pXRF in the Geoscience: Application to Environmental, Regional and Exploration Geology.

Portable XRF Instruments: A Mineral Exploration Prospective

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Portable XRF Service

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University of Western Australia

Session #128: T41

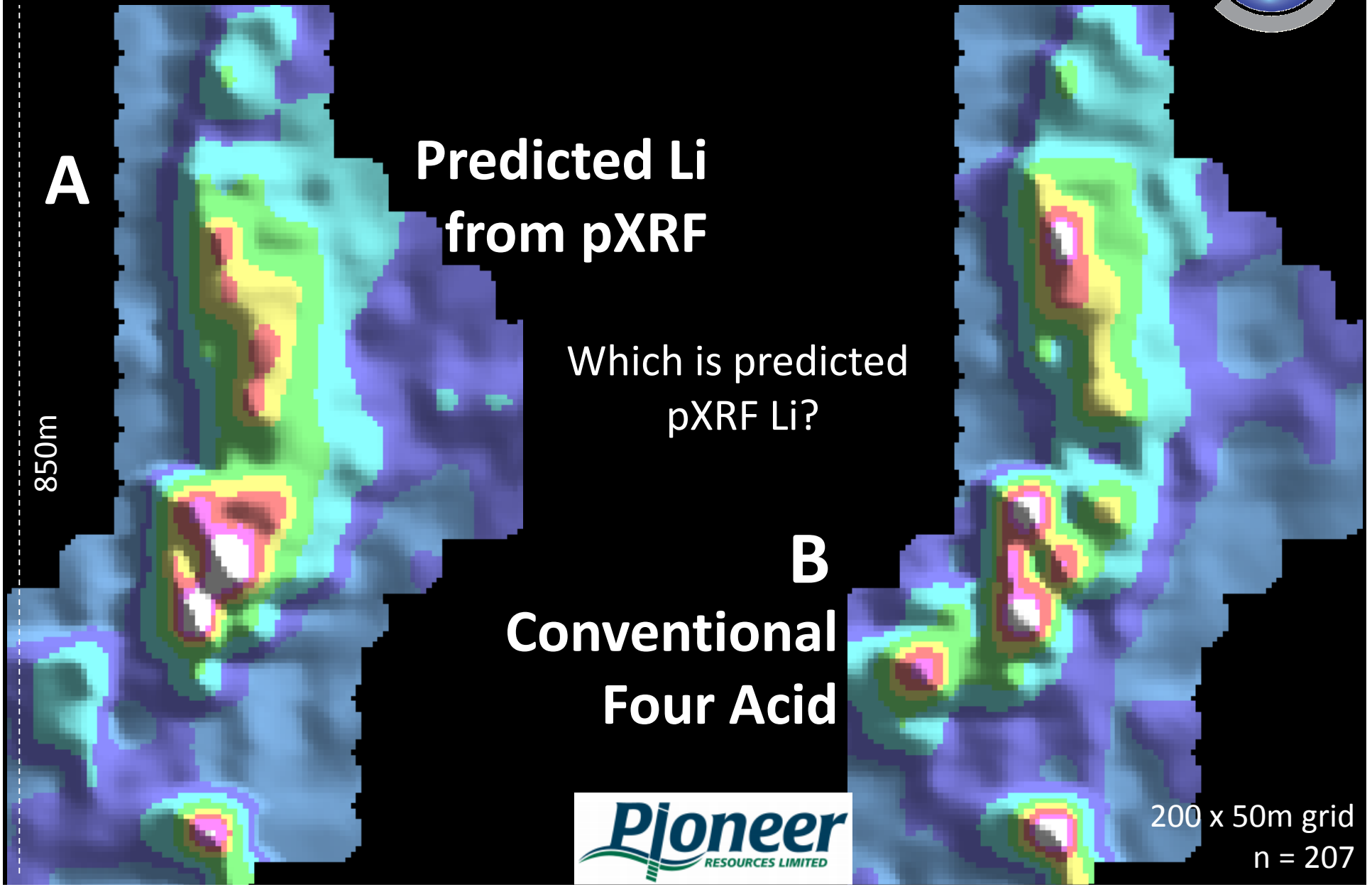
26

September

2016

Denver, CA

Both images are derived from the SAME samples
Laboratory Li, predicted Li from pXRF instrument



Portable XRF Instruments

BRUKER

Thermo SCIENTIFIC

OLYMPUS

OXFORD INSTRUMENTS

SPECTRO

Portable XRF Instruments

BRUKER

Thermo SCIENTIFIC

OLYMPUS

OXFORD INSTRUMENTS

SPECTRO

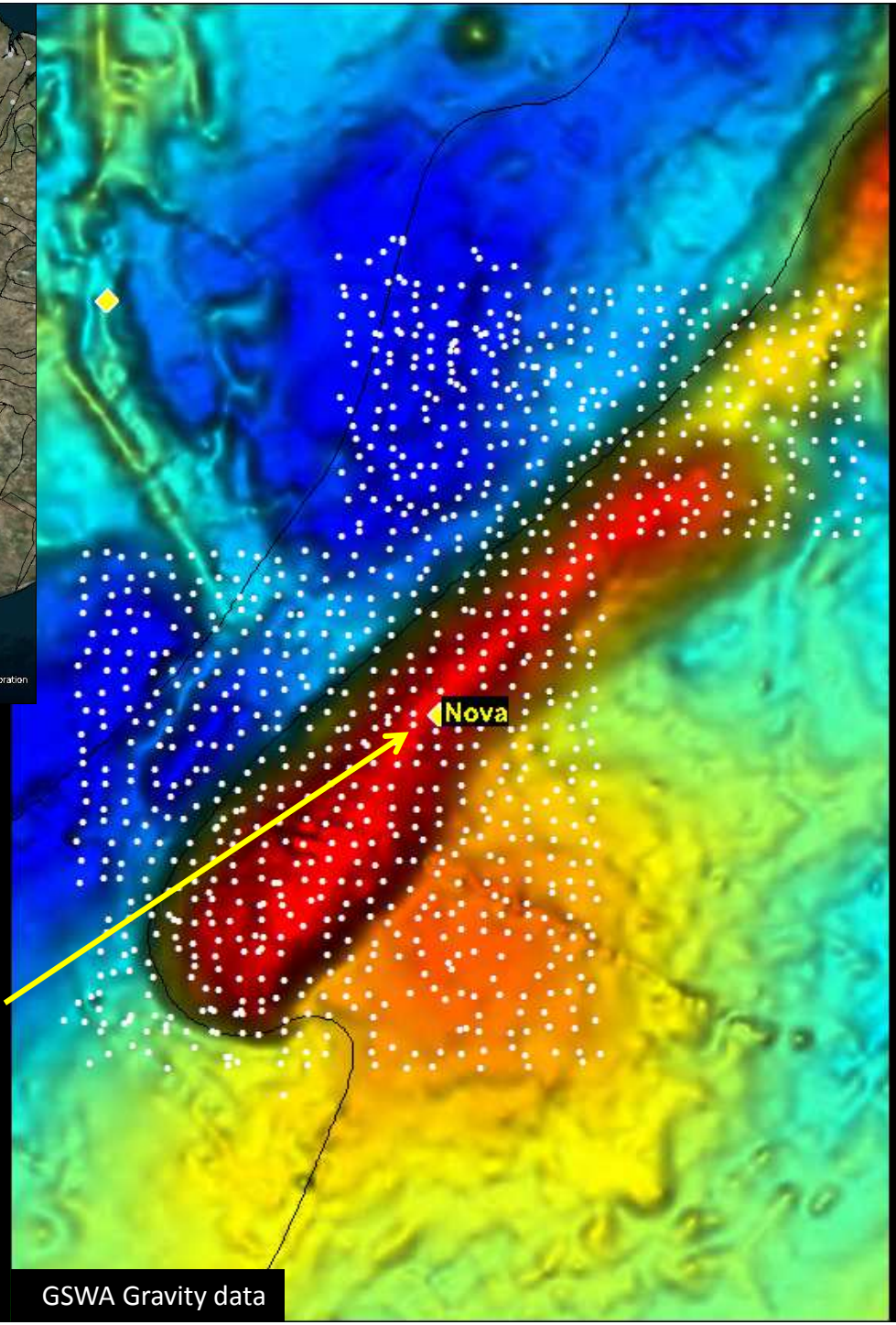
Which one is BEST?

