Performance Comparison of Portable XRF Instruments: A Mineral Exploration Industry Prospective

Presented by Dr Nigel Brand
Portable XRF Service

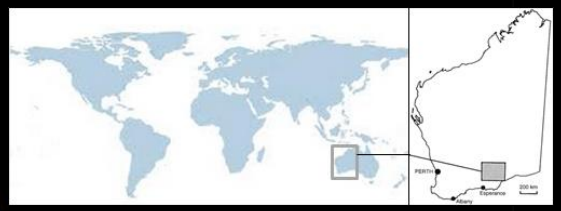
THE 9th INTERNATIONAL CONFERENCE ON THE ANALYSIS OF GEOLOGICAL AND ENVIRONMENTAL MATERIALS

9-14 AUGUST 2015

MONTANUNIVERSITÄT LEOBEN

Styria, AUSTRIA

Both images are of Ni derived from the SAME samples



pXRF

A

B

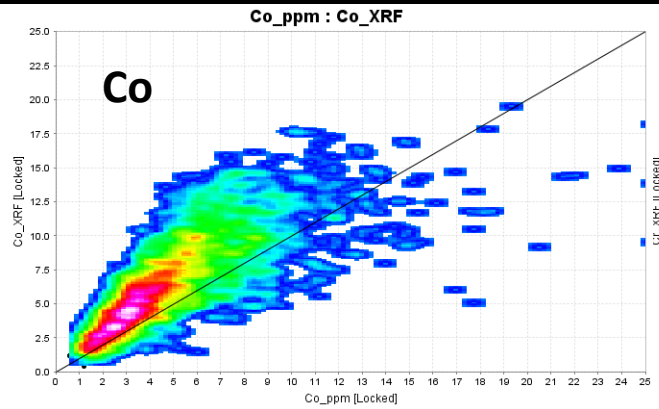
Conventional Aqua Regia

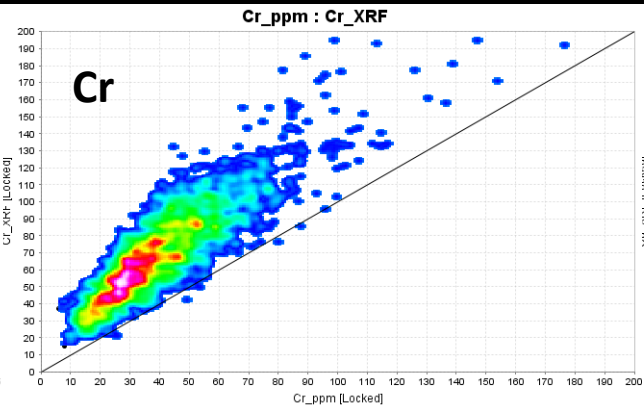
10km

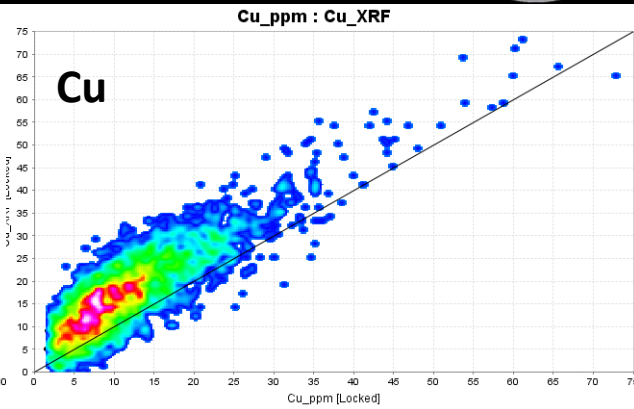
Which is the pXRF image?

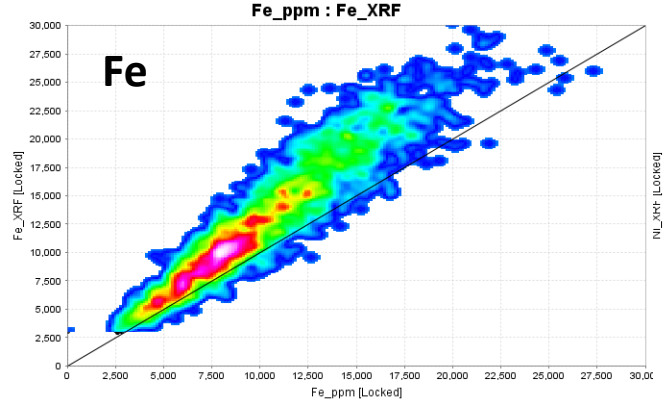
n = 2240

Aqua Regia (x) vs pXRF (y) data

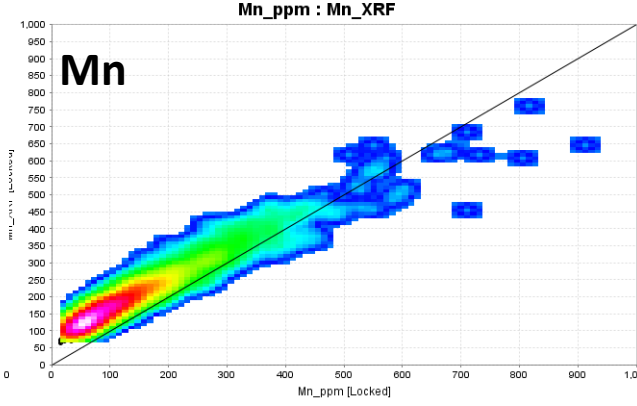


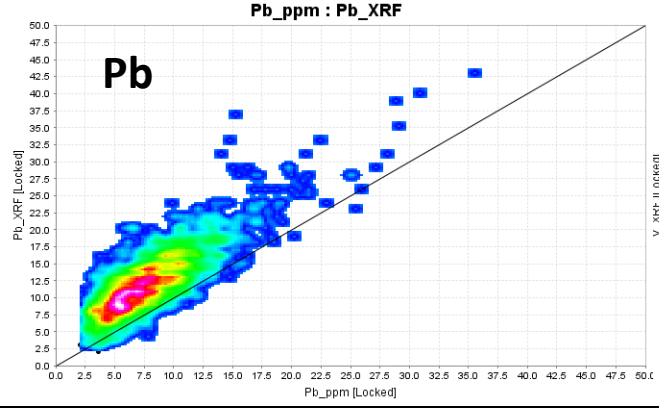


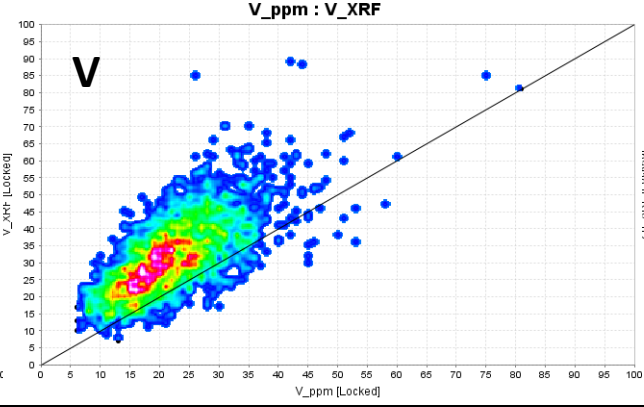


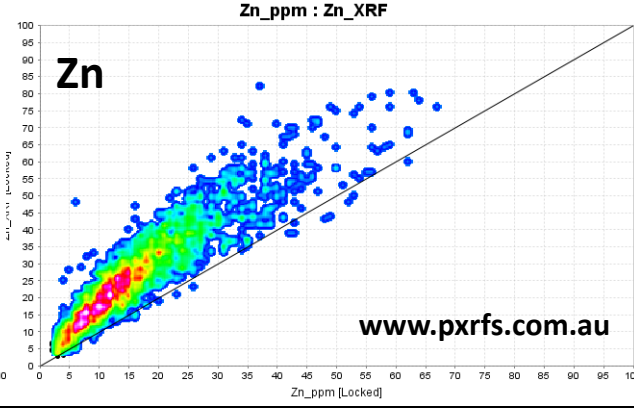


AR data under reports in comparison to pXRF data (which should be expected)









www.pxrfs.com.au

Talk Outline

- Performance Comparison - pXRFs
  - Mining Mode
  - Soil Mode
- Certified Reference Materials
- Influence of batteries on hand held units
- Deterioration of instruments performance
- Beam times (accuracy and precision)
- Geochemical Mapping
  - Terrain mapping
  - Province mapping & Mineral discovery
- Raw vs LOD data
- Conclusions

