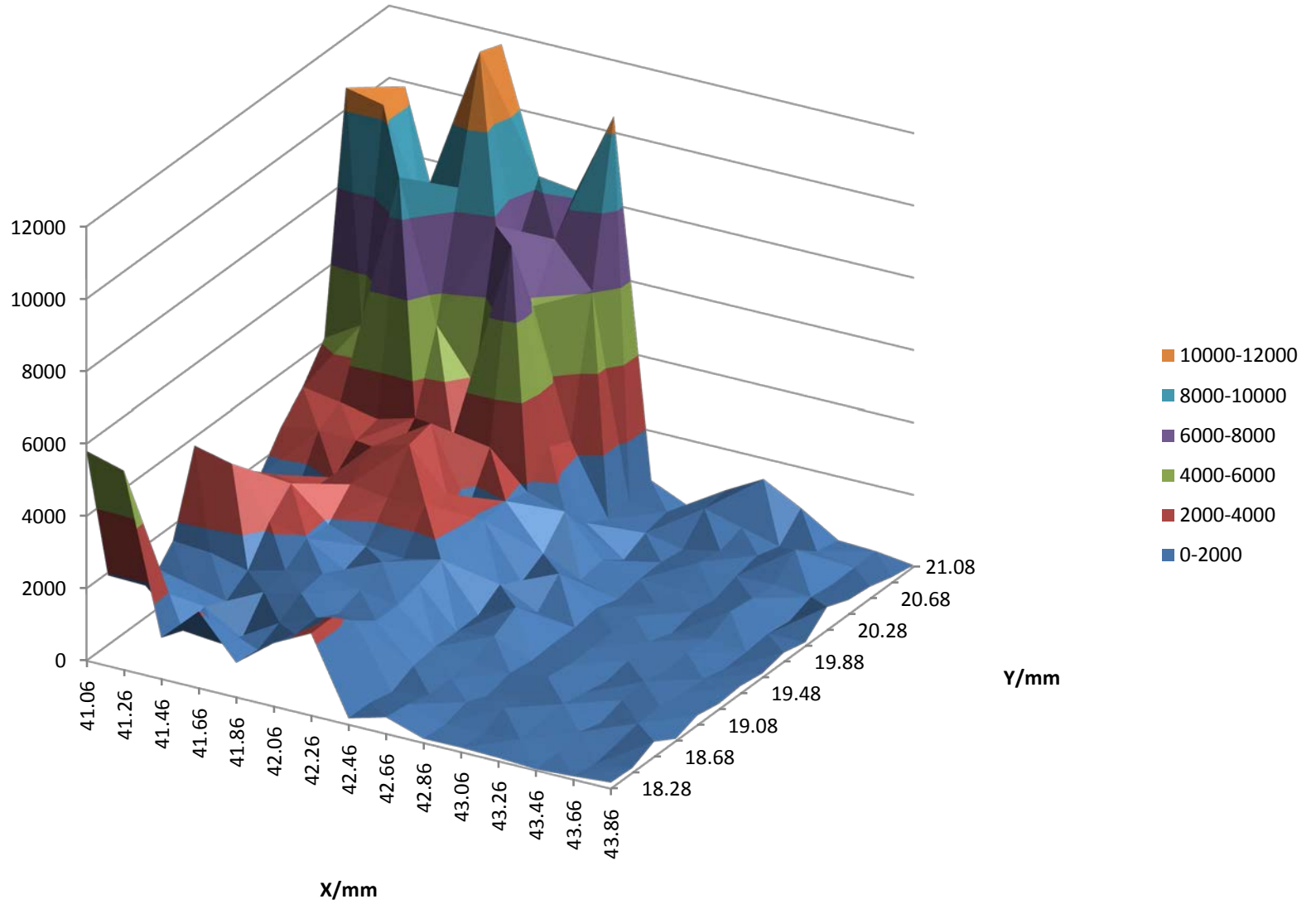


**Quantification done with the Tracer III V +  
Area 3 mm 4mm on each surface**

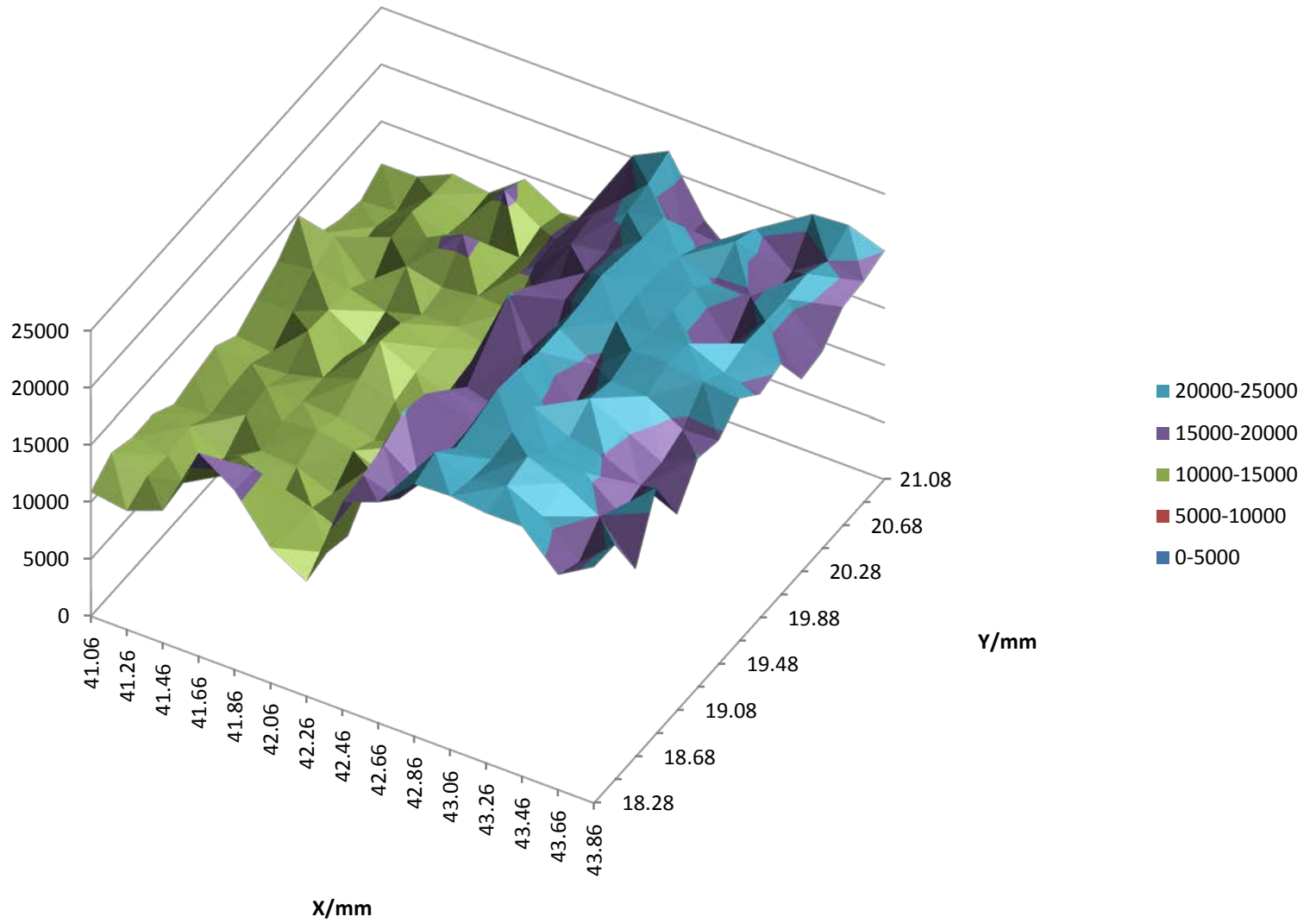
	BrNL105 a clean	BrNL105 a
FeKa1	0.49	1.52
NiKa1	0.17	0.06
CuKa1	77.16	77.80
ZnKa1	15.89	10.10
AsKa1	0.06	0.62
AsKb1	0.04	0.47
PbLb1	1.39	3.37
AgKa1	0.02	0.08
SnKa1	2.71	5.57