Fraser Range

Sample …201 collected within 1.2 km of Nova discovey

- **271 ppm Ni**
- **90 ppm Cu**

This is the needle in the haystack sample



Open File Government data set

Surface regolith samples

Collected on ~4km x 4km grid

All samples have commercial laboratory assays

All samples collected pre-discovery

NOVA (Ni) in ground value: **US$4B**

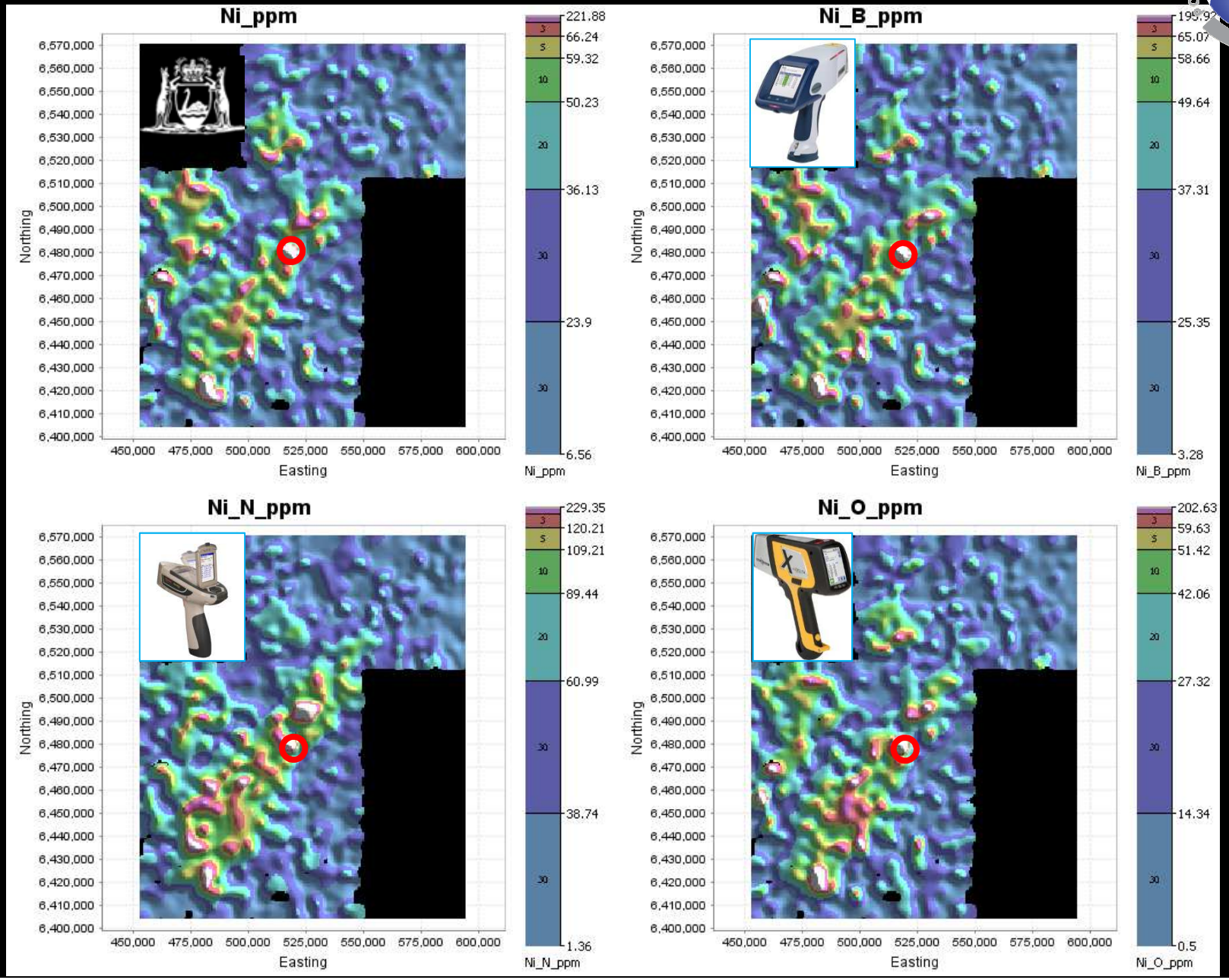
10.2Mt at 2.4% Ni, 1.0% Cu and 0.08% Co March 2013

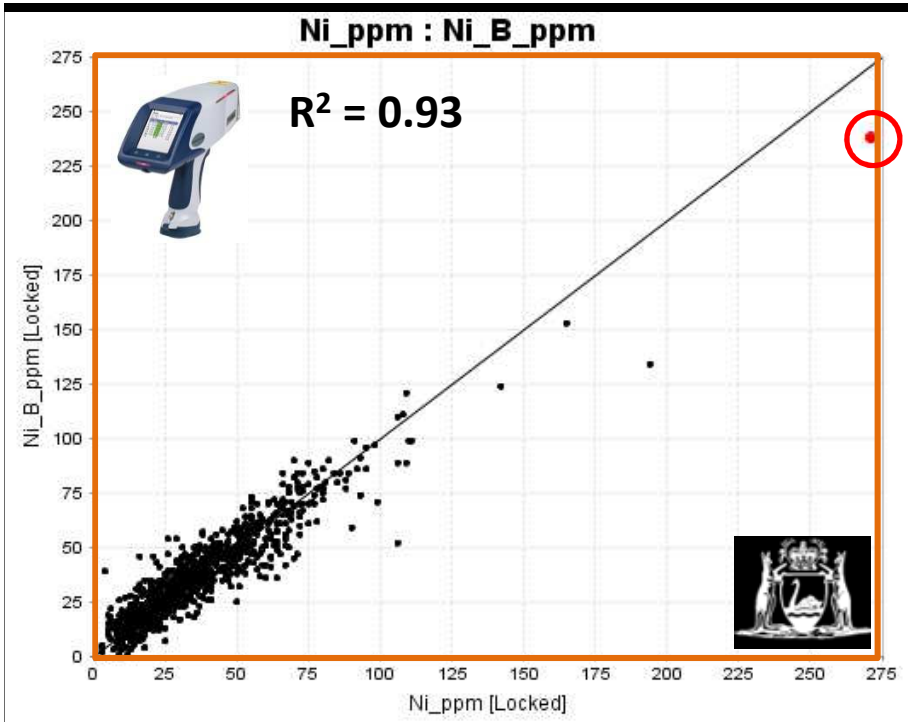
Government Wet Chemistry Data (raw)

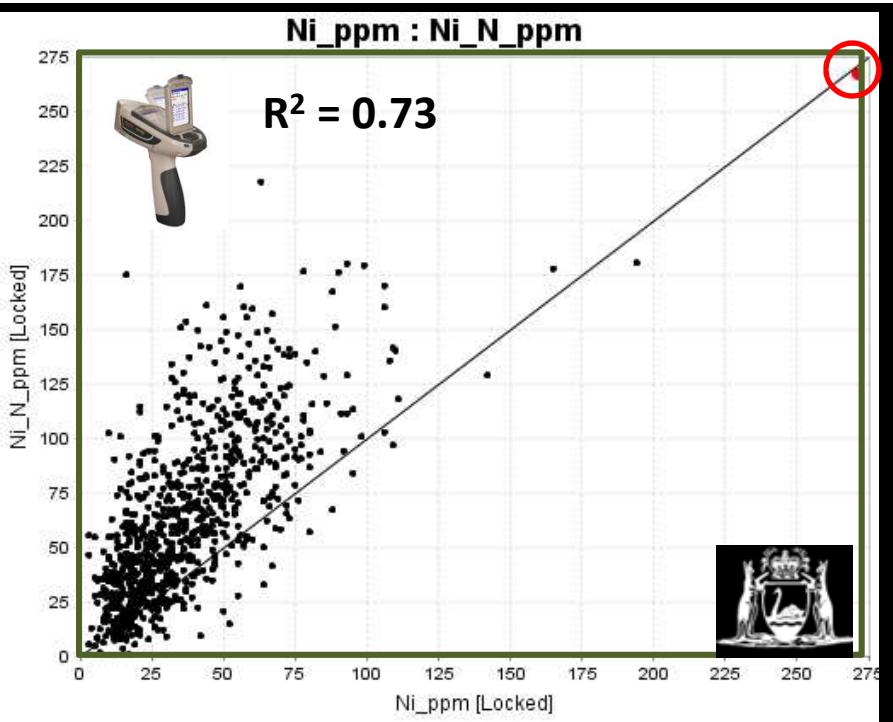
Bruker Titan S1
(geochem app)

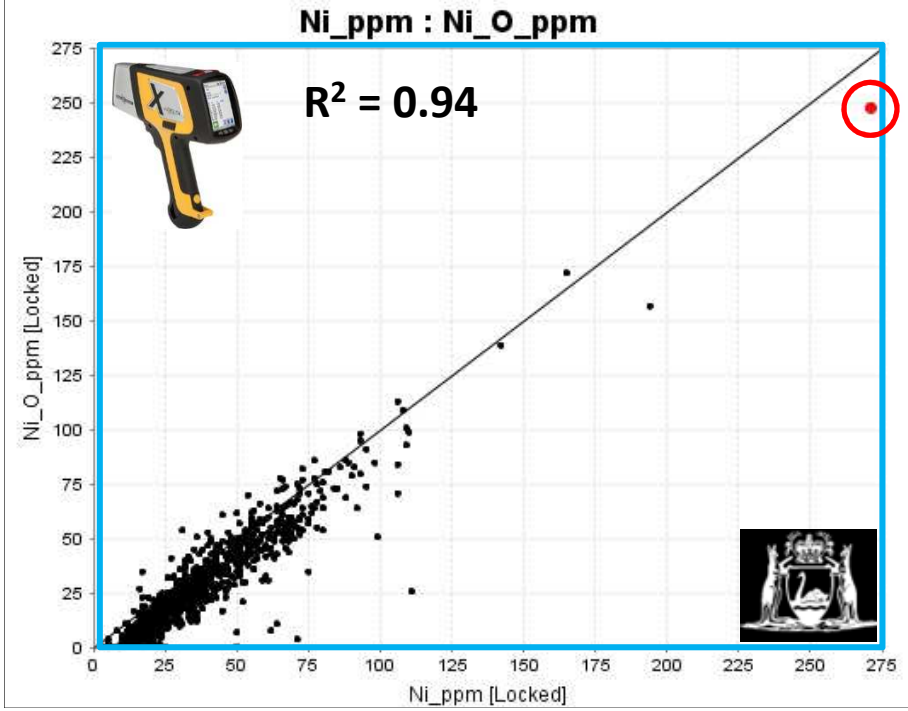
Niton XLtGold++
(soil mode)