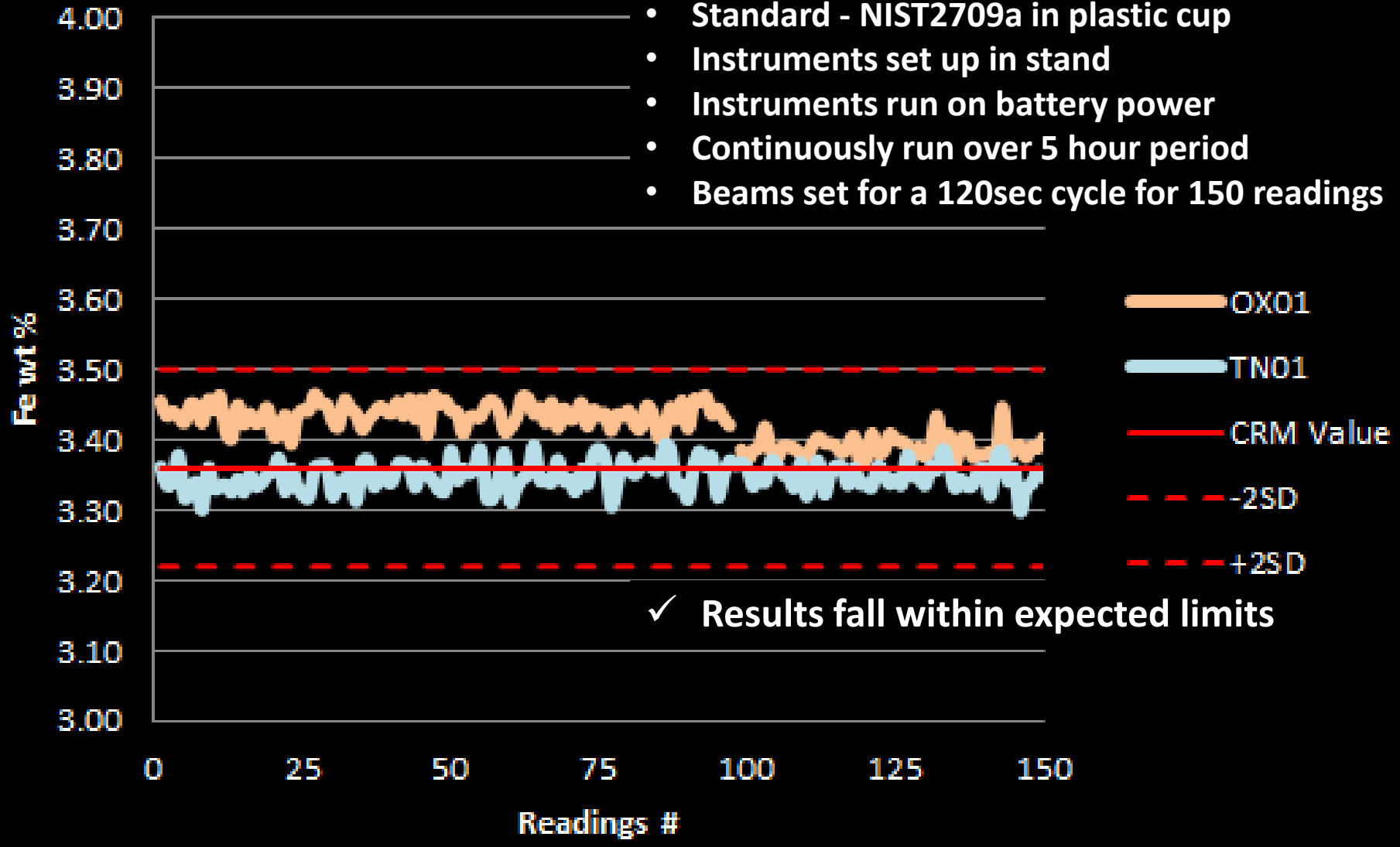
Baseline Response Two manufactures

Manufacturers	Olympus Innov-X	Thermo-Niton
pXRF Instrument	Delta Premium	XL3t 950s GOLDD+
Anode		
Tube Voltage (kV_{max})		
Tube Power (μA_{max})		
Resolution (eV)		
Detector area		
Electronics		
Power Source Used		
Element Range	Mg (Z12) and greater	
Application Modes	Mining and Soil Modes	
Cycle Time	120 seconds in Mining 180 seconds Soil Mode	
Windows	Propylene3	

Baseline Response (Mining Mode)

NIST2709a

- Standard - NIST2709a in plastic cup
- Instruments set up in stand
- Instruments run on battery power
- Continuously run over 5 hour period
- Beams set for a 120sec cycle for 150 readings