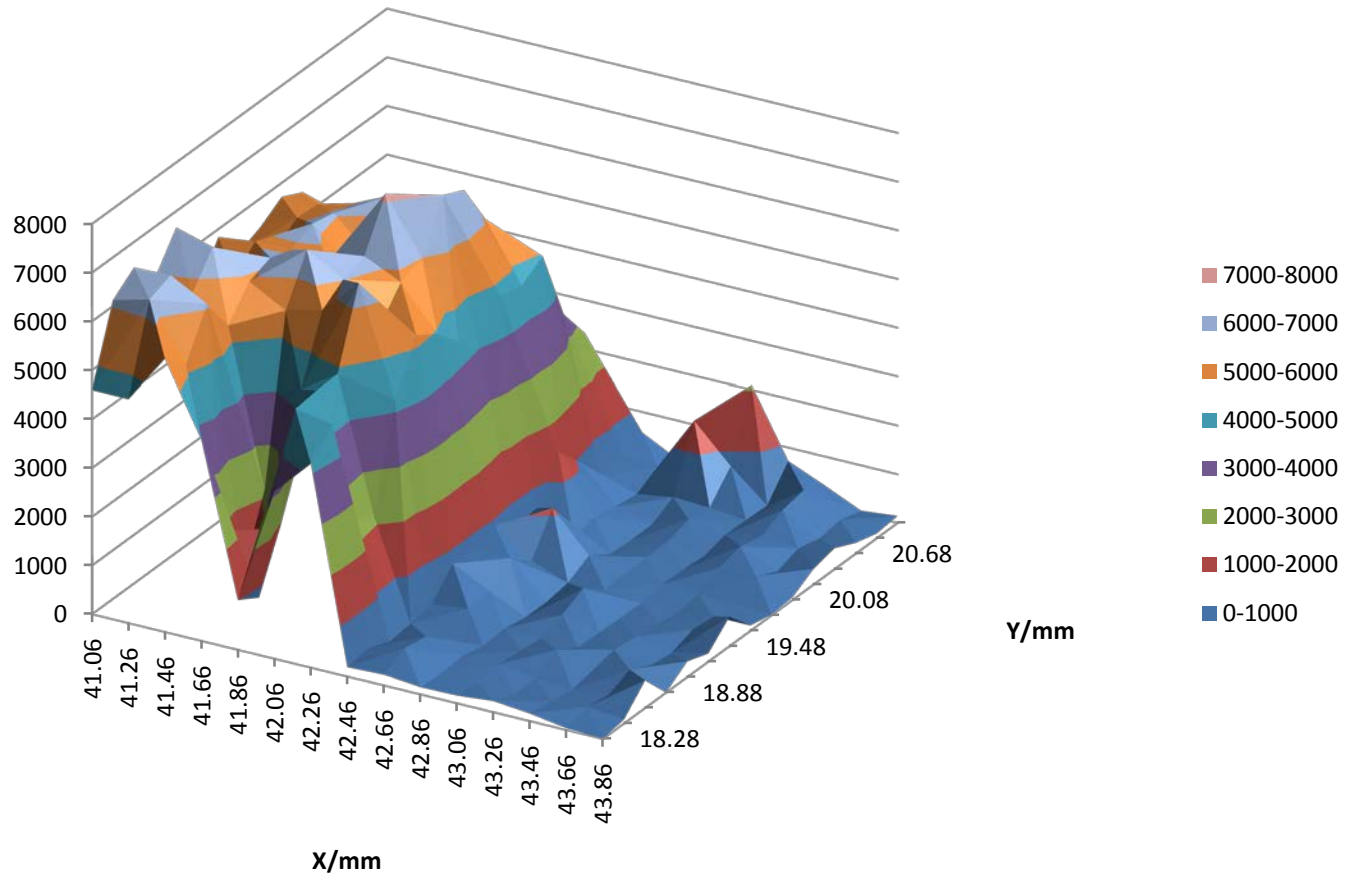
# Si K12



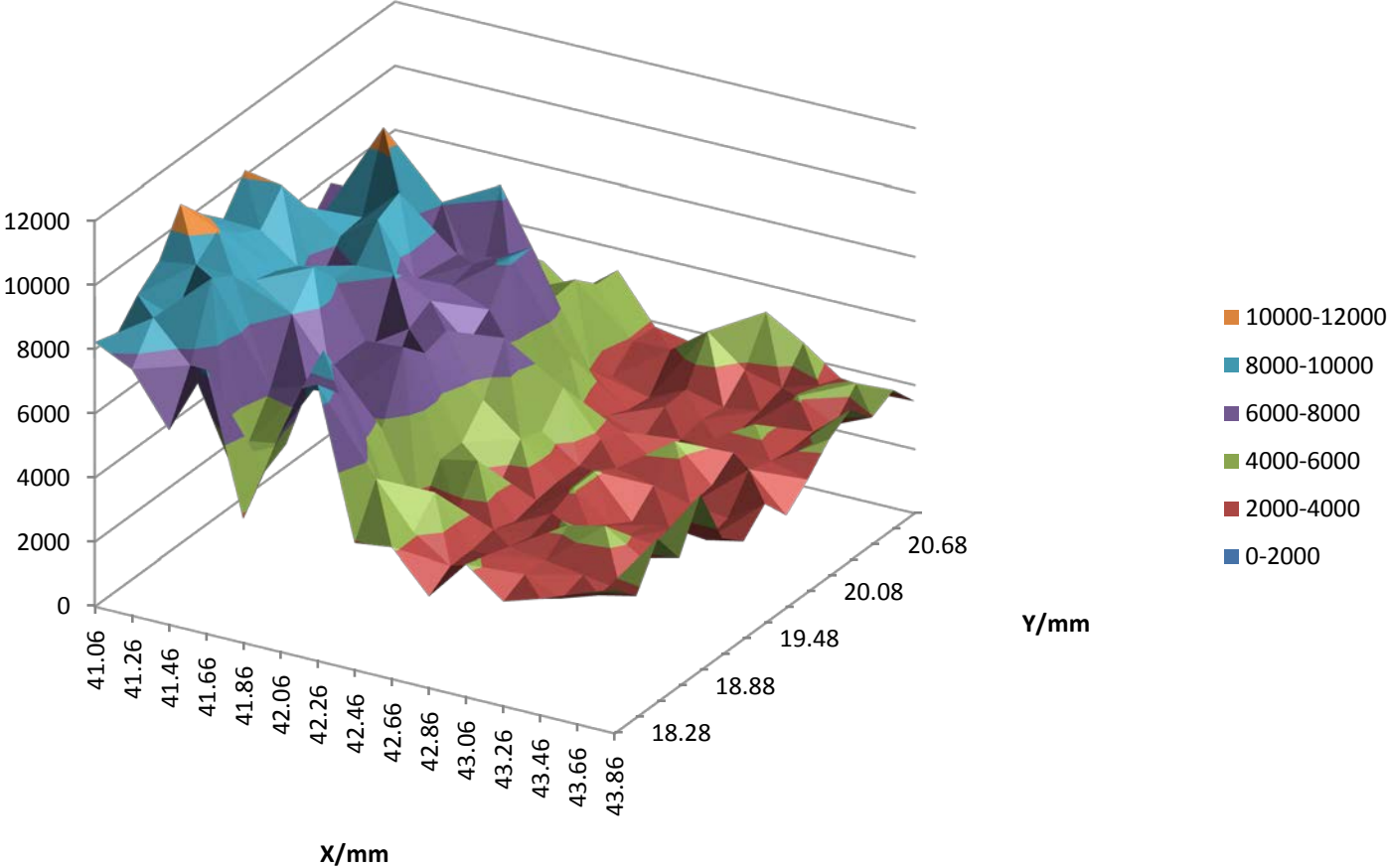
# Ni K12



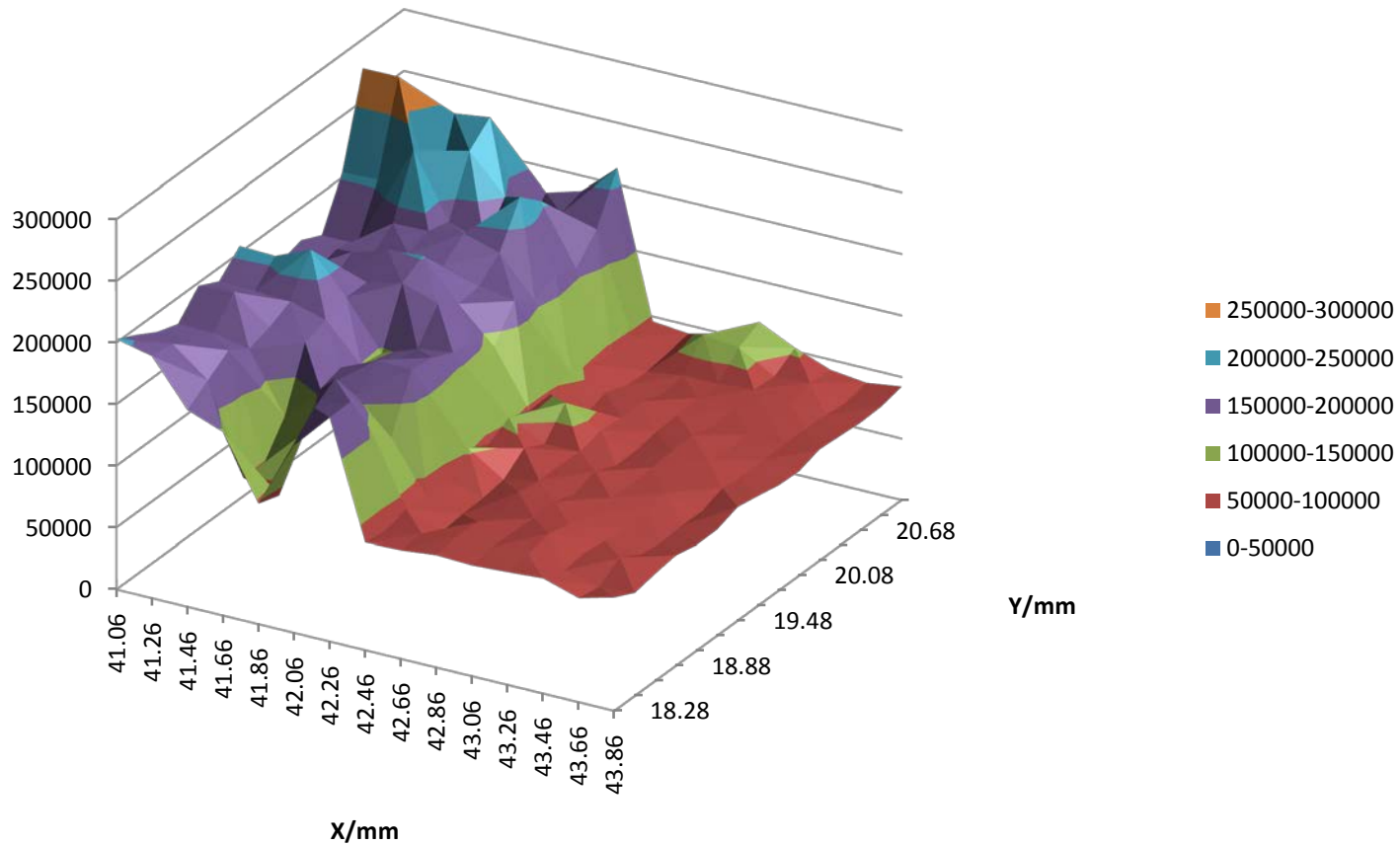