Olympus Delta Premium
(soil mode)

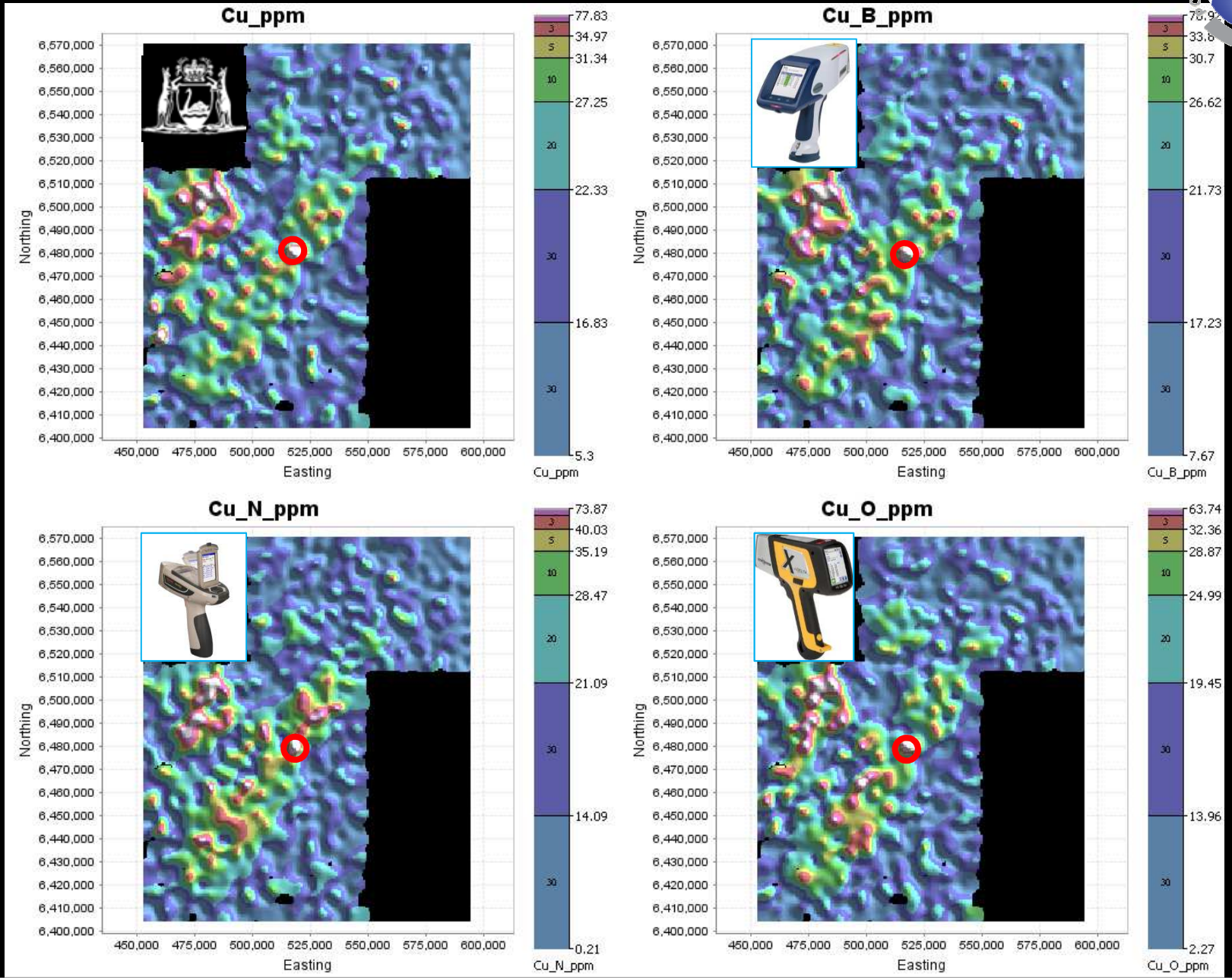

Ni_ppm
Northing
6,570,000
6,560,000
6,550,000
6,540,000
6,530,000
6,520,000
6,510,000
6,500,000
6,490,000
6,480,000
6,470,000
6,460,000
6,450,000
6,440,000
6,430,000
6,420,000
6,410,000
6,400,000
450,000
475,000
500,000
525,000
550,000
575,000
600,000
Easting
3
5
10
20
30
30
221.88
66.24
59.32
50.23
36.13
23.9
6.56
Ni_ppm
Ni_B_ppm
65.07
58.66
49.64
37.31
25.35
3.28
Ni_B_ppm
Ni_N_ppm
229.35
120.21
109.21
89.44
60.99
38.74
1.36
Ni_N_ppm
Ni_O_ppm
202.63
59.63
51.42
42.06
27.32
14.34
0.5
Ni_O_ppm