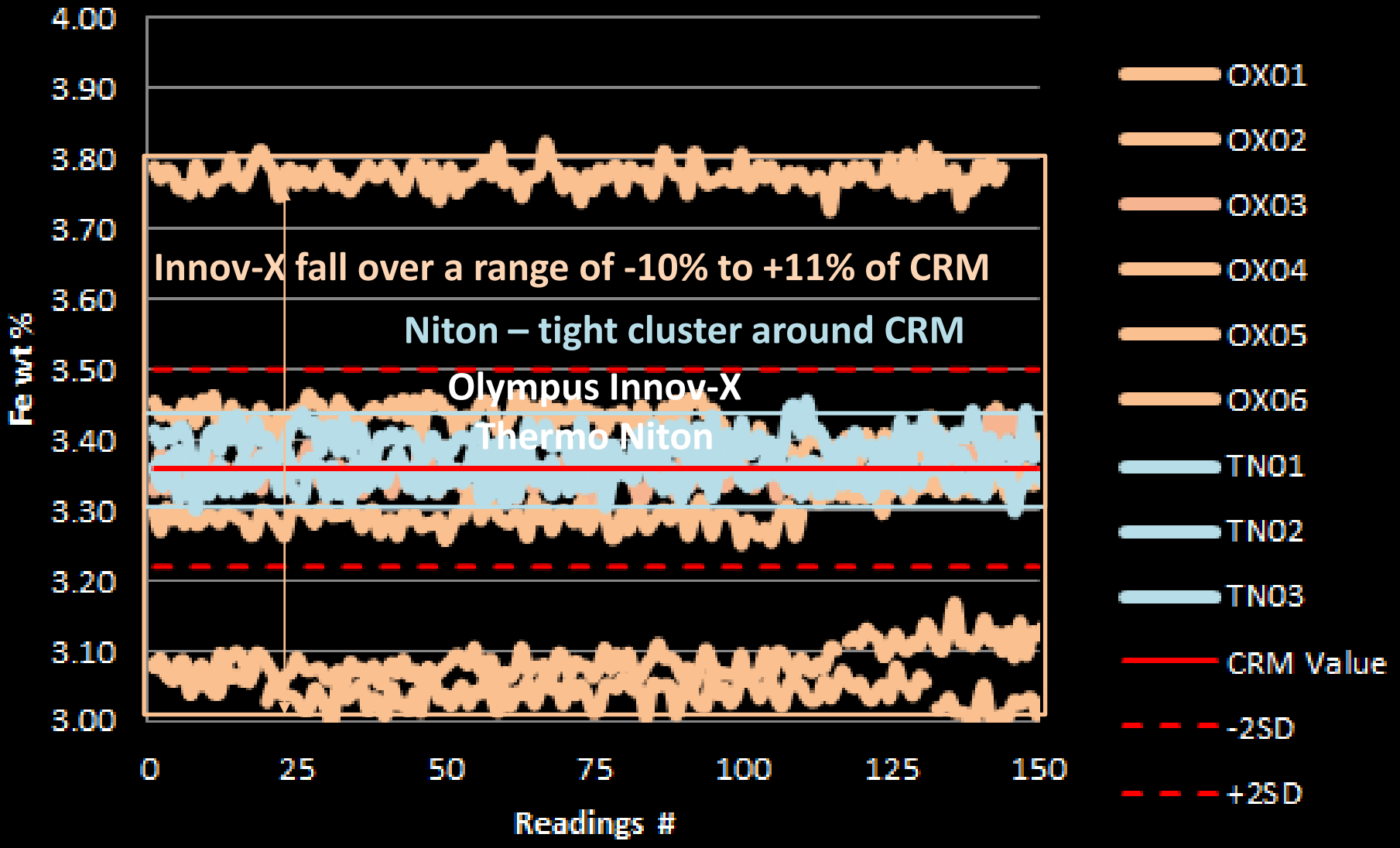


✓ Results fall within expected limits

What happens when more instruments are tested?

Baseline Response (Mining Mode)

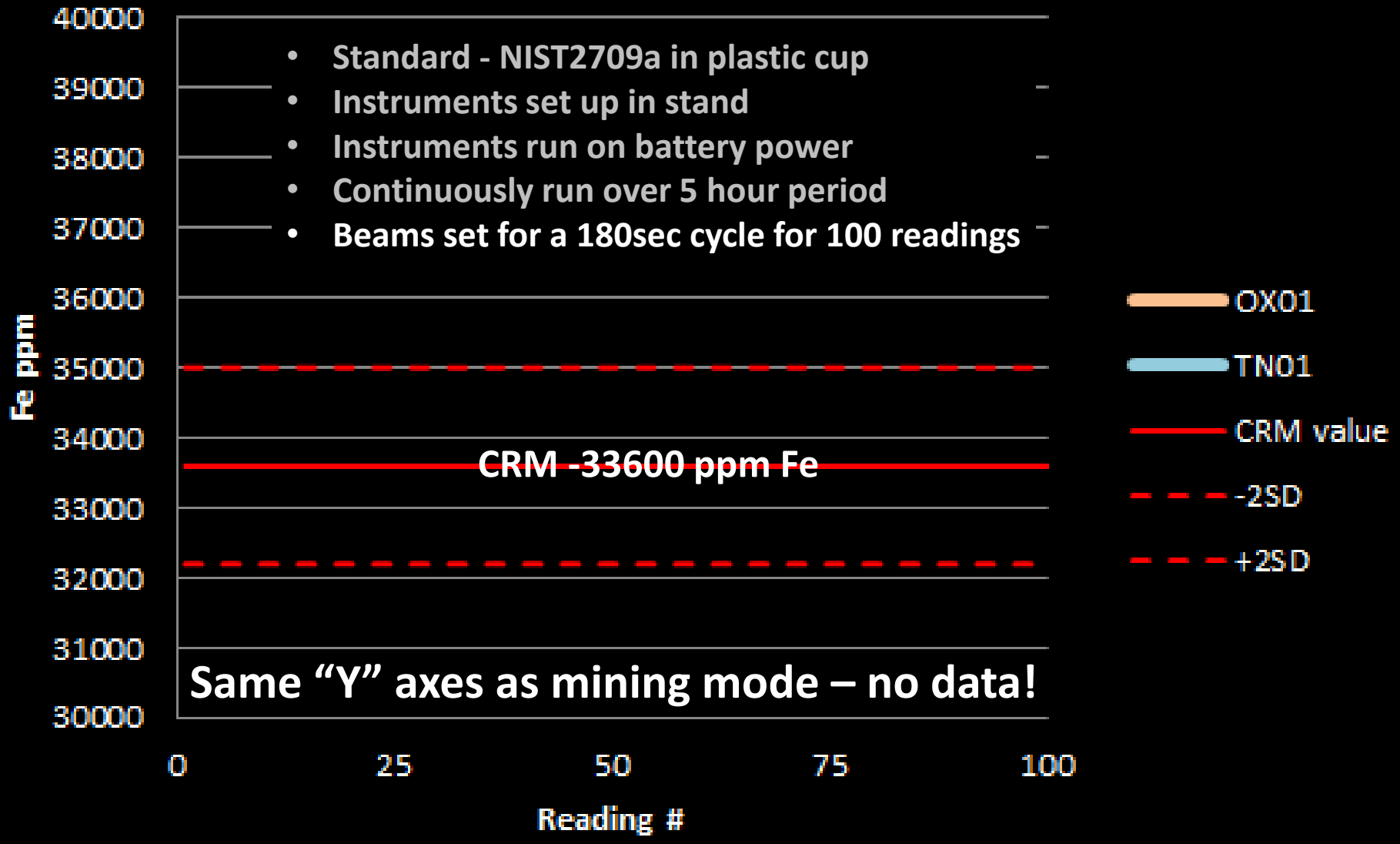
NIST2709a



Baseline Response SOIL MODE

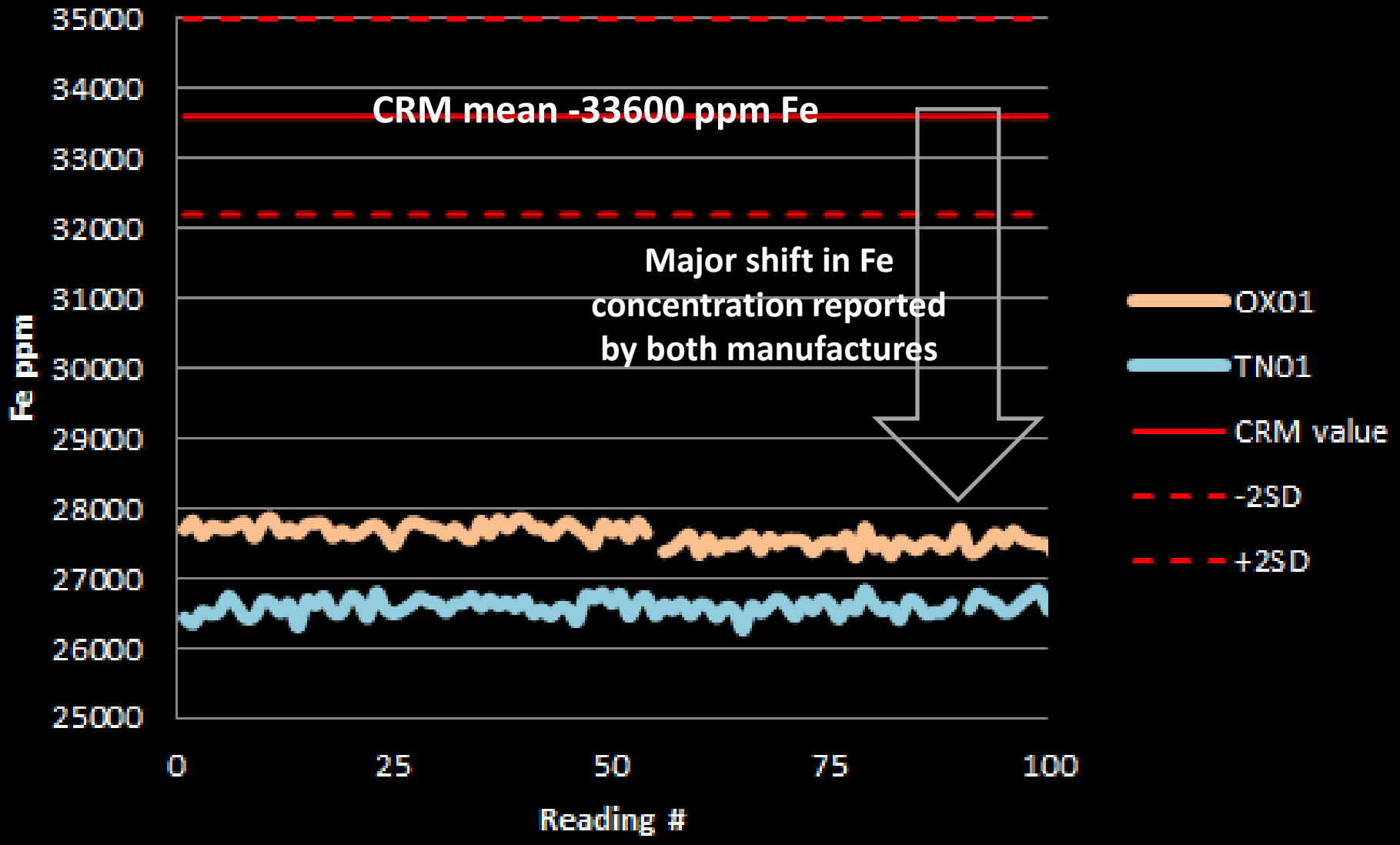
Baseline Response (Soil Mode)