# P K12



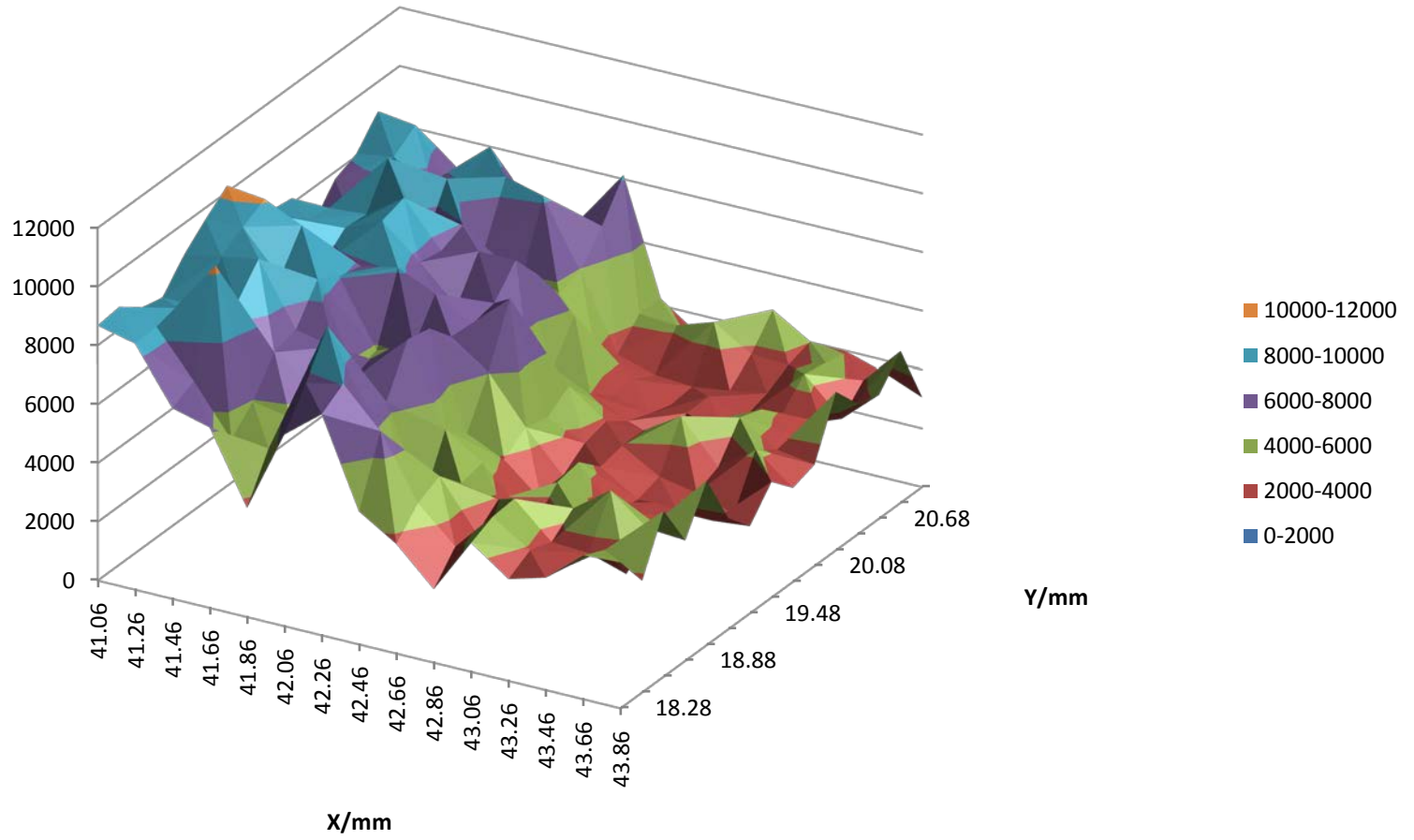
# As K12



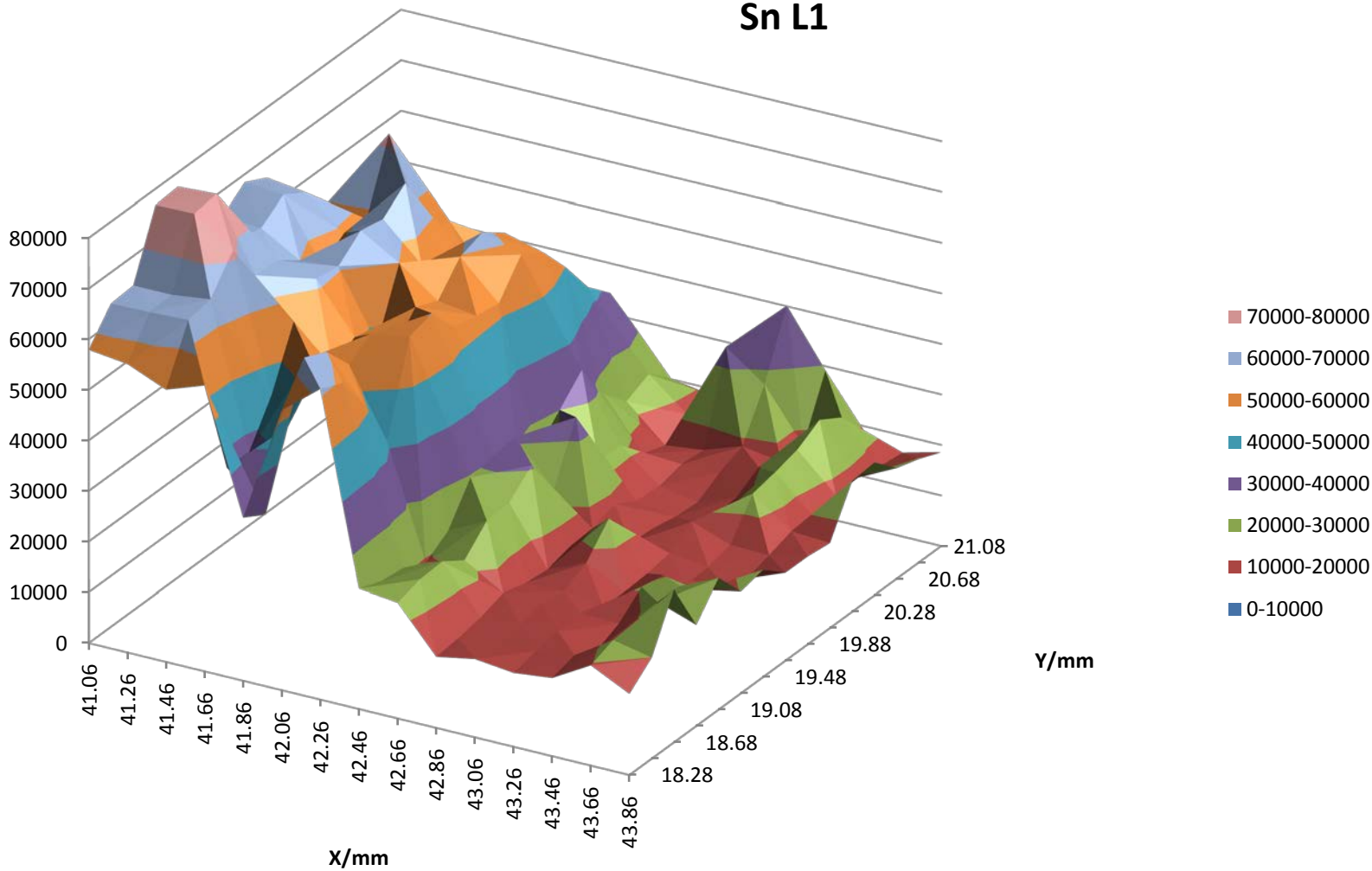
# Fe K12



# Pb L1

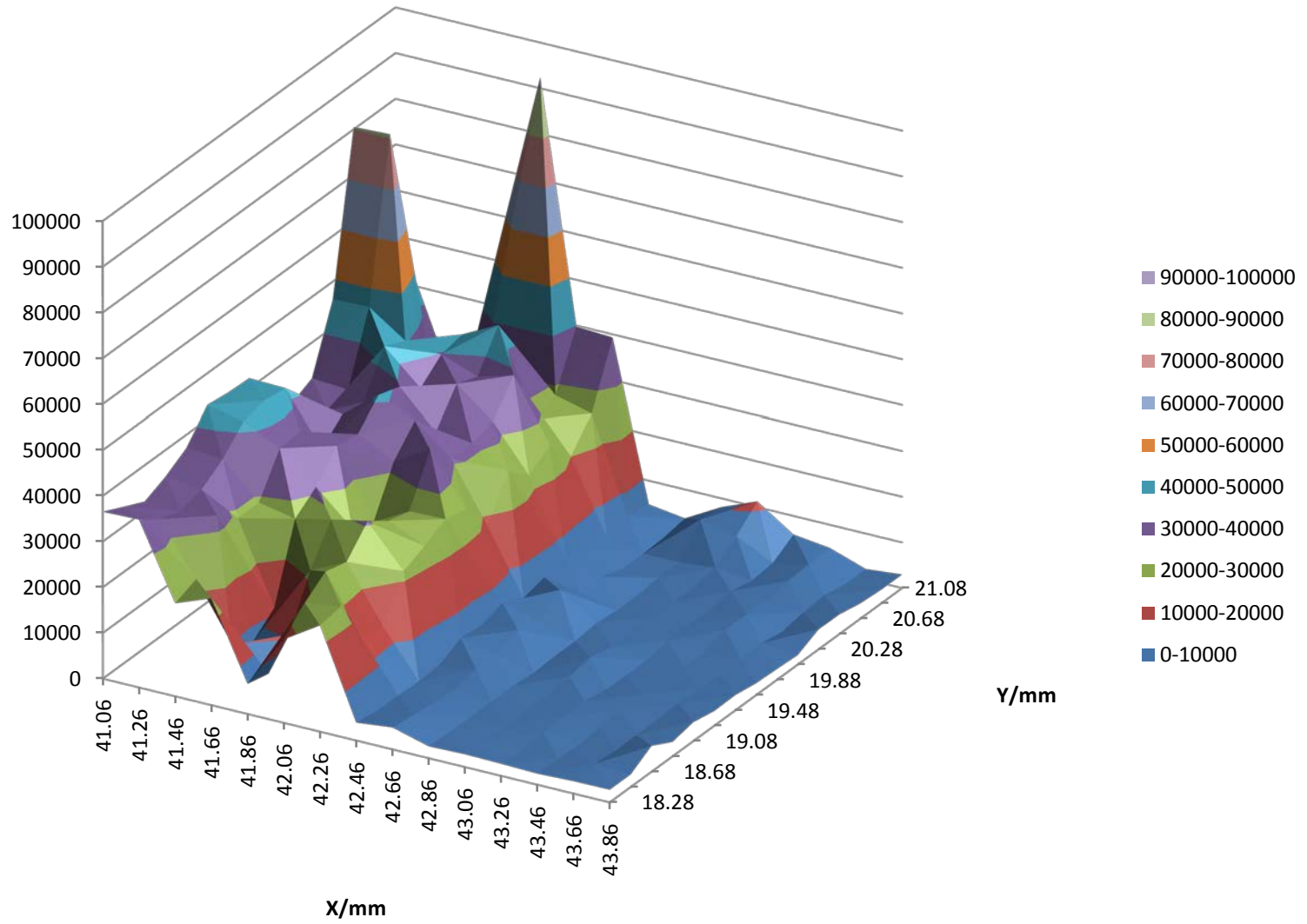