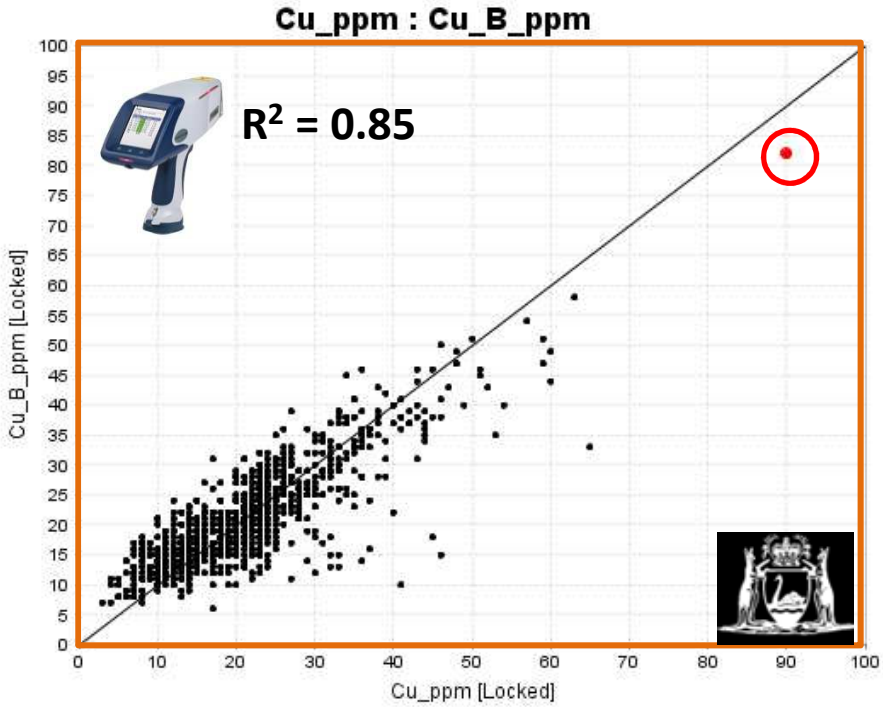


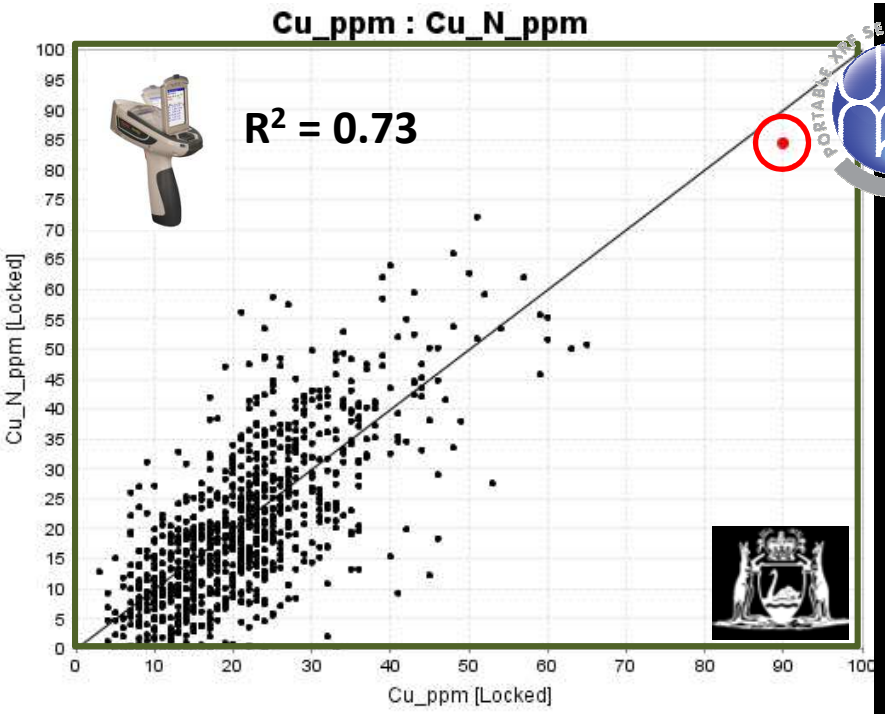


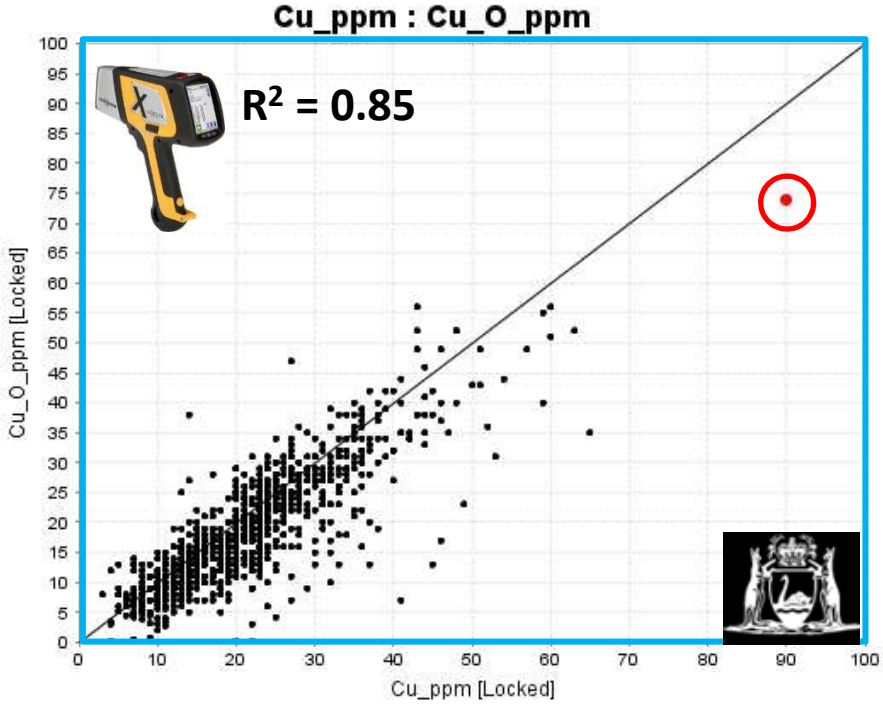


	Ni_ppm	Ni_B_ppm	Ni_N_ppm	Ni_O_ppm
Min	3	1	0.055	0.5
Max	271	238	267.56	248
Mean	35.48	35.84	60.69	26.52
Sdev	23.58	22.22	38.84	24.23
RSD	66.48	62.00	64.00	91.38


Cu_ppm
Northing
Easting
6,570,000
6,560,000
6,550,000
6,540,000
6,530,000
6,520,000
6,510,000
6,500,000
6,490,000
6,480,000
6,470,000
6,460,000
6,450,000
6,440,000
6,430,000
6,420,000
6,410,000
6,400,000
450,000
475,000
500,000
525,000
550,000
575,000
600,000
77.83
34.97
31.34
27.25
22.33
16.83
5.3
Cu_ppm
Cu_B_ppm
Northing
Easting
78.9
33.6
30.7
26.62
21.73
17.23
7.67
Cu_B_ppm
Cu_N_ppm
Northing
Easting
73.87
40.03
35.19
28.47
21.09
14.09
0.21
Cu_N_ppm
Cu_O_ppm
Northing
Easting
63.74
32.36
28.87
24.99
19.45
13.96
2.27
Cu_O_ppm



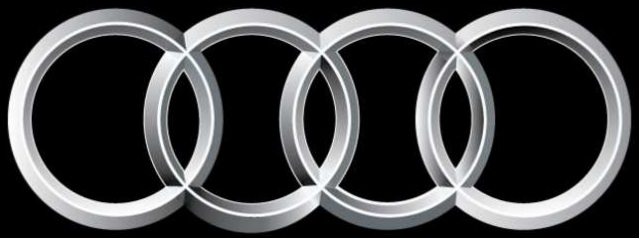




	Cu_ppm	Cu_B_ppm	Cu_N_ppm	Cu_O_ppm
Min	3	6	0.02	0.15
Max	90	82	84.5	74
Mean	21.37	21.43	20.49	18.73
Sdev	10.14	8.63	13.44	9.71
RSD	47.44	40.28	65.59	51.85

Which is BEST?

- All instruments found “needle in haystack”
- All instruments are considered “fit for purpose”
- Personal preference



- – go “test drive” them

Can pXRF technology find a mineral deposit?

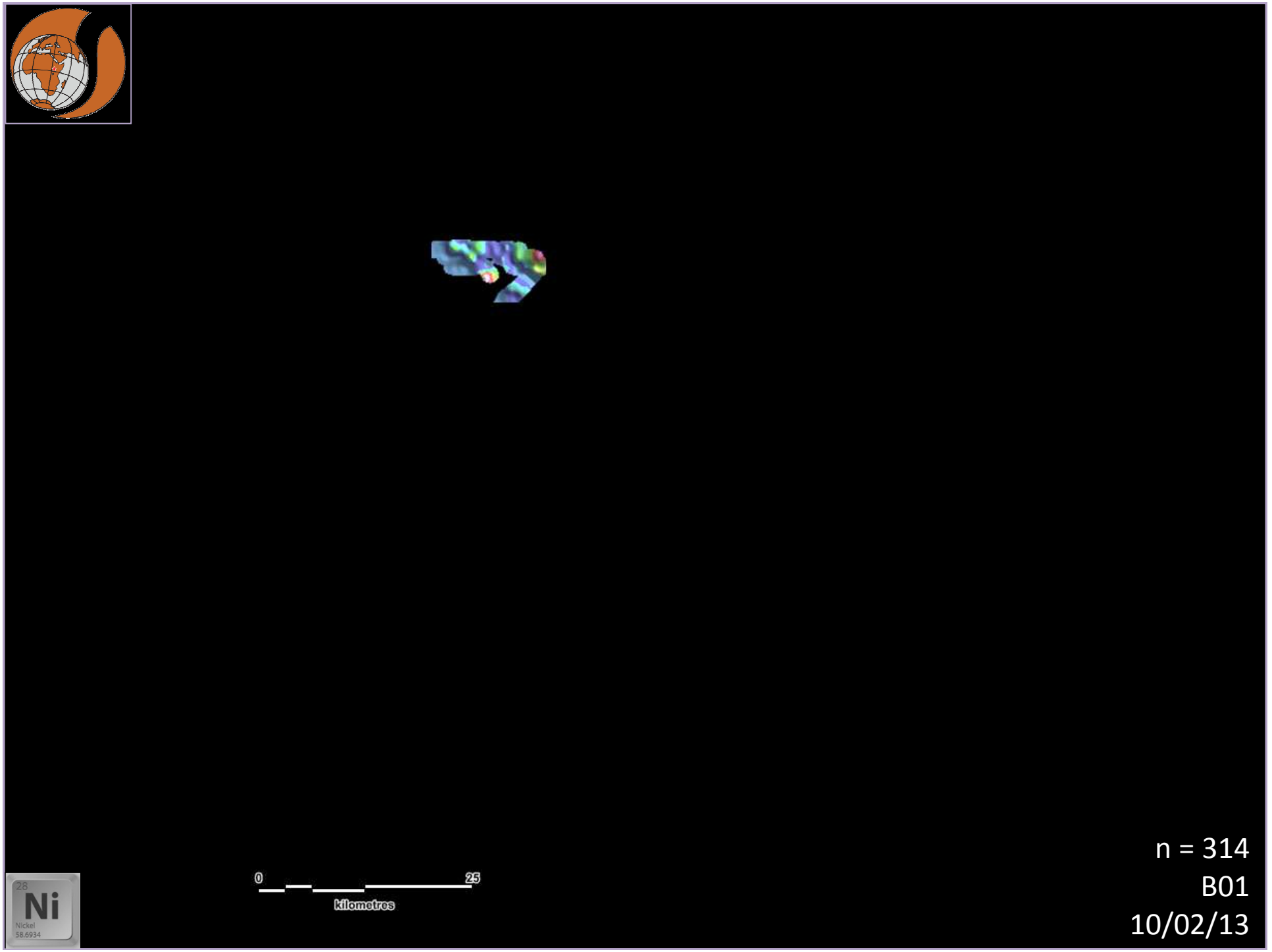
- Residual terrain
- Surface geochemistry “fit for purpose”
- pXRF analysis “fit for purpose” verified with laboratory analysis.