NIST2709a



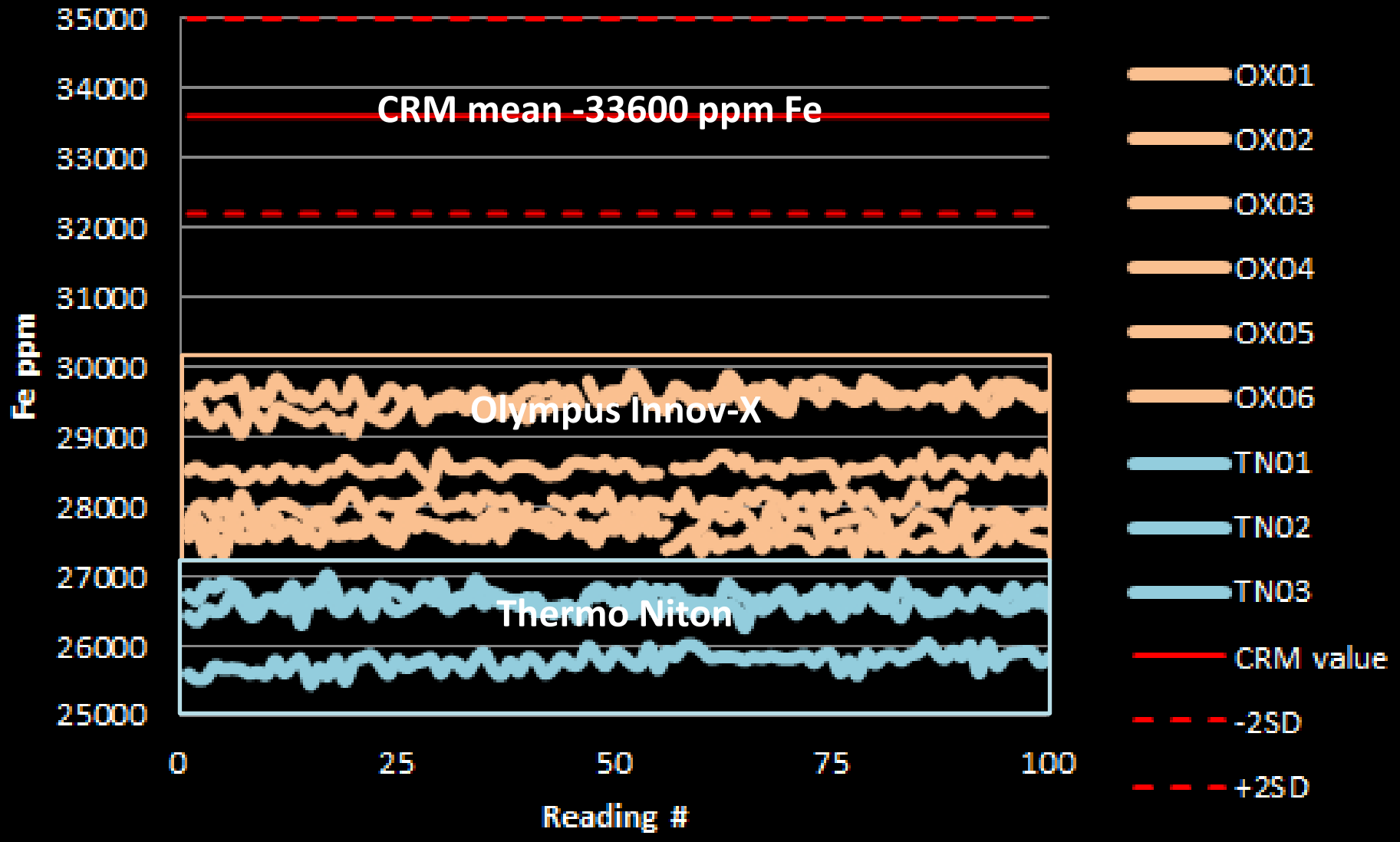
Baseline Response (Soil Mode)

NIST2709a



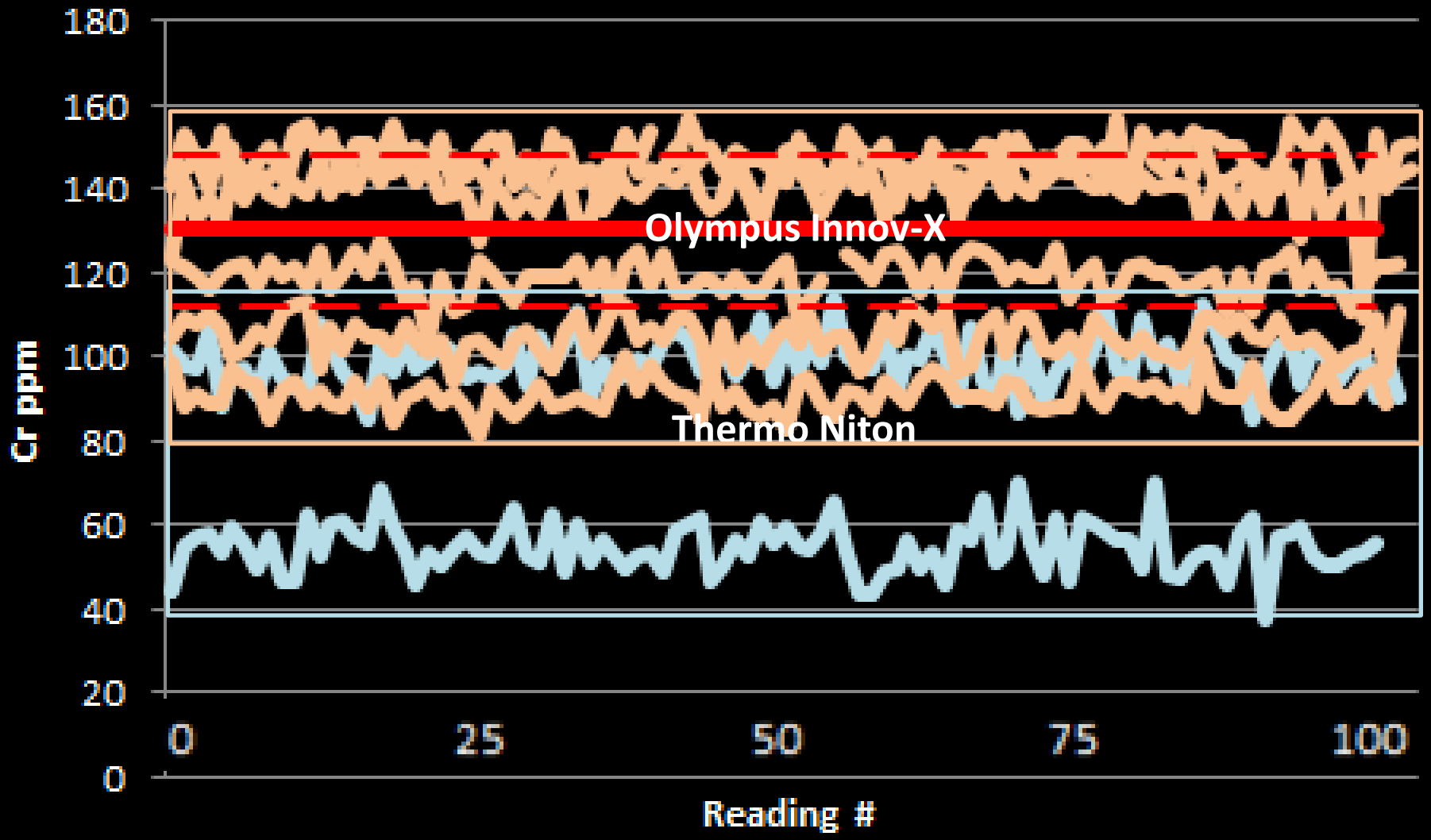
Baseline Response (Soil Mode)