# Sn L1

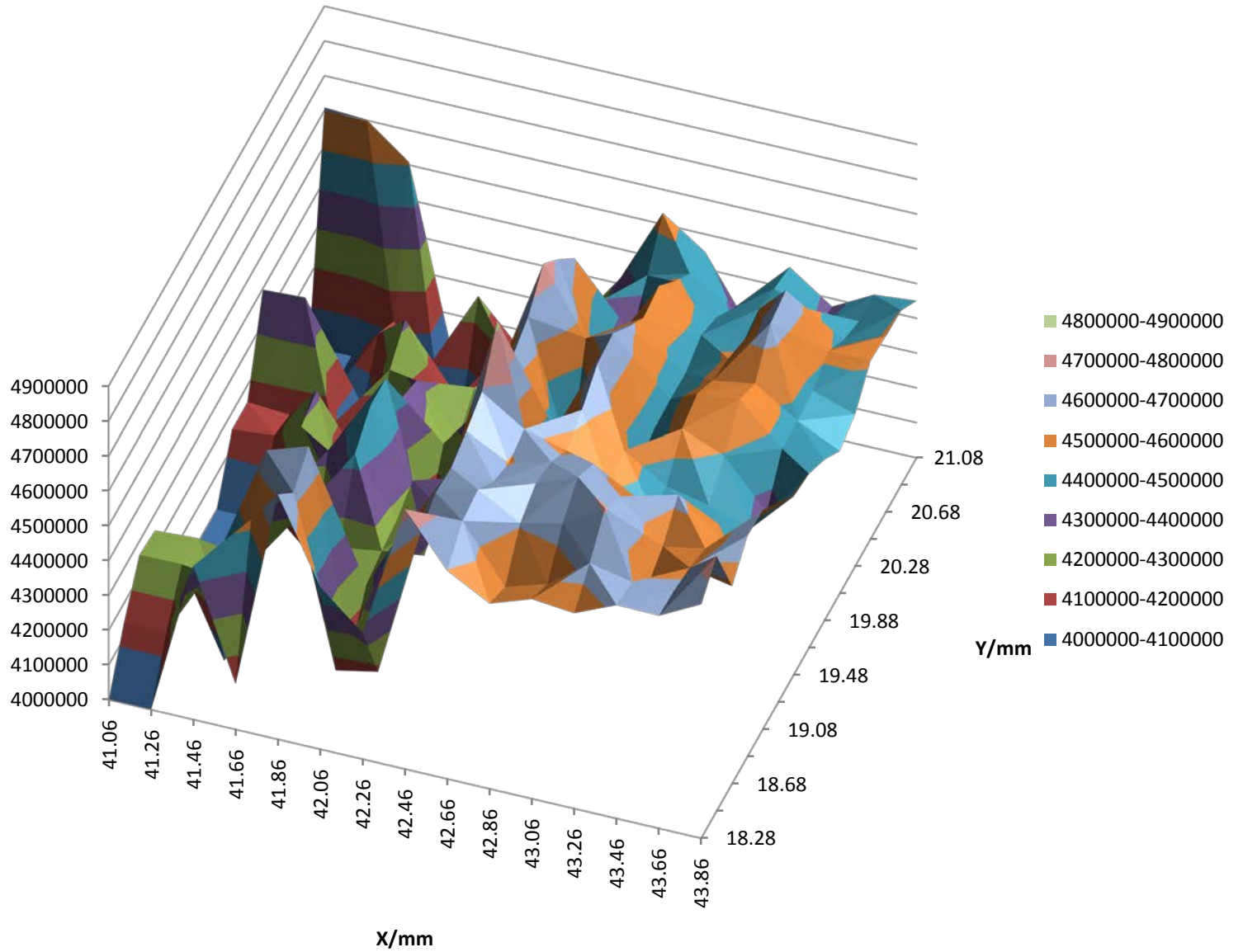




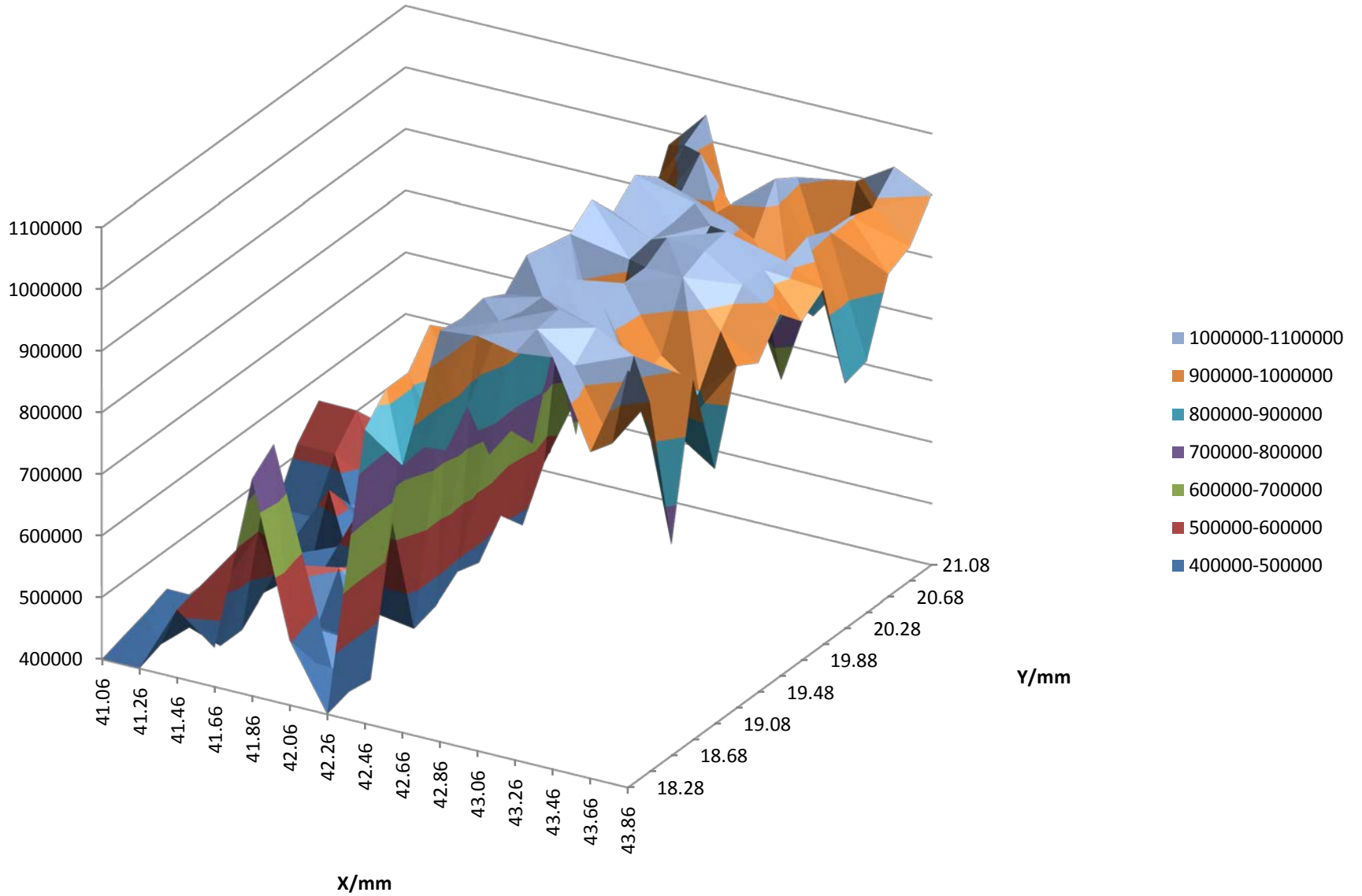
# Ca K12



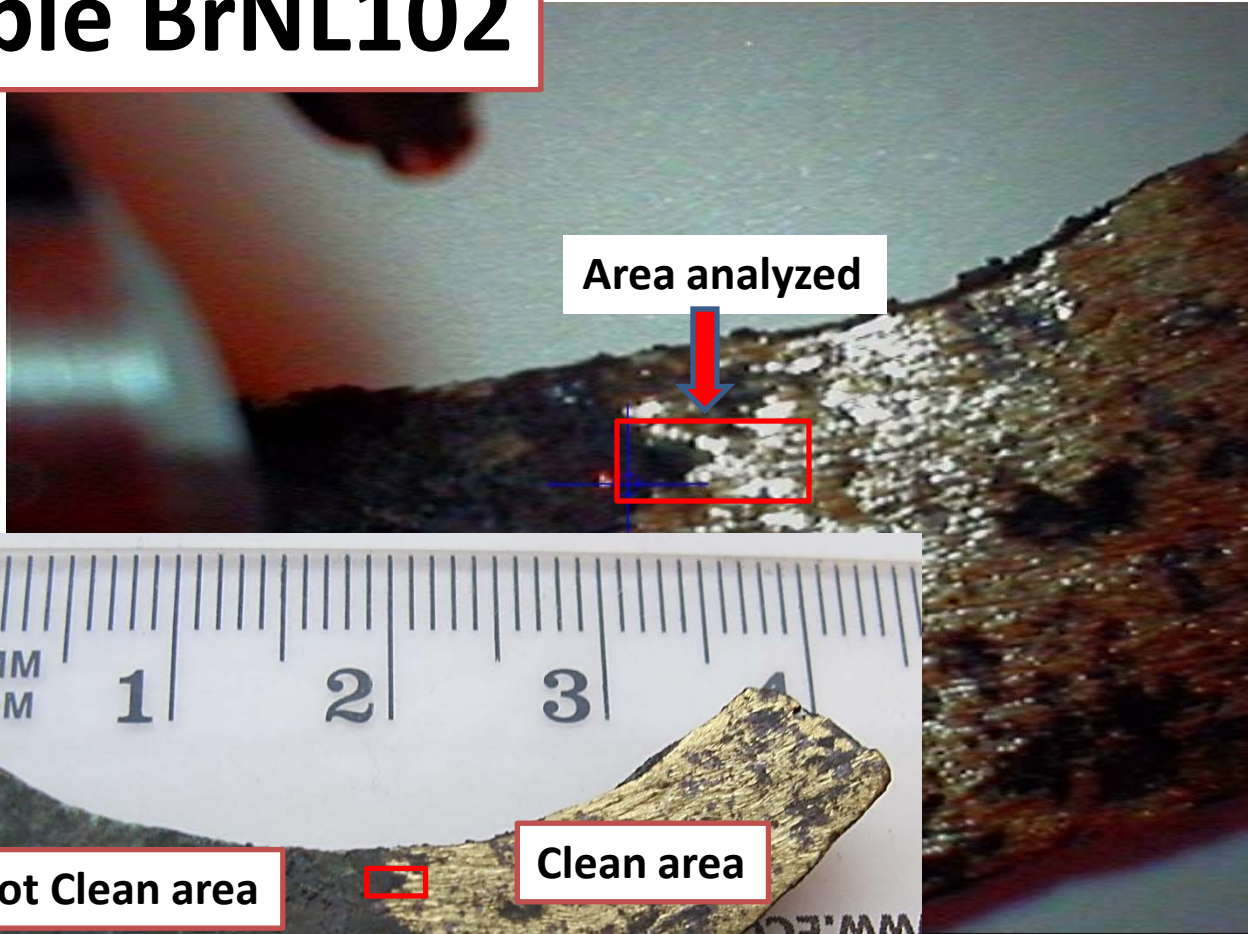