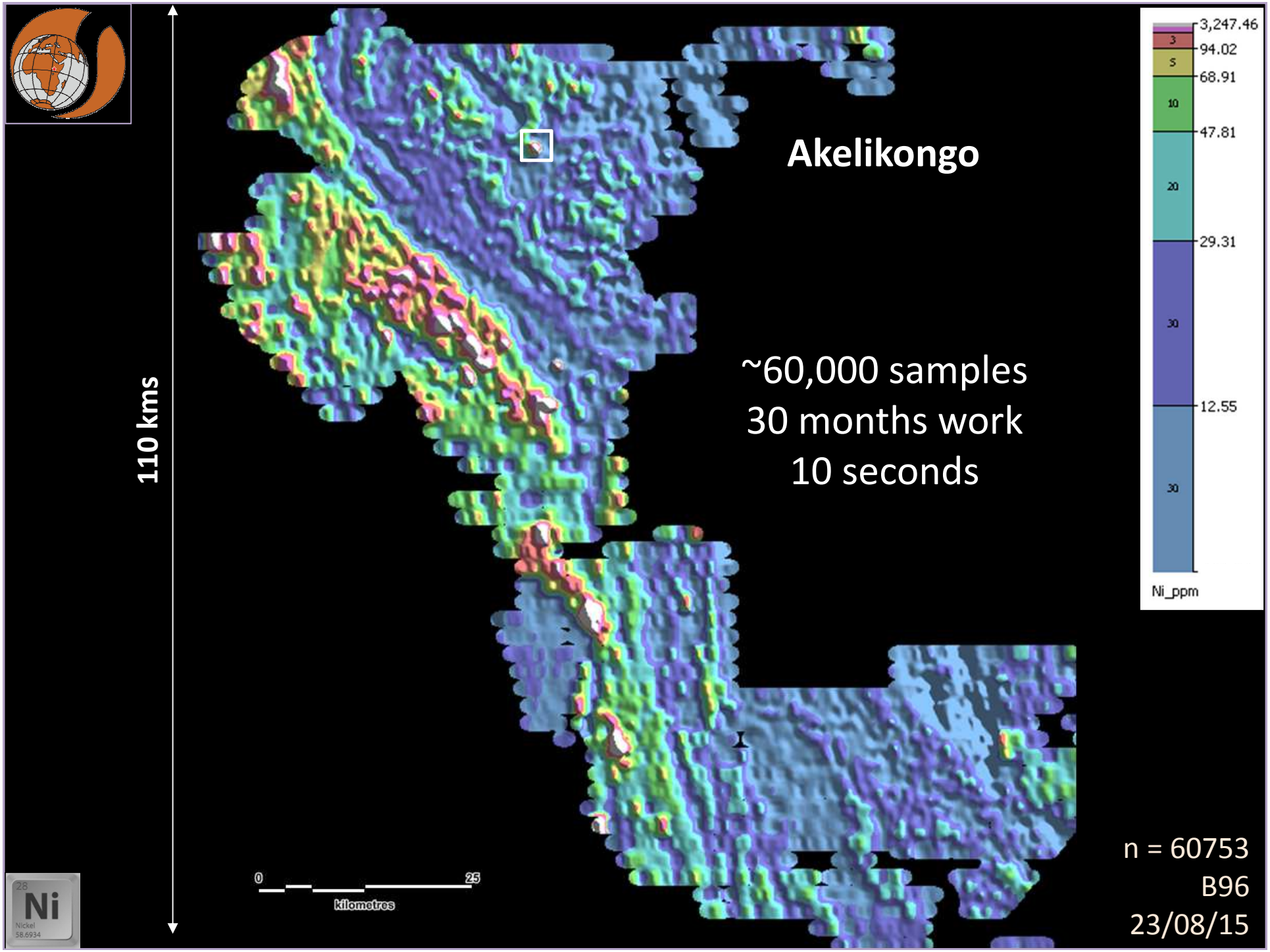
Weekly Time Slices (30 months)

Images of Ni

~60,000 samples

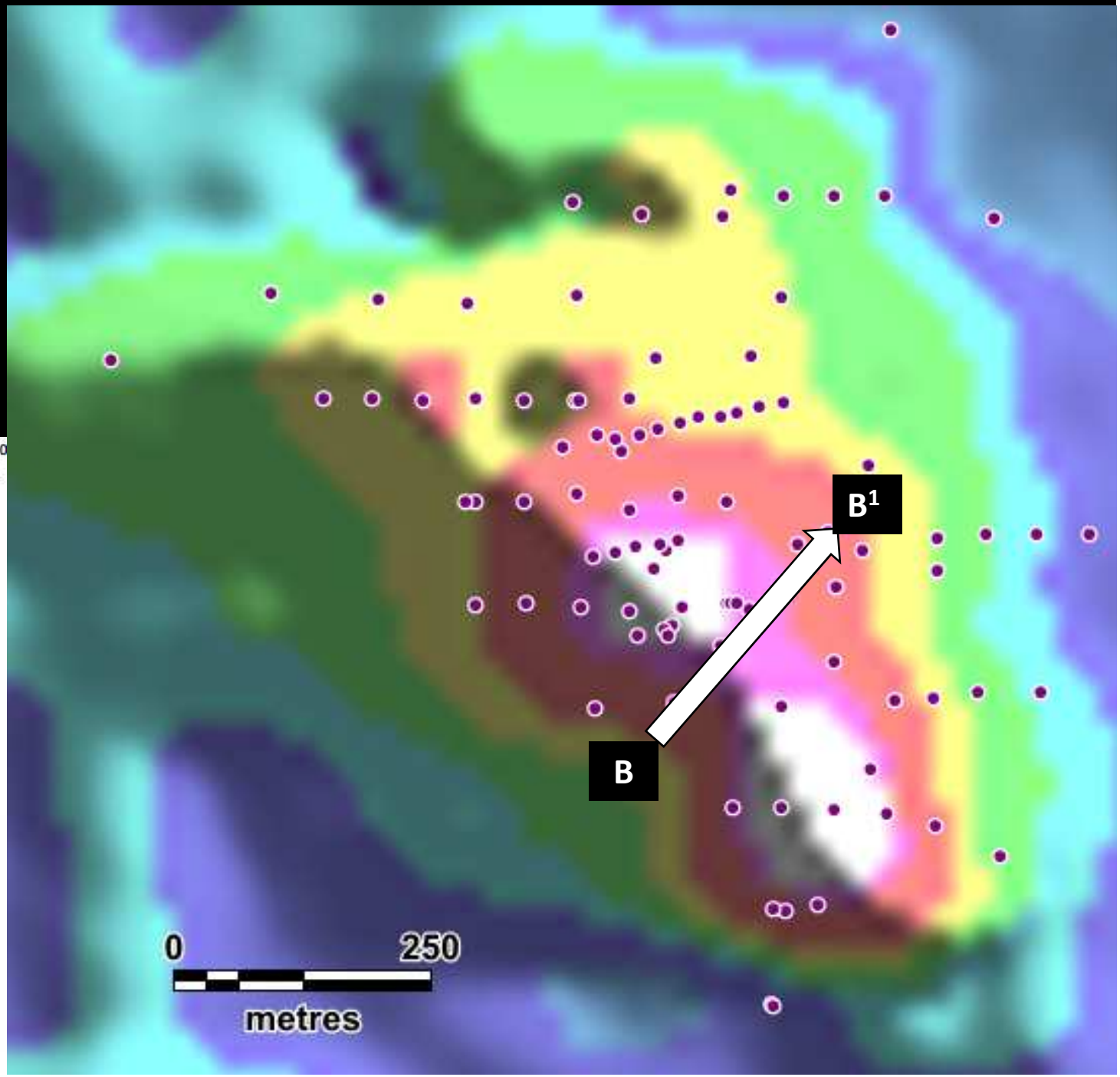
Grid - 1000 x 100m grid
110 km strike


28
Ni
Nickel
58.6934
0
25
kilometres
n = 314
B01
10/02/13


Akelikongo
~60,000 samples
30 months work
10 seconds
110 kms
3,247.46
94.02
68.91
47.81
29.31
12.55
Ni_ppm
0
25
kilometres
28
Ni
Nickel
58.6934
n = 60753
B96
23/08/15