NIST2709a



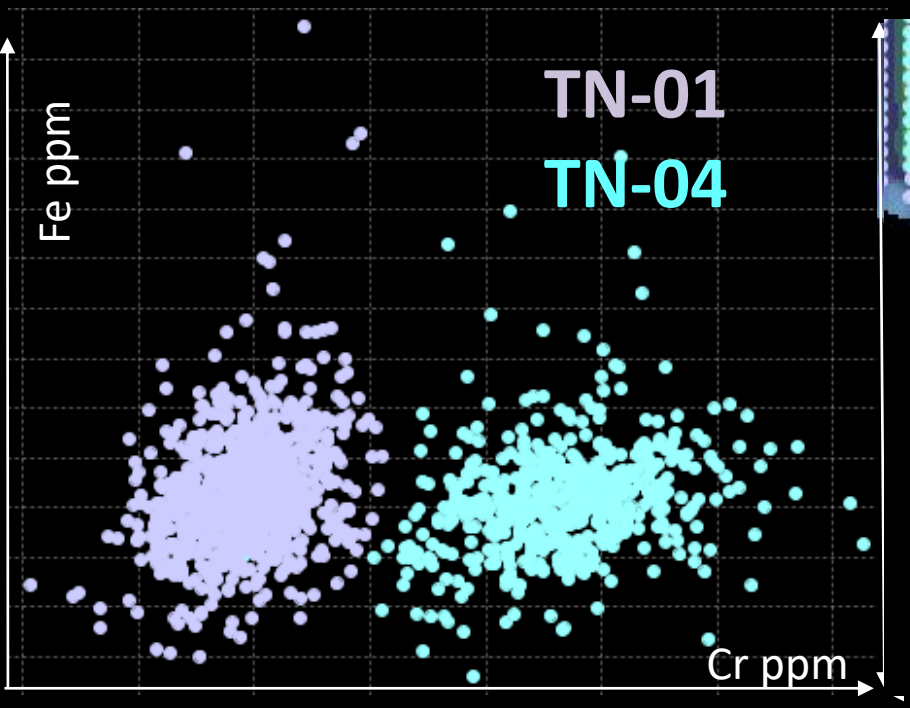
Baseline Response (Soil Mode)