# Cu K12



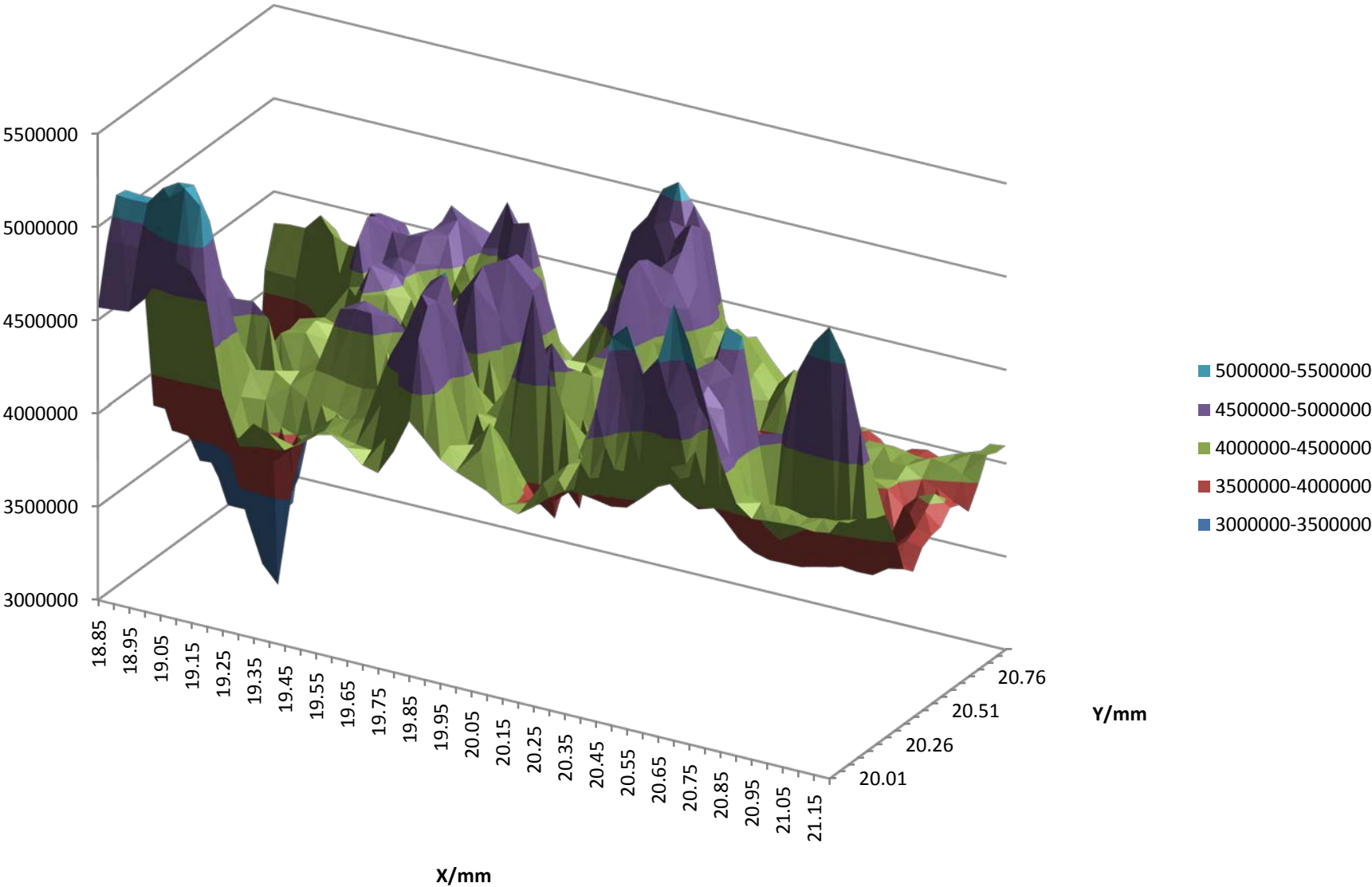
# Zn K12



# Sample BrNL102

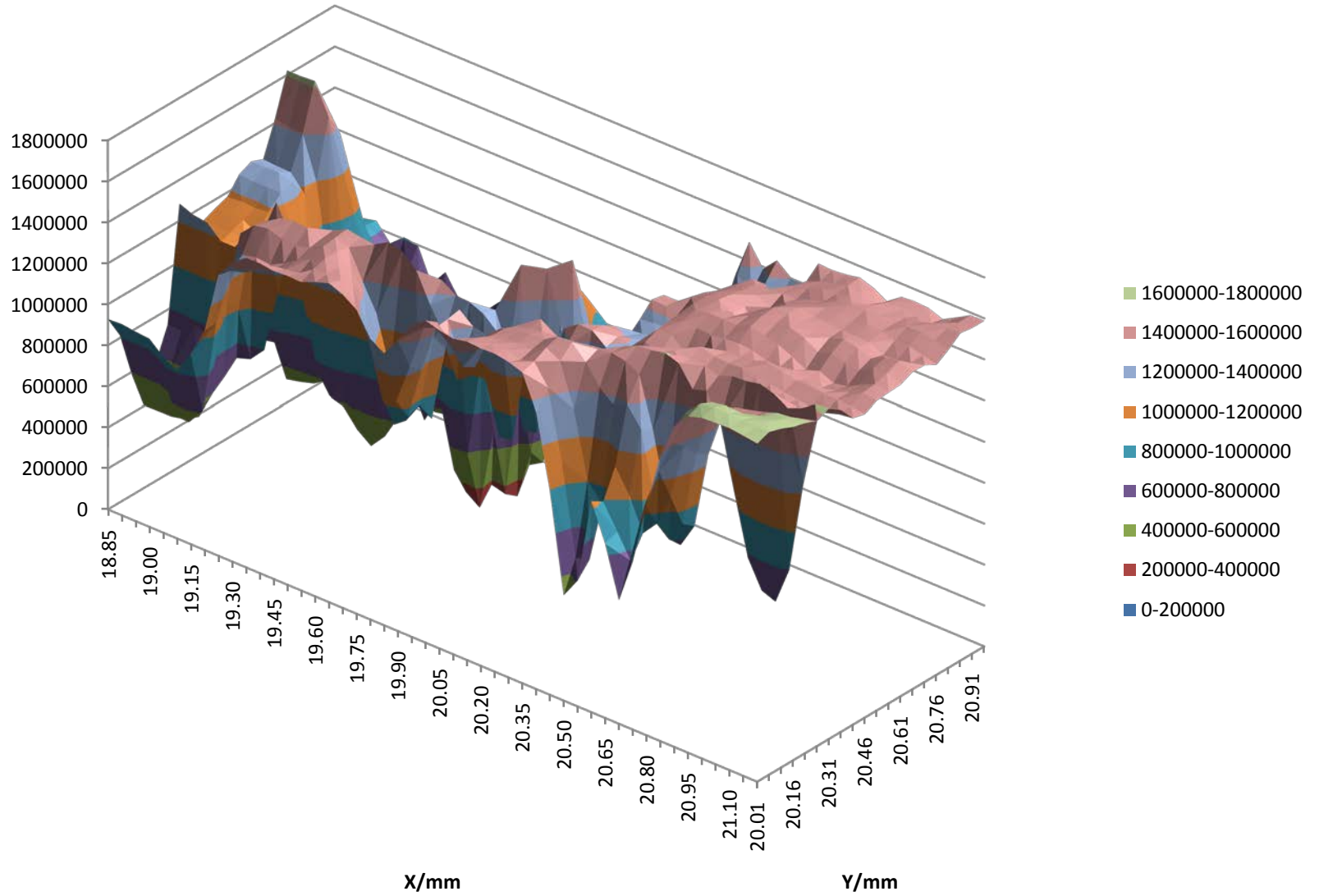