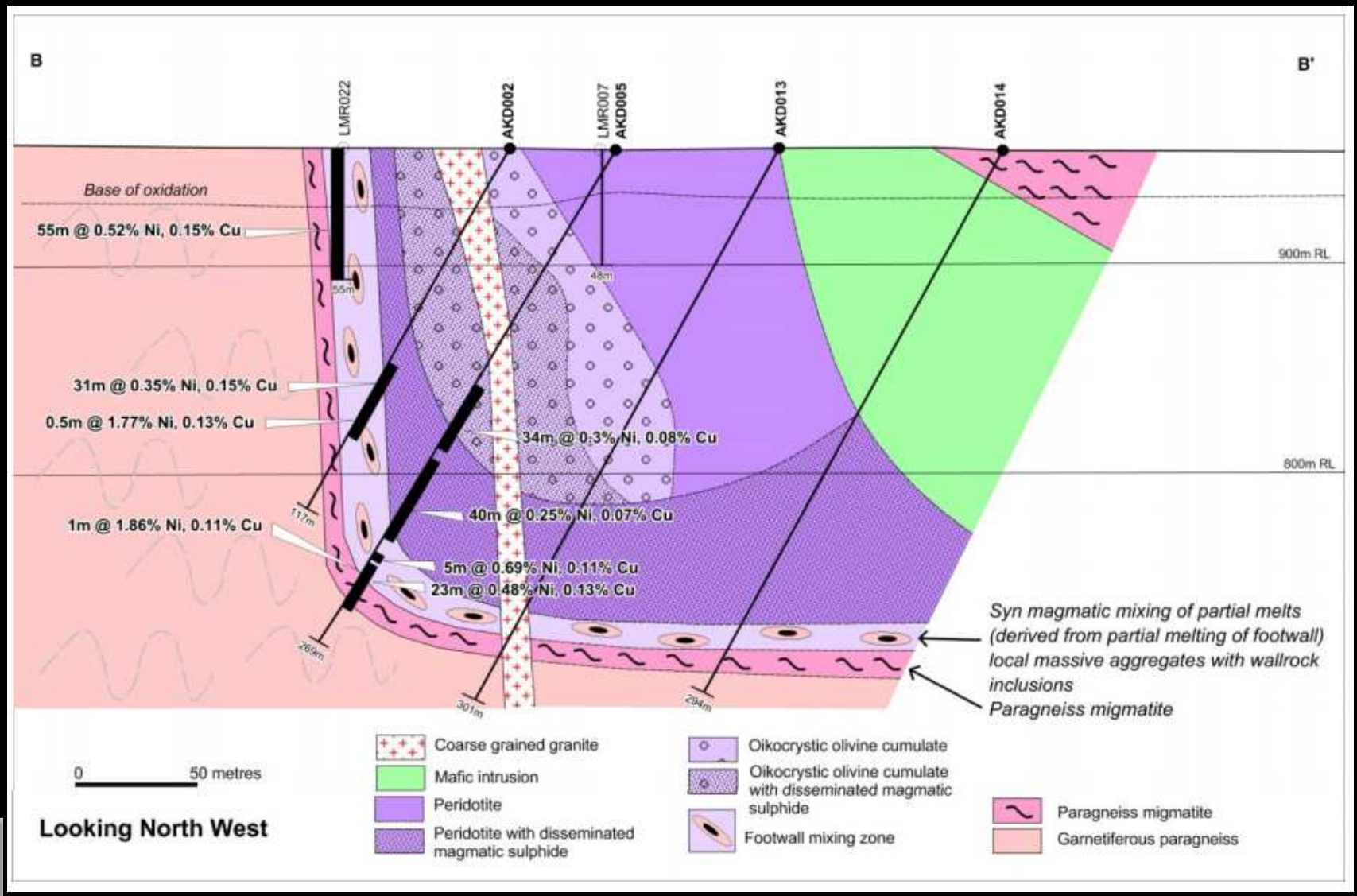
Grids

Infill grid
200 x 50 m



Ni-Cu mineralisation across width of intrusive

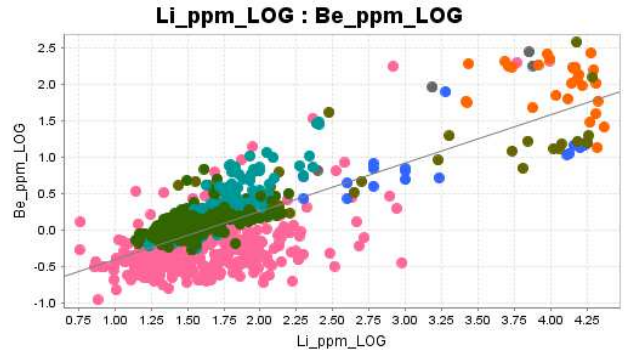
ASX: 08/10/2015

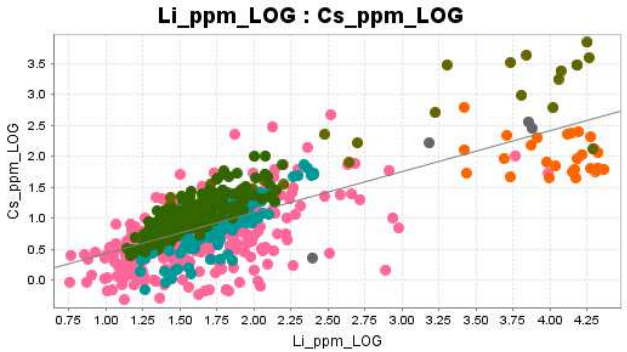


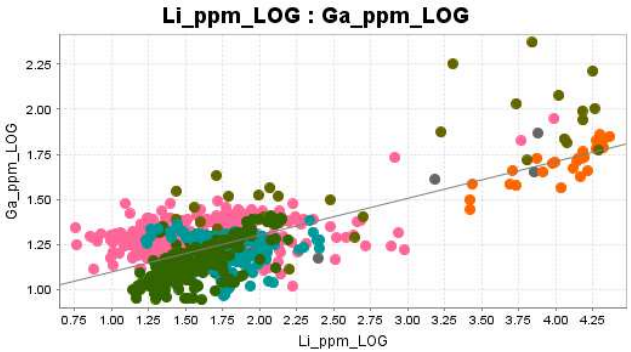
28 Ni Nickel 58.6934

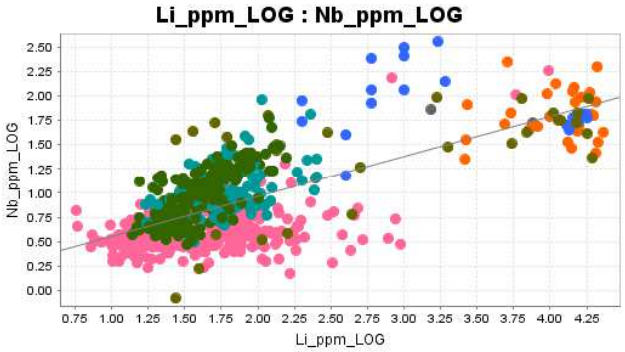
Detecting the undetectable

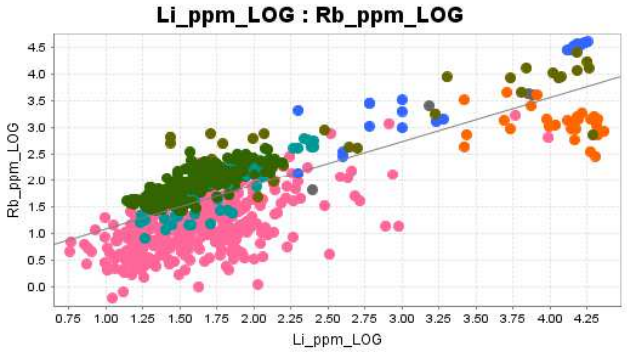
LCT Pegmatite elements

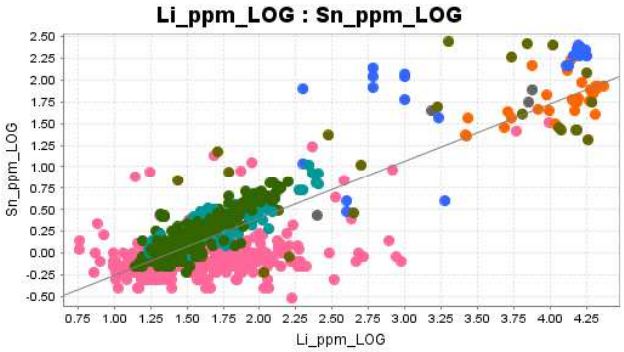


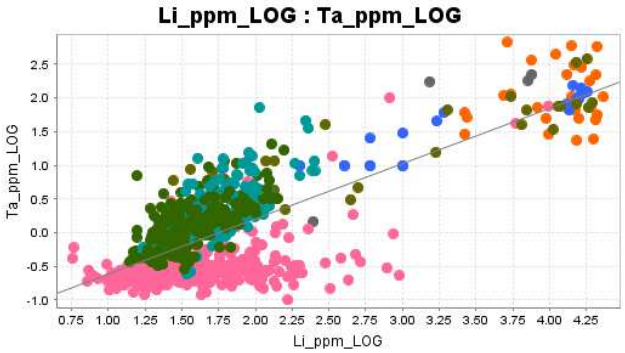


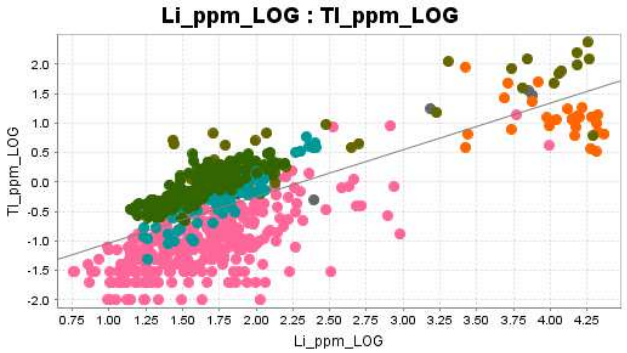










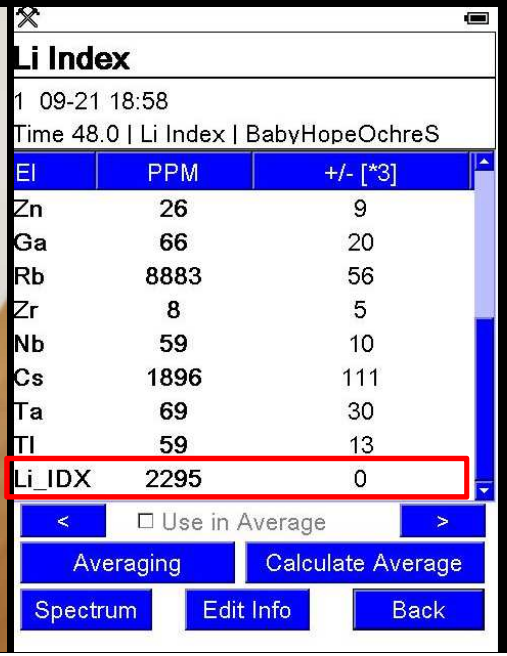


Correlation	Li_ppm_LOG
Li_ppm_LOG	1
Be_ppm_LOG	0.78
Cs_ppm_LOG	0.73
Ga_ppm_LOG	0.72
Nb_ppm_LOG	0.7
Rb_ppm_LOG	0.74