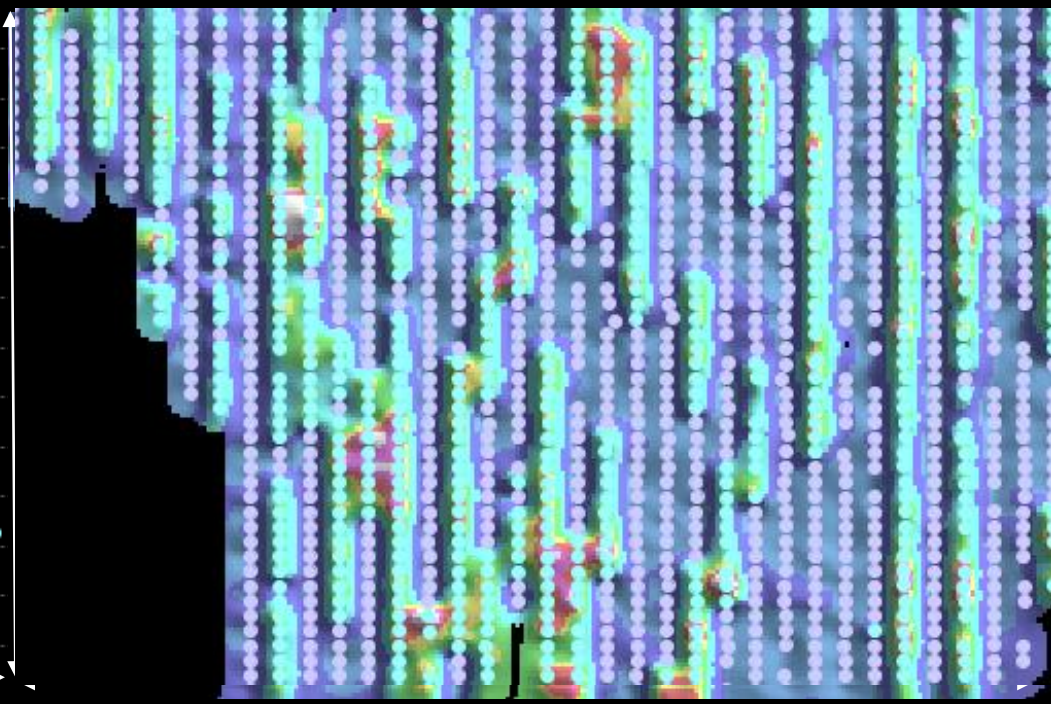
NIST2709a



Mixing data from different Instruments

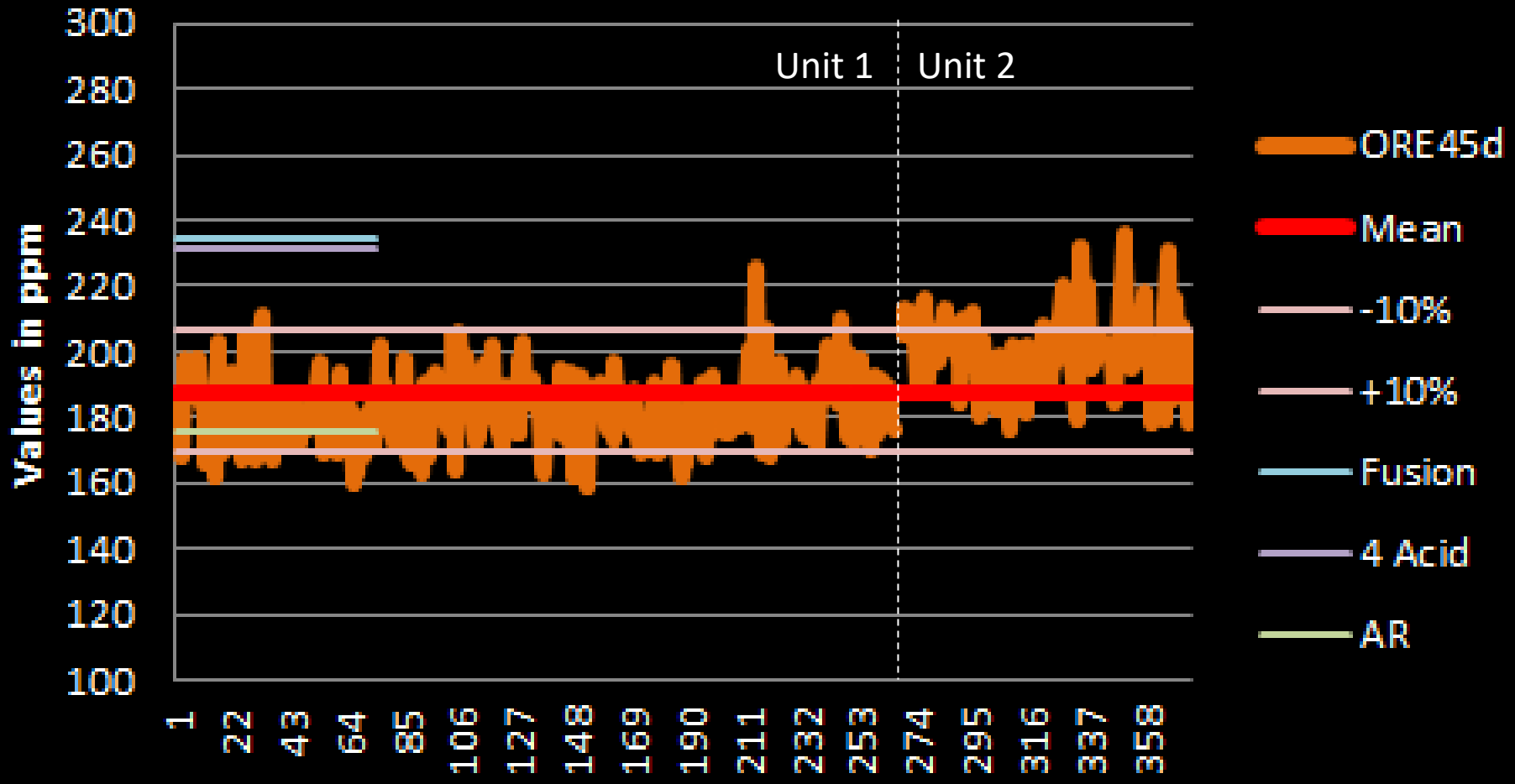
- Variation in instrument response has significant implications when mixed.