# Cu K12

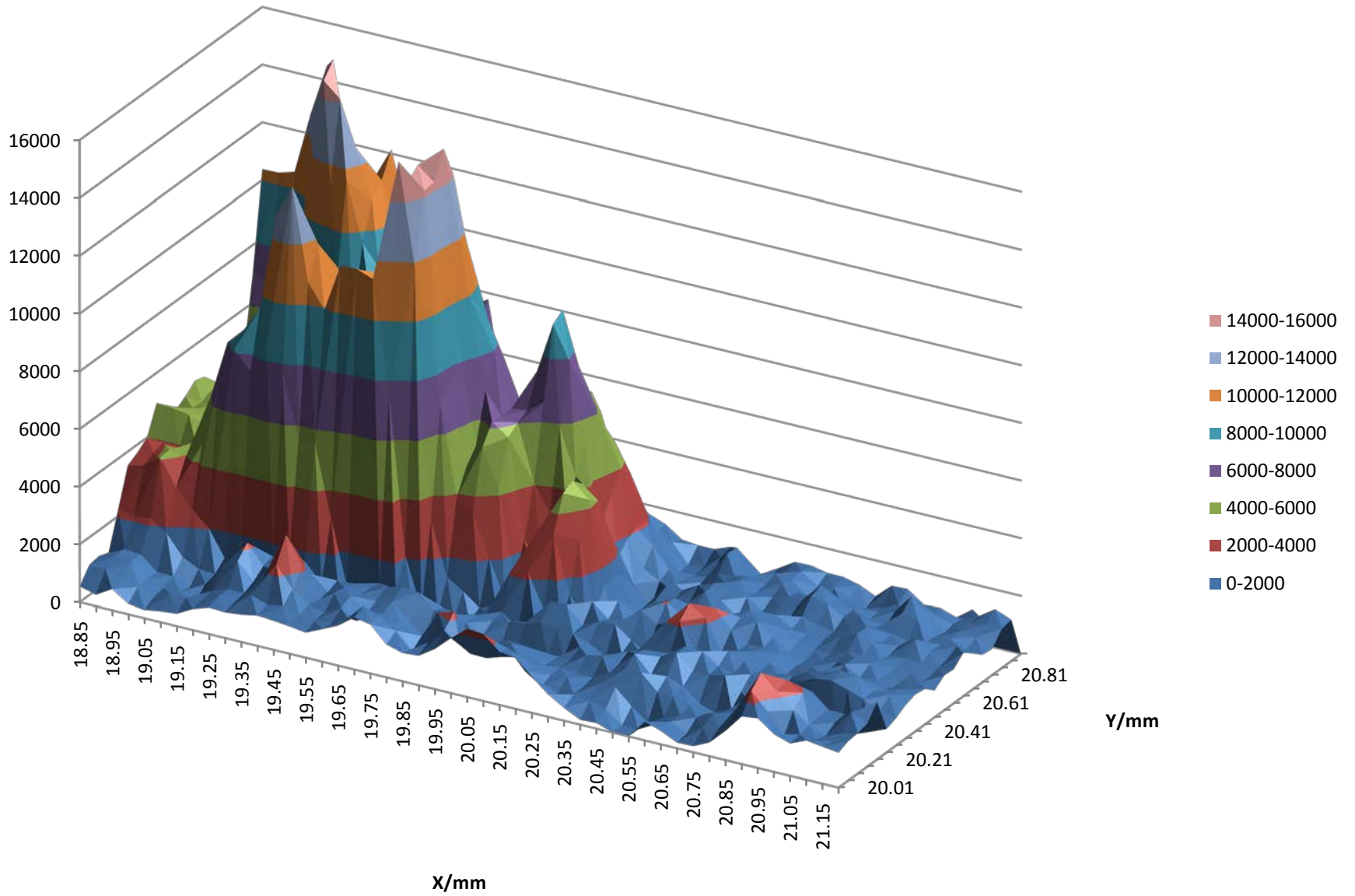




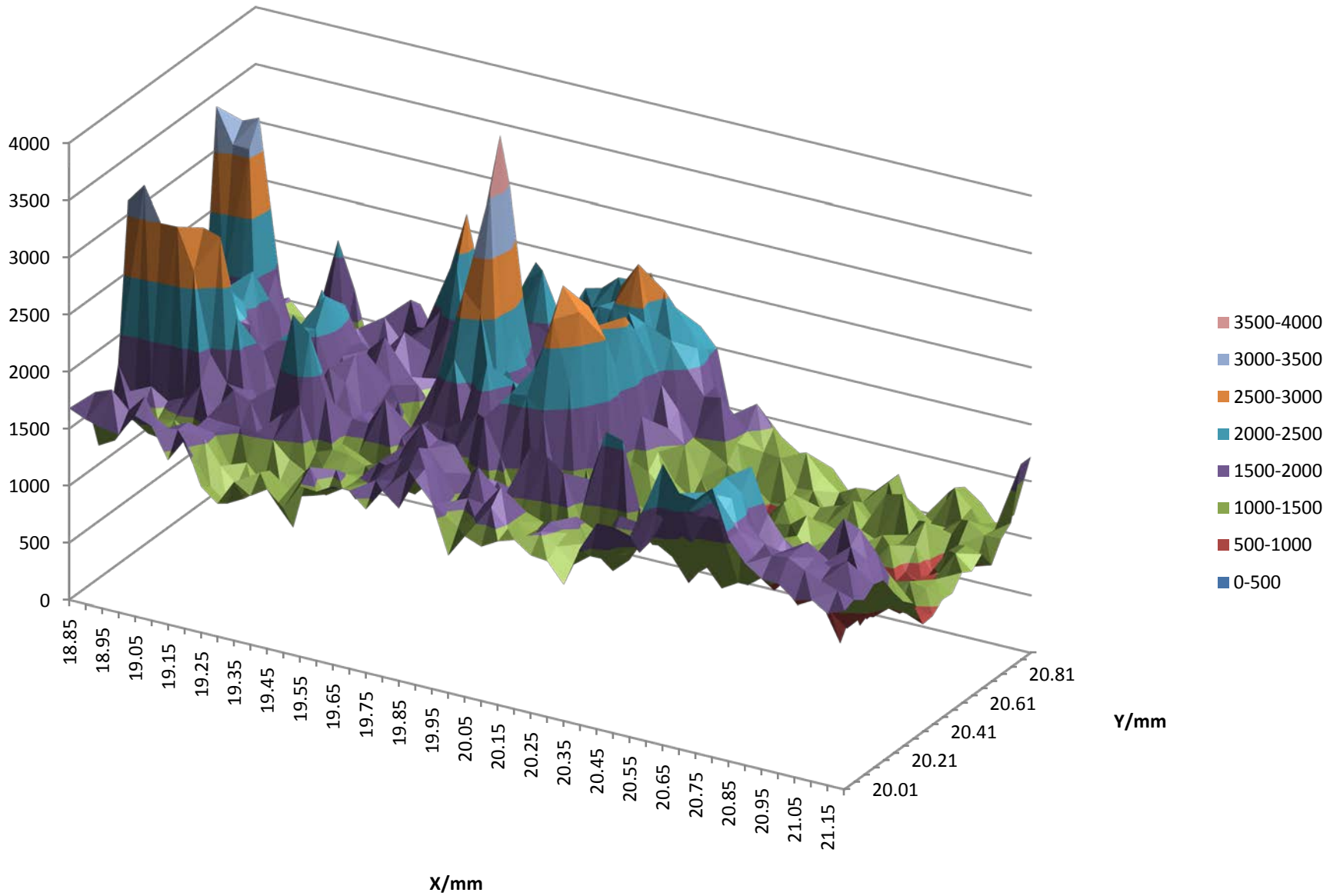
# Zn K12



# Pb M1

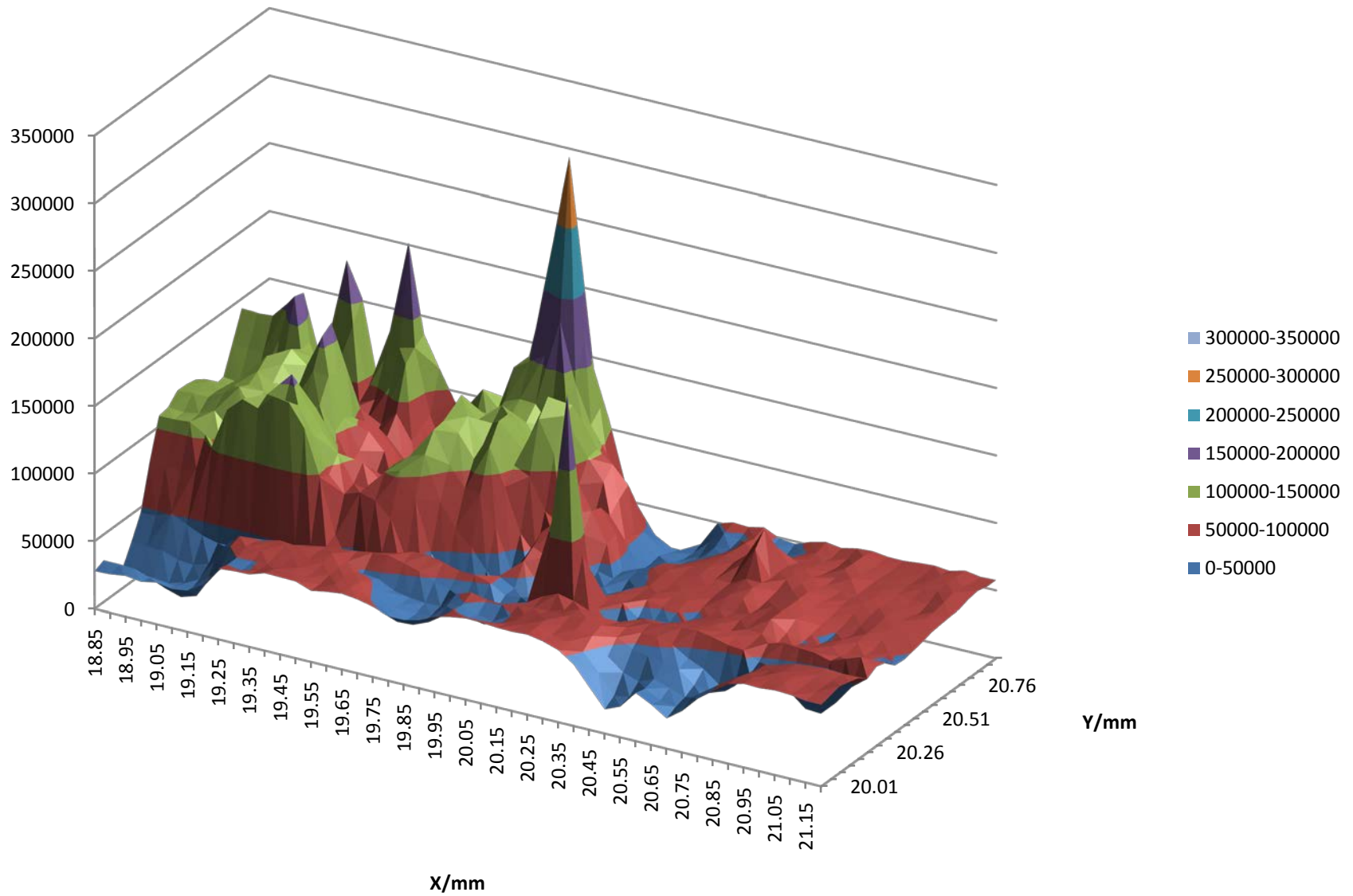