Sn_ppm_LOG	0.84
Ta_ppm_LOG	0.77
Tl_ppm_LOG	0.7

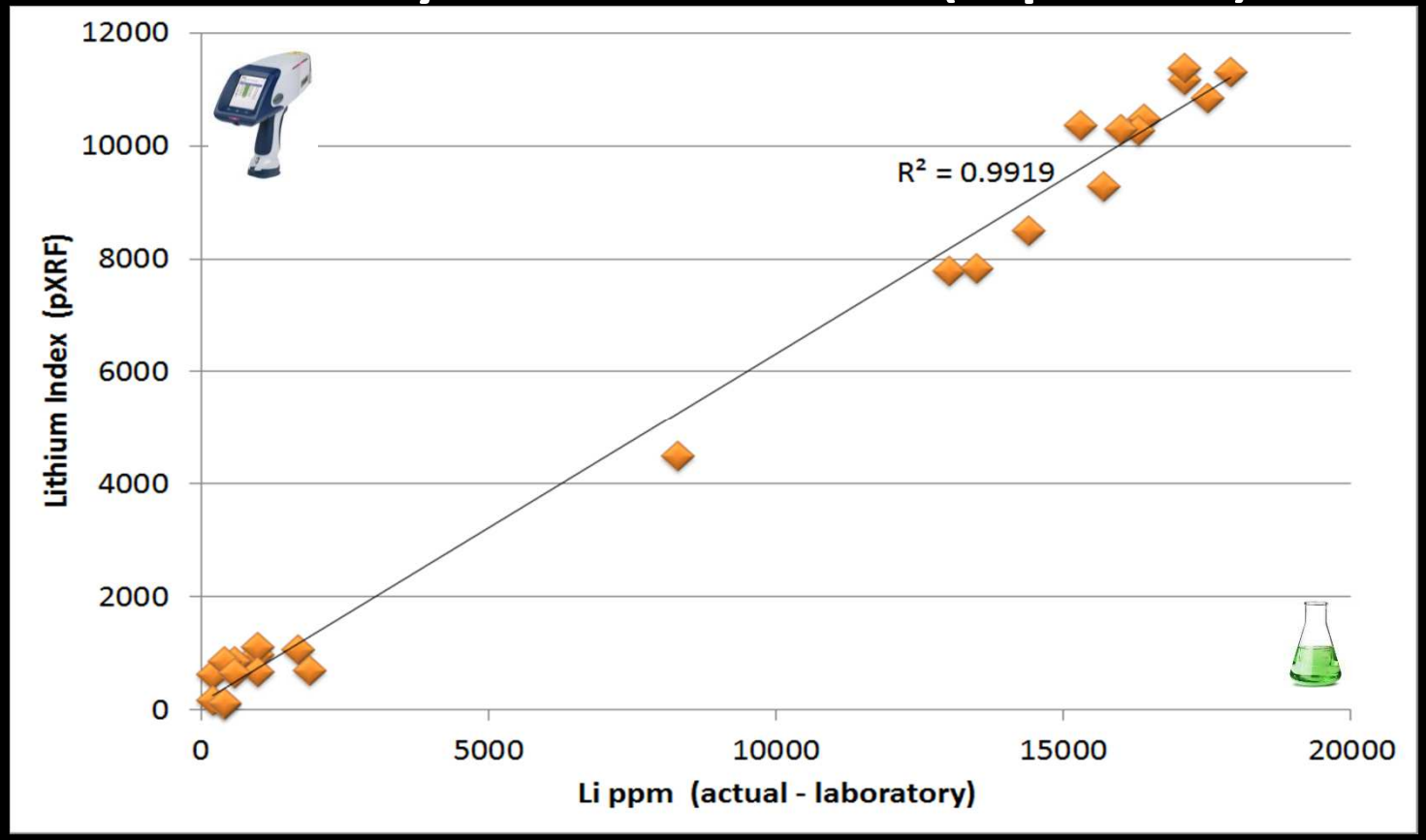
Detecting the undeletable

- Portable XRF (pXRF) detect down to Mg (Z12).
- pXRF cannot detect lithium (Z3) directly
- pXRF can detect elements associated with **LCT Pegmatites**.
  - LCT pegmatite contain Ga, Rb, Nb, Sn, Cs, Ta & Tl
- Derive an algorithm to estimation of the Li content
  - the **Lithium Index**.
- Develop a Lithium Index calibration

LCT elements	Z#	Detectable by pXRF	Detection limit (CAMIRO)
Li	3	NO	n/a
Be	4	NO	n/a
Ga	31	YES	<5
Rb	37	YES	<5
Nb	41	YES	<5
Sn	50	YES	<20
Cs	55	YES	<20
Ta	73	YES	<10
Tl	81	YES	<5

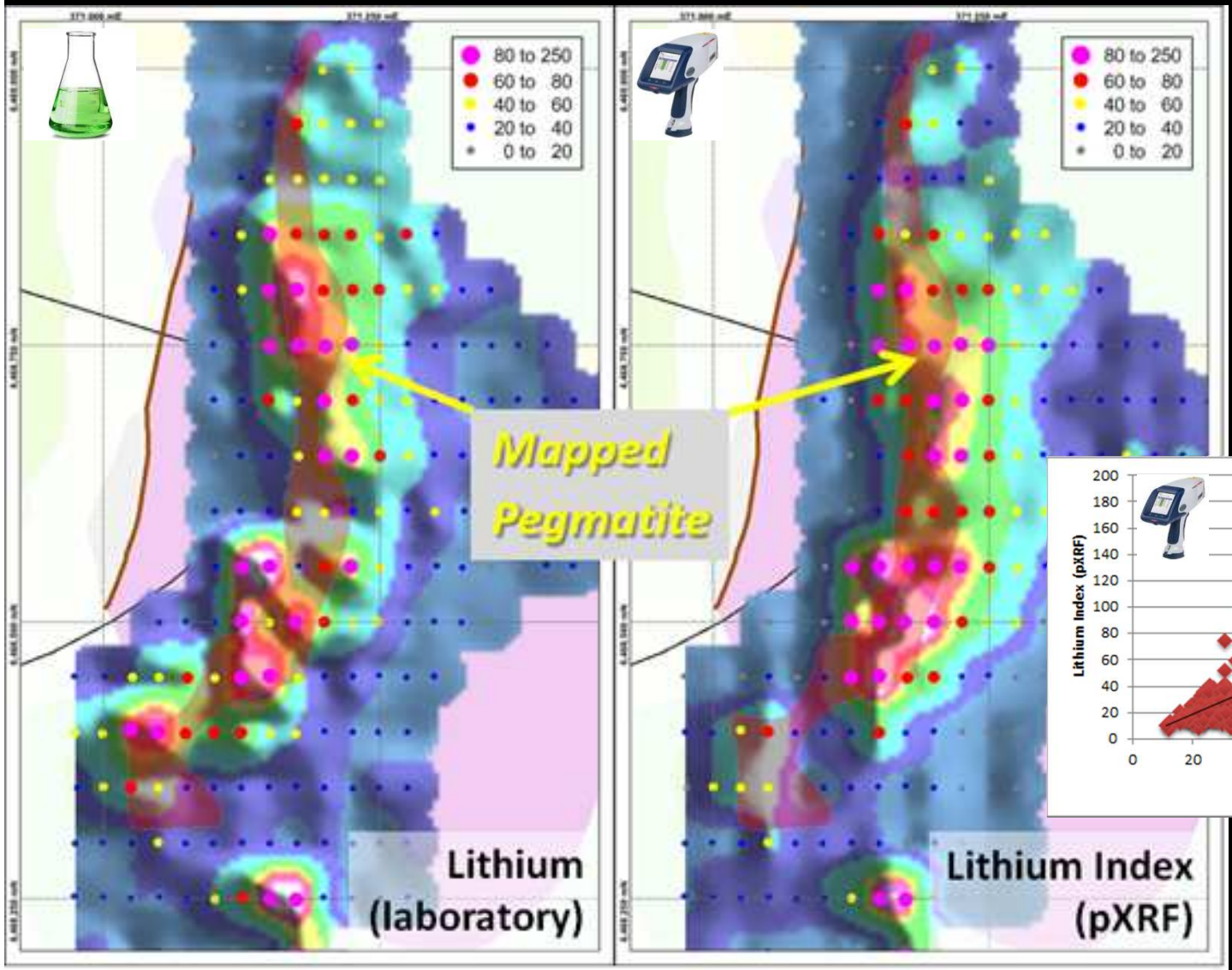


Blind test 1
Li assay vs Li Index (BpXRF)