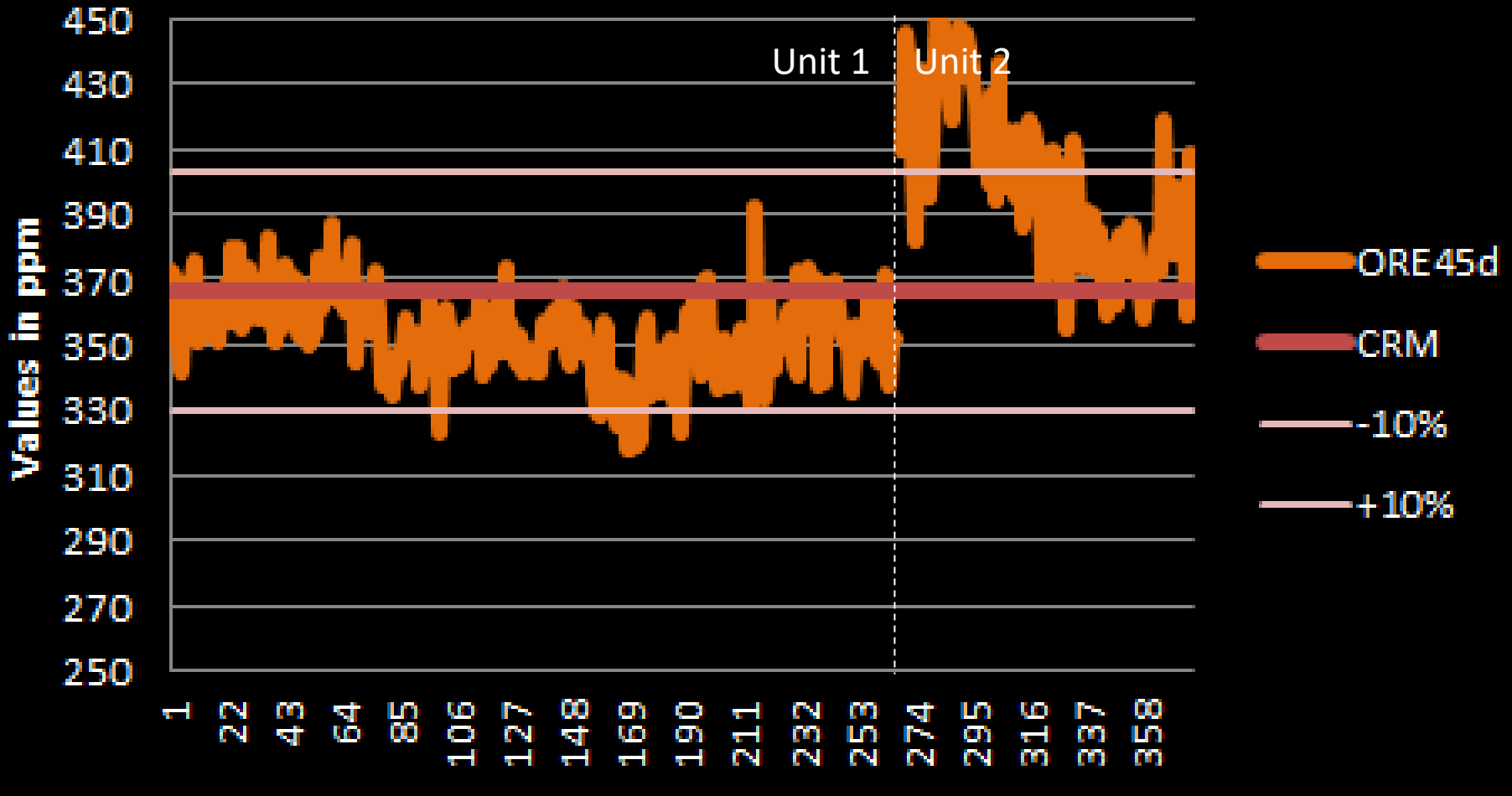


n = 1415

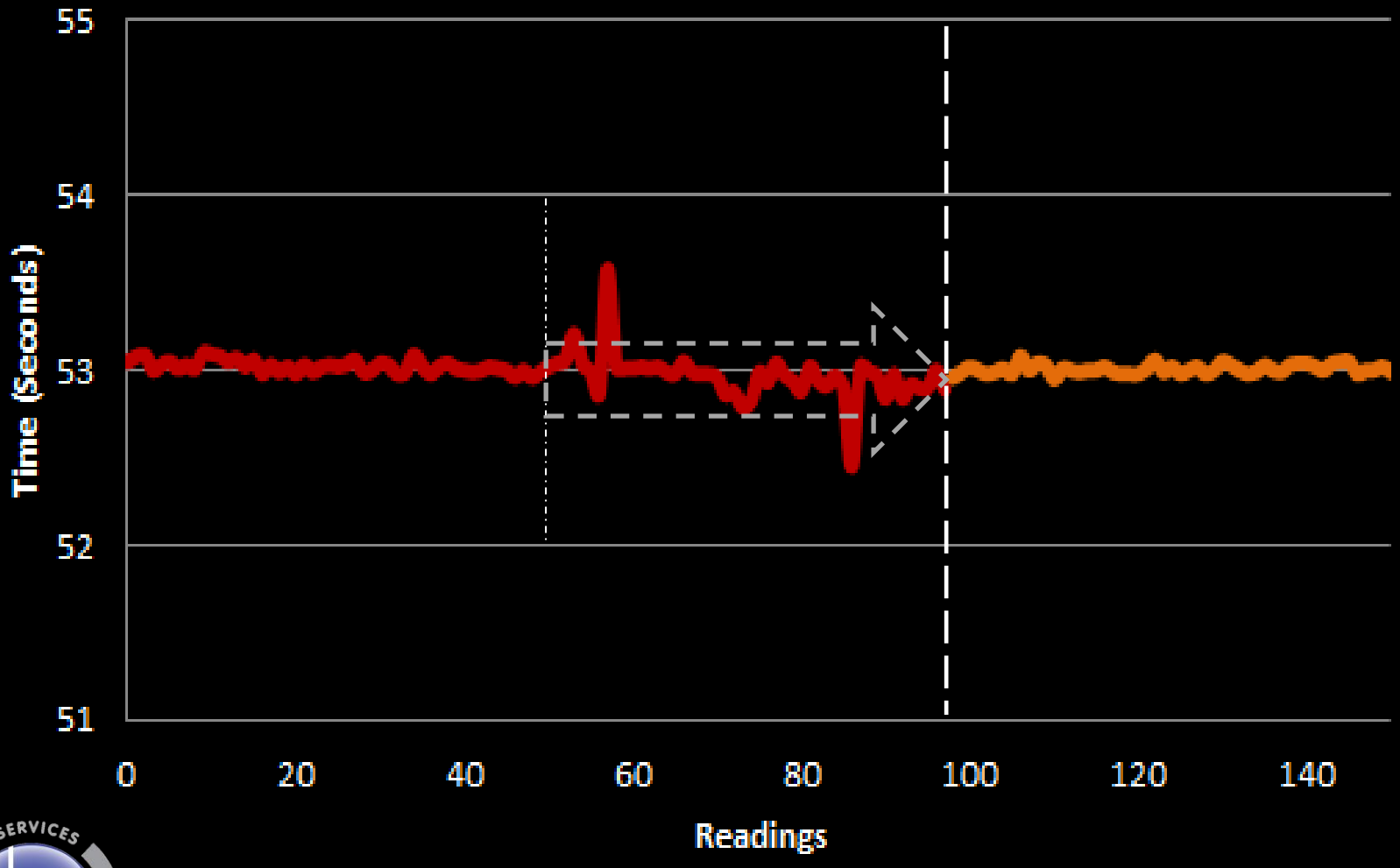
pXRF CRMs - OREAS 45d: Ni



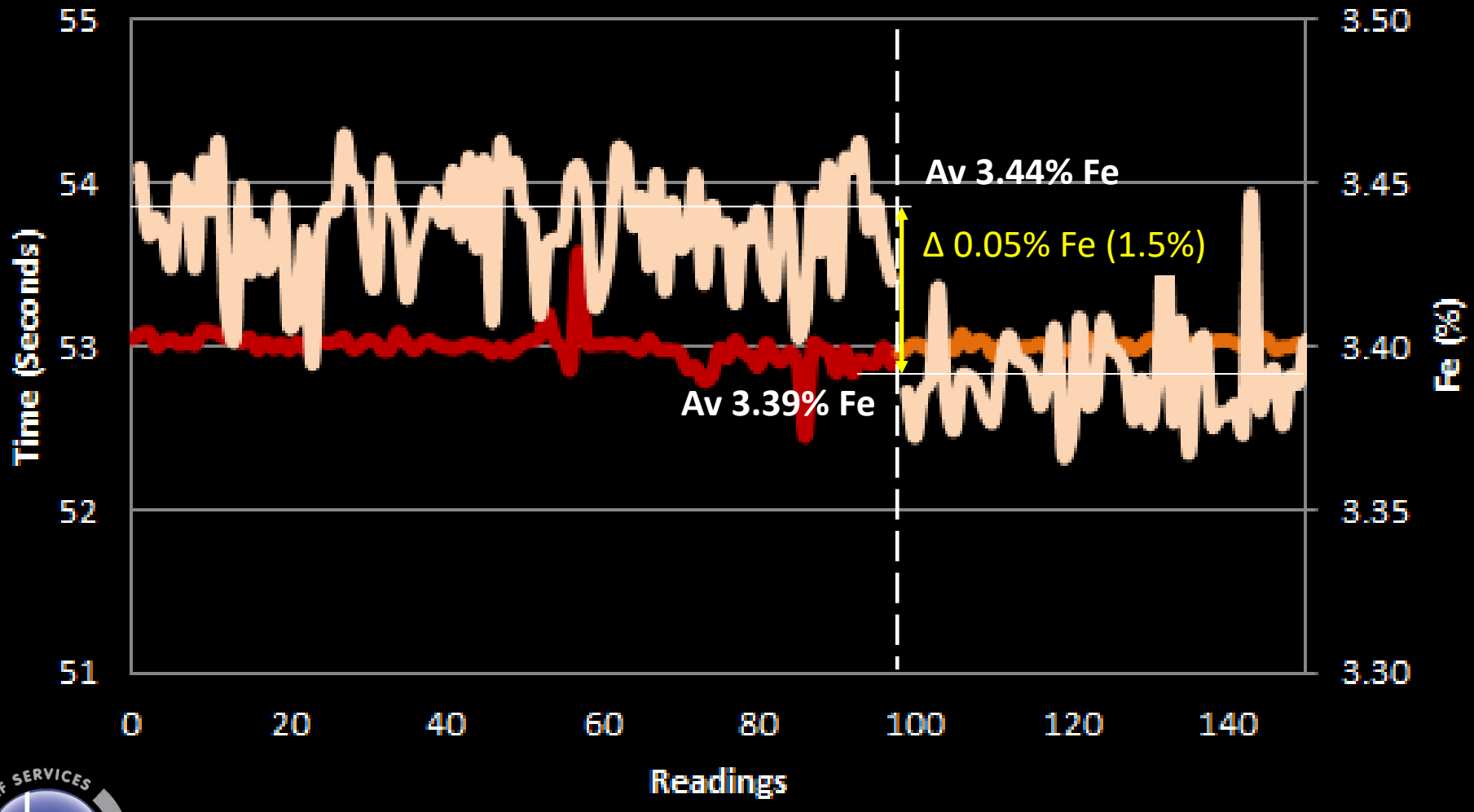
pXRF CRMs - Cr


Values in ppm
450
430
410
390
370
350
330
310
290
270
250
Unit 1
Unit 2
1
22
43
64
85
106
127
148
169
190
211
232
253
274
295
316
337
358
ORE45d
CRM
-10%
+10%