# Sn L1

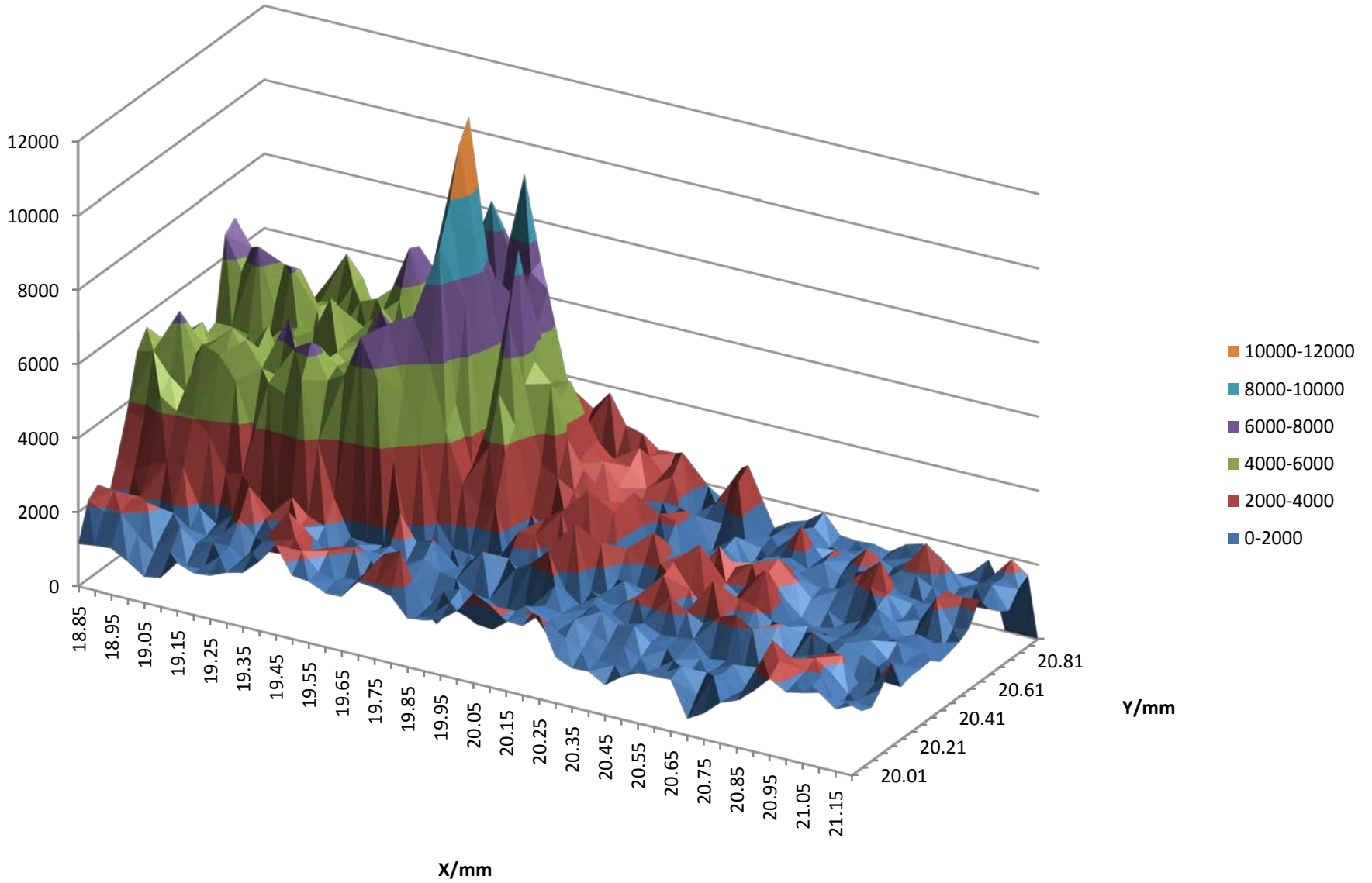




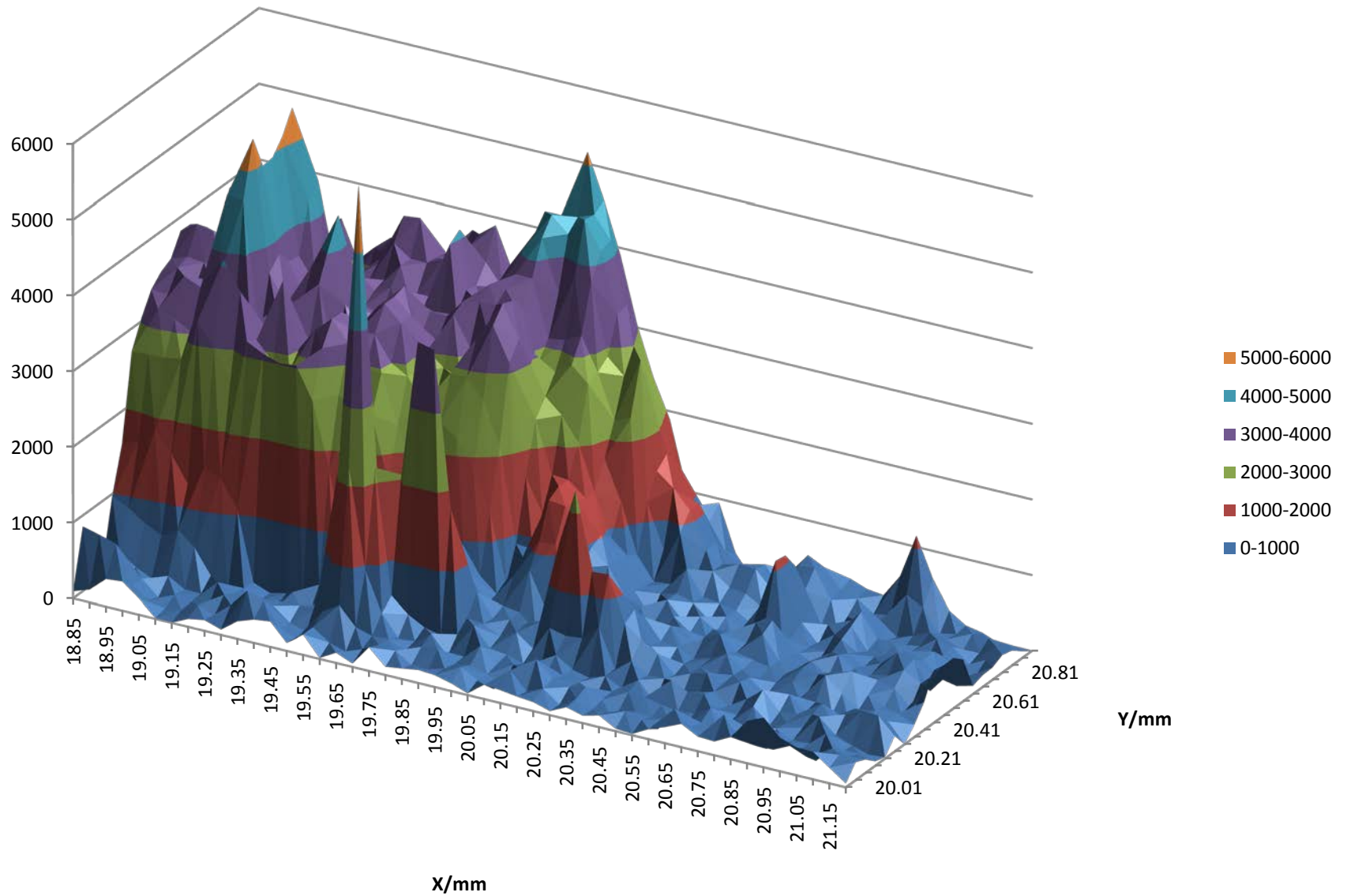
# Fe K12



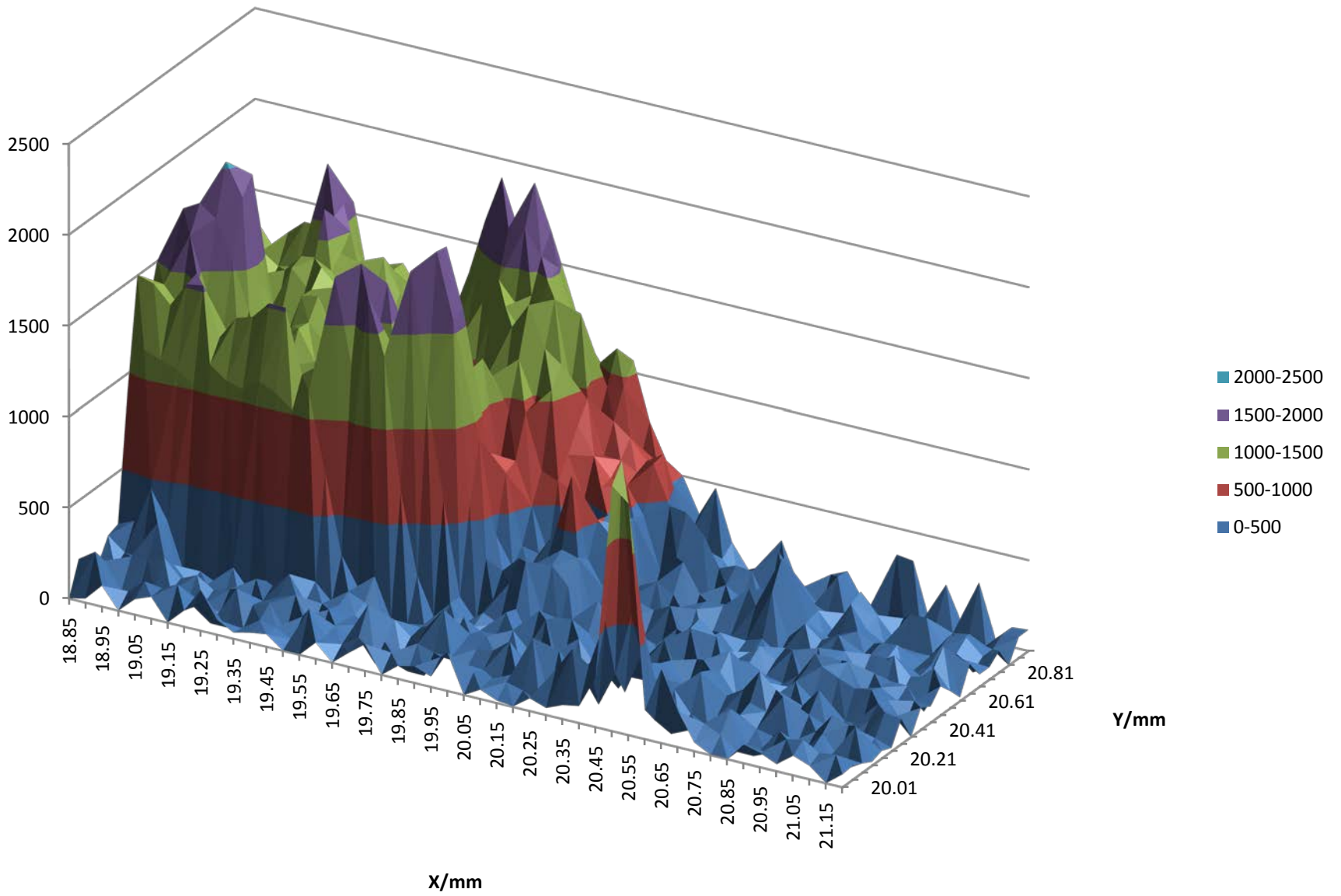