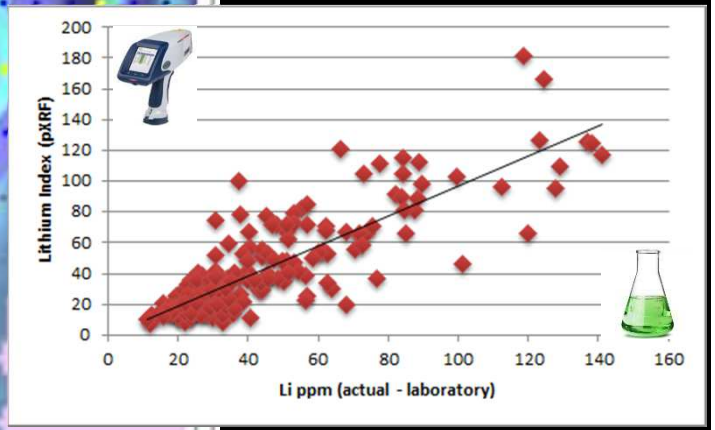


"This is an exceptional outcome giving Poseidon confidence to apply cost effect and rapid analysis techniques on site" (POS: ASX 21st July 2016).

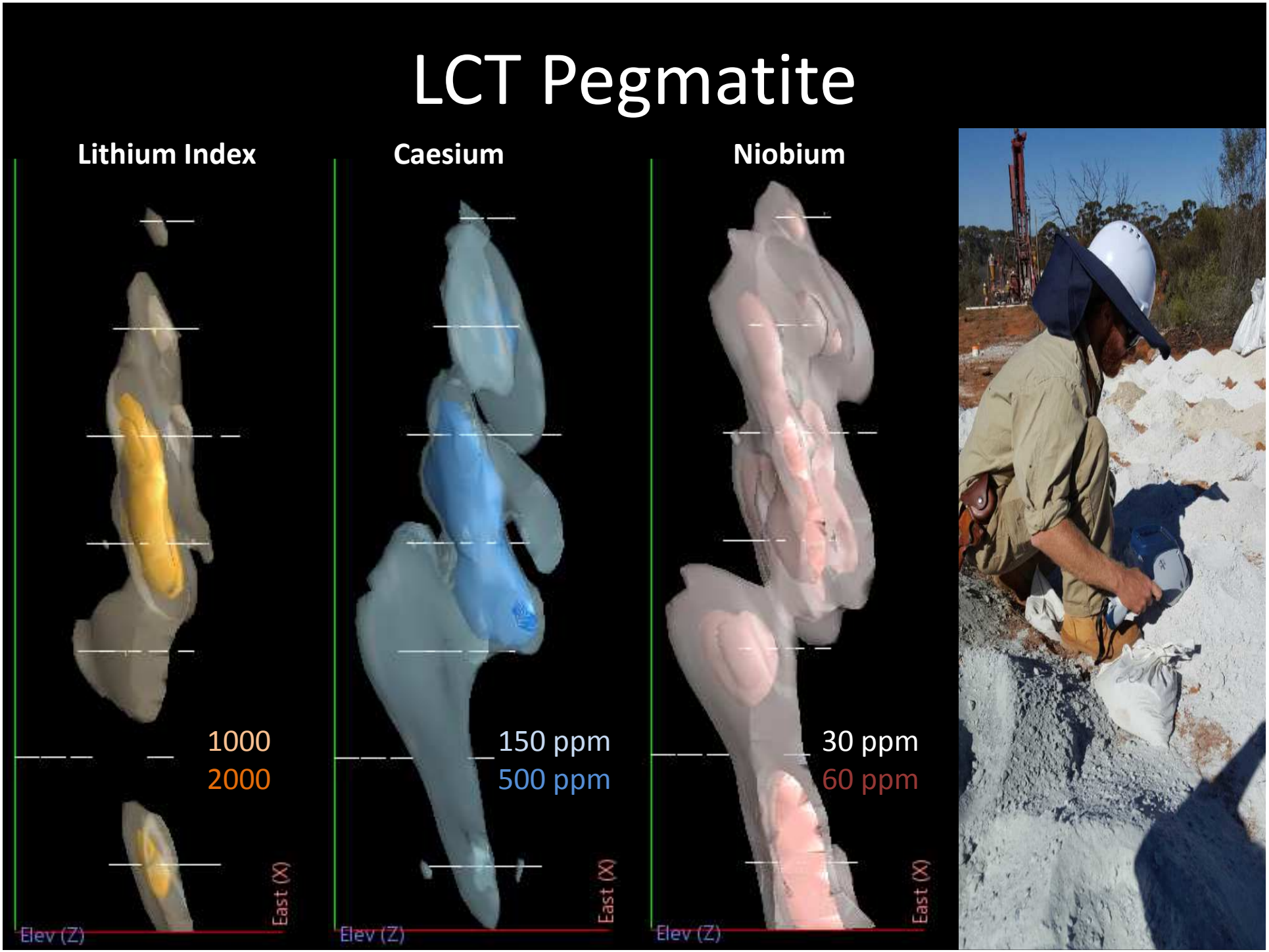
Blind Test 2
Li assay vs Li –index (BpXRF)



"Pioneer considers…… to being cost efficient, it ensures very rapid information turn-around". (PIO: ASX 27th July 2016).

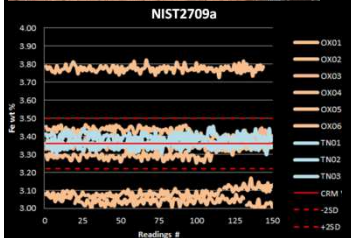


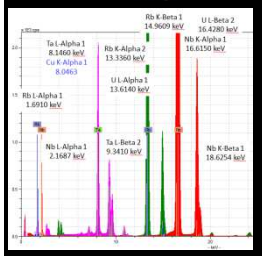
LCT Pegmatite

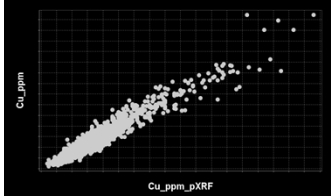


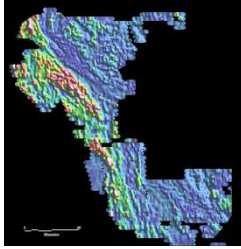
Any Tips?

Yes and well documented









Tips

Have a understanding of pXRF technology

Develop a SOP for your instrument

Develop an analytical strategy – field/camp

Instruments are individual **Never** mix data

Monitor instrument performance (CRMs)

If it seems unlikely it probably is (eg Au)

View you spectra – it’s the samples DNA

Verify results with wet chemistry

Develop confidence in the technology

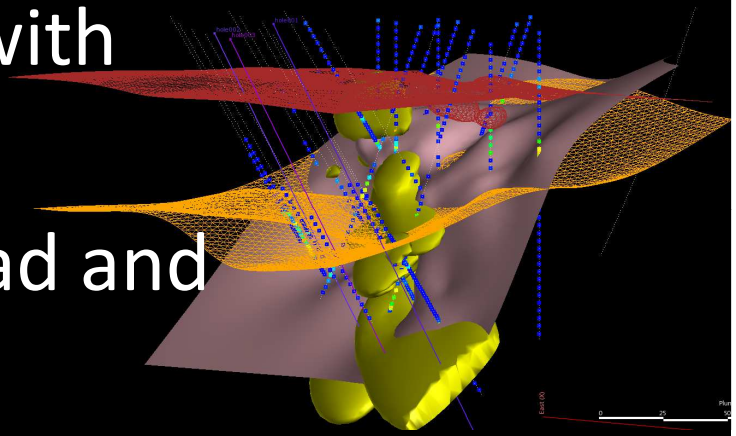
Be consistent

Enjoy

What's Next

- Acceptance: pXRF technology is proven!
  - use it – don't keep proving it works.
- Integration: pXRF technology with other technologies
- Versatility: Become a "rev" head and take full control of your pXRF
  - Develop your own fundamental calibration

SWIR, pXRF and Au fire assay data



Acknowledgments

- Portable XRF Services Management and Staff
- Sipa Resources (ASX: SRI)
- Pioneer Resources (ASX: PIO)
- Poseidon Nickel (ASX: POS)
- Bruker Elemental (Alexander Seyfarth)
- All the great work conducted by the known and the unknown to bring this technology to where it is today.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