# As K12



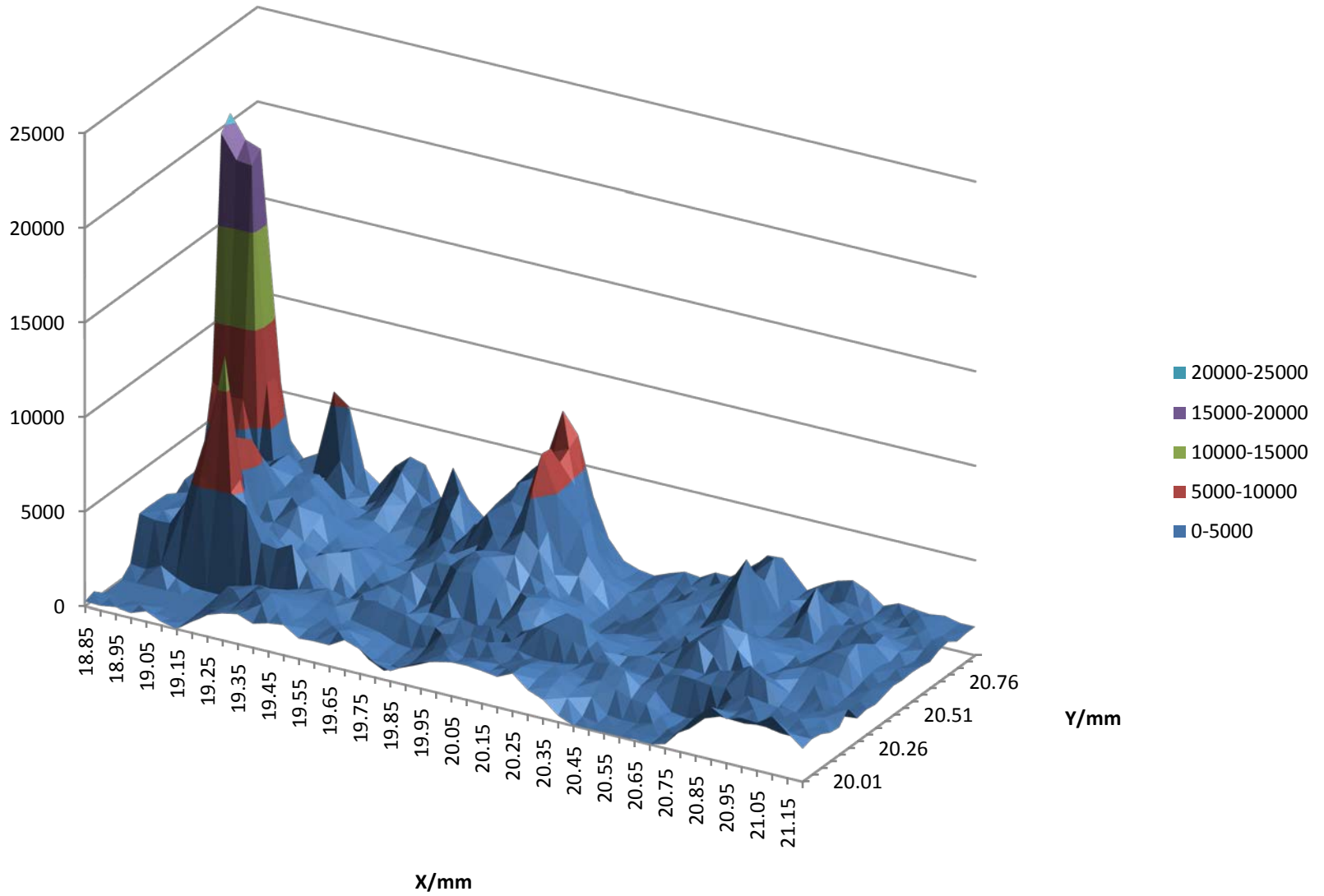
# Si K12



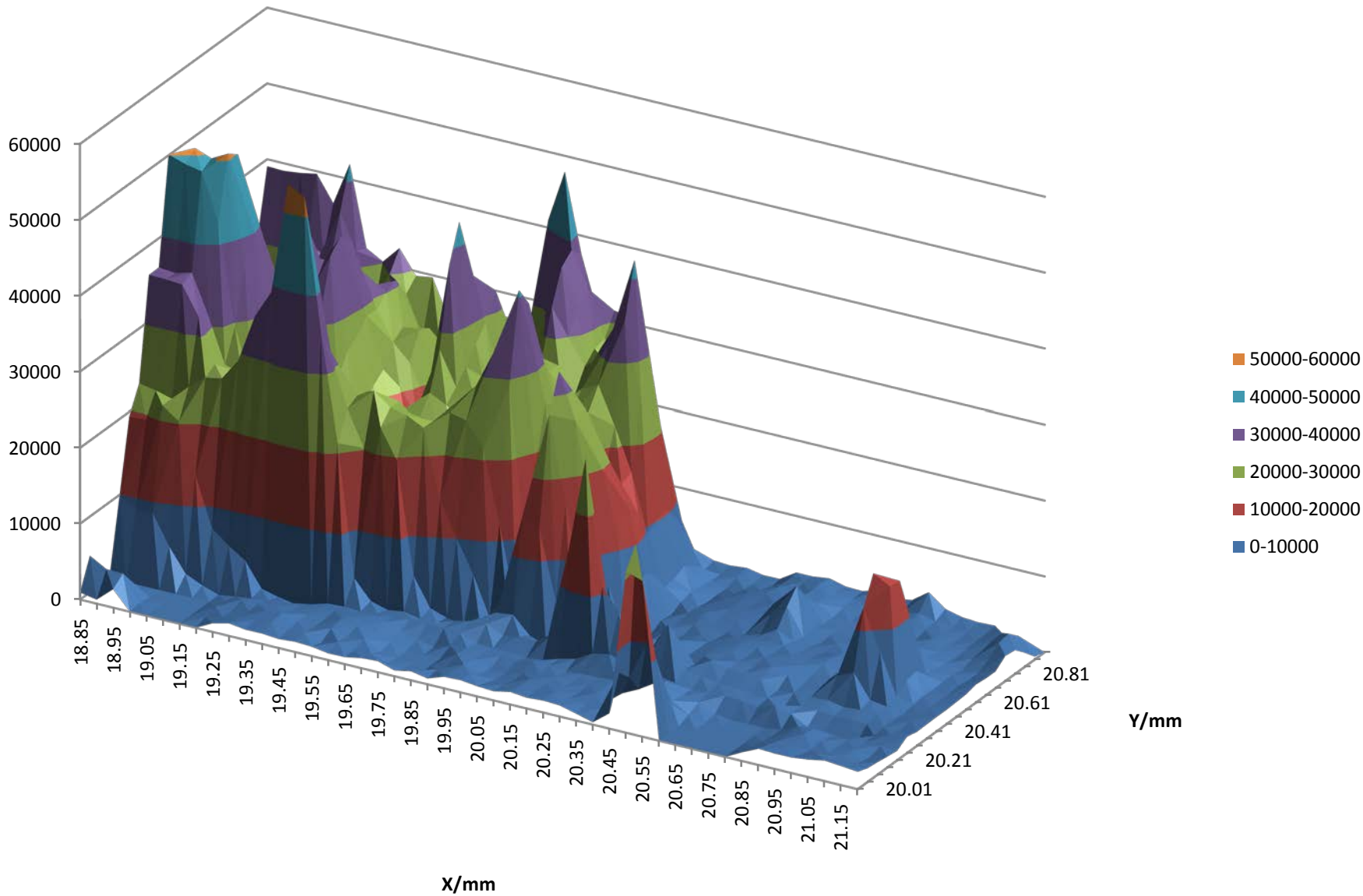
# P K12



# K K12



# Ca K12





# Rh L1