Influence of Batteries on Analysis

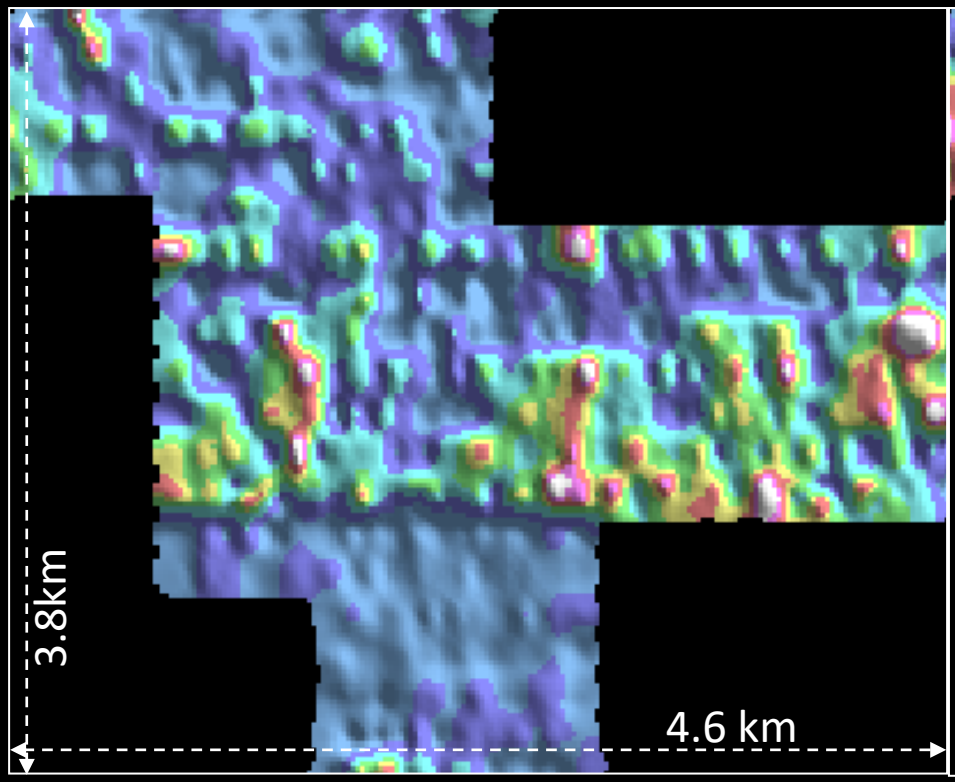


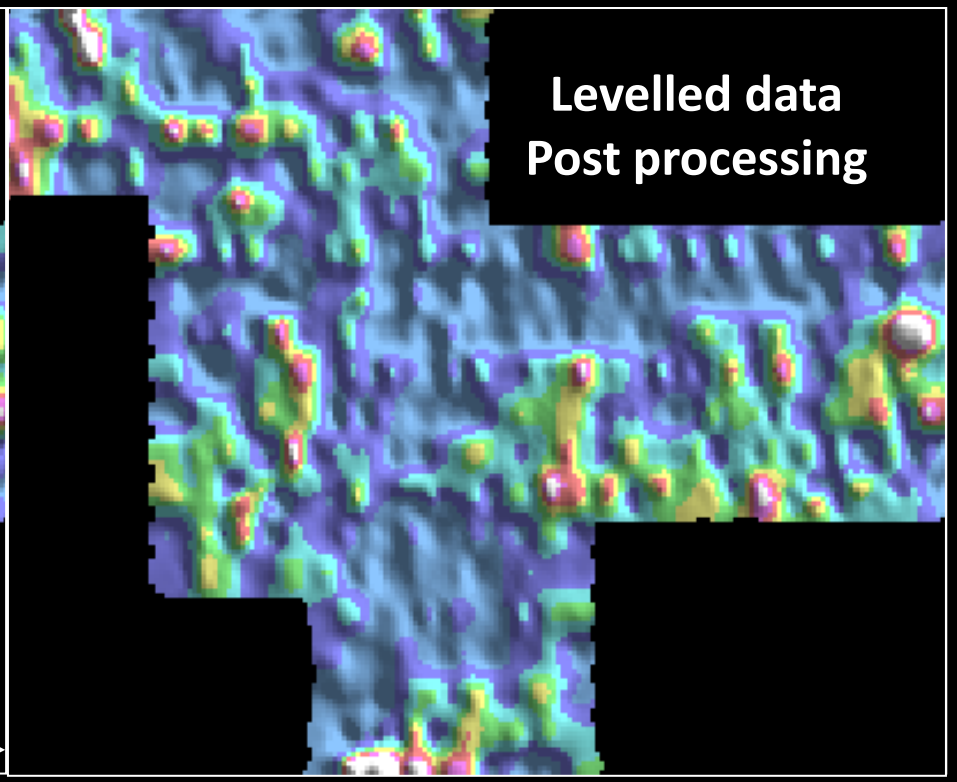
Influence of Batteries on Analysis



Beam 1

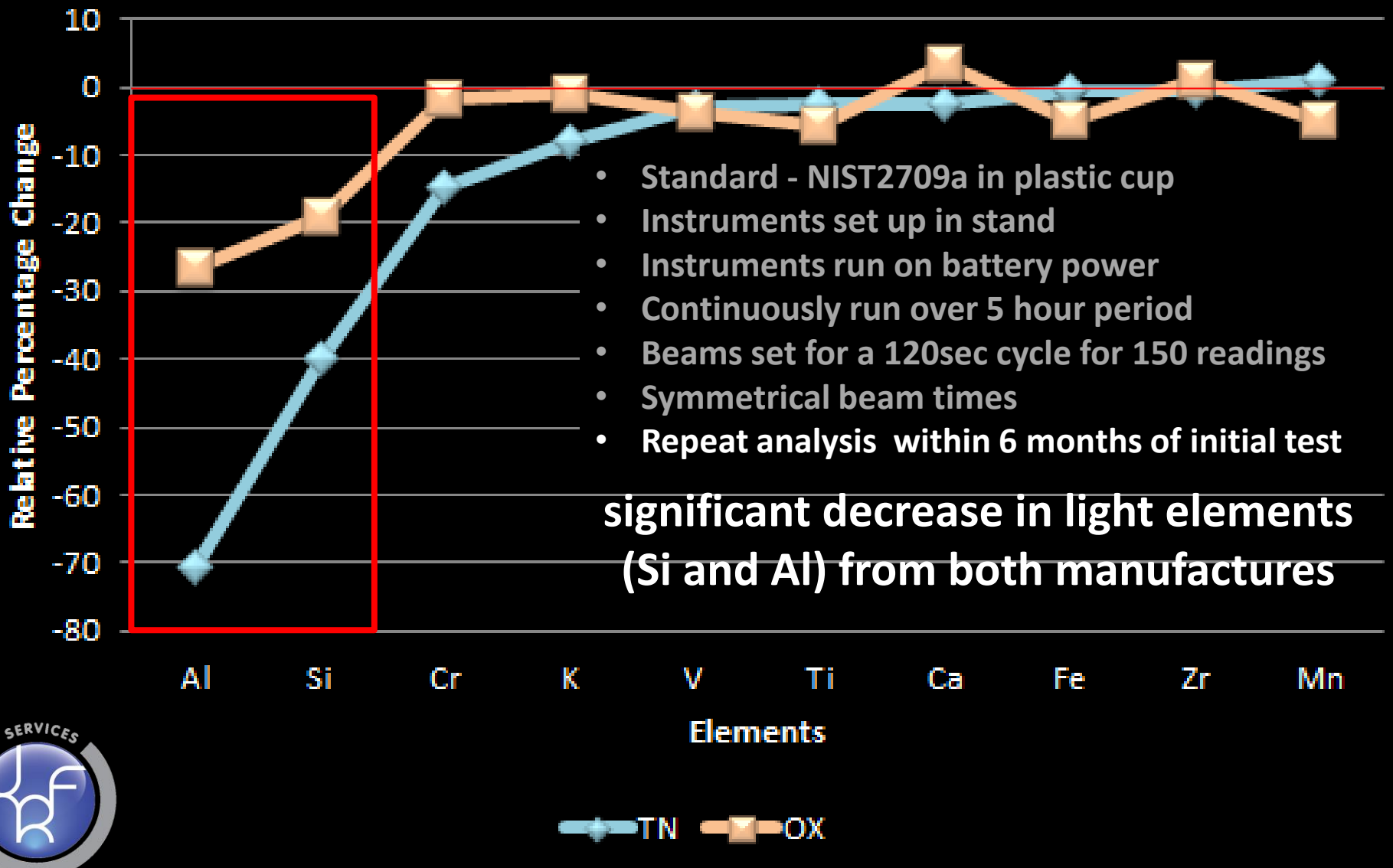
Influence of Battery's Cu in soils





Medium - Soils
Grid = 200 x 40m
n = 1250

Repeat baseline response – Mining Mode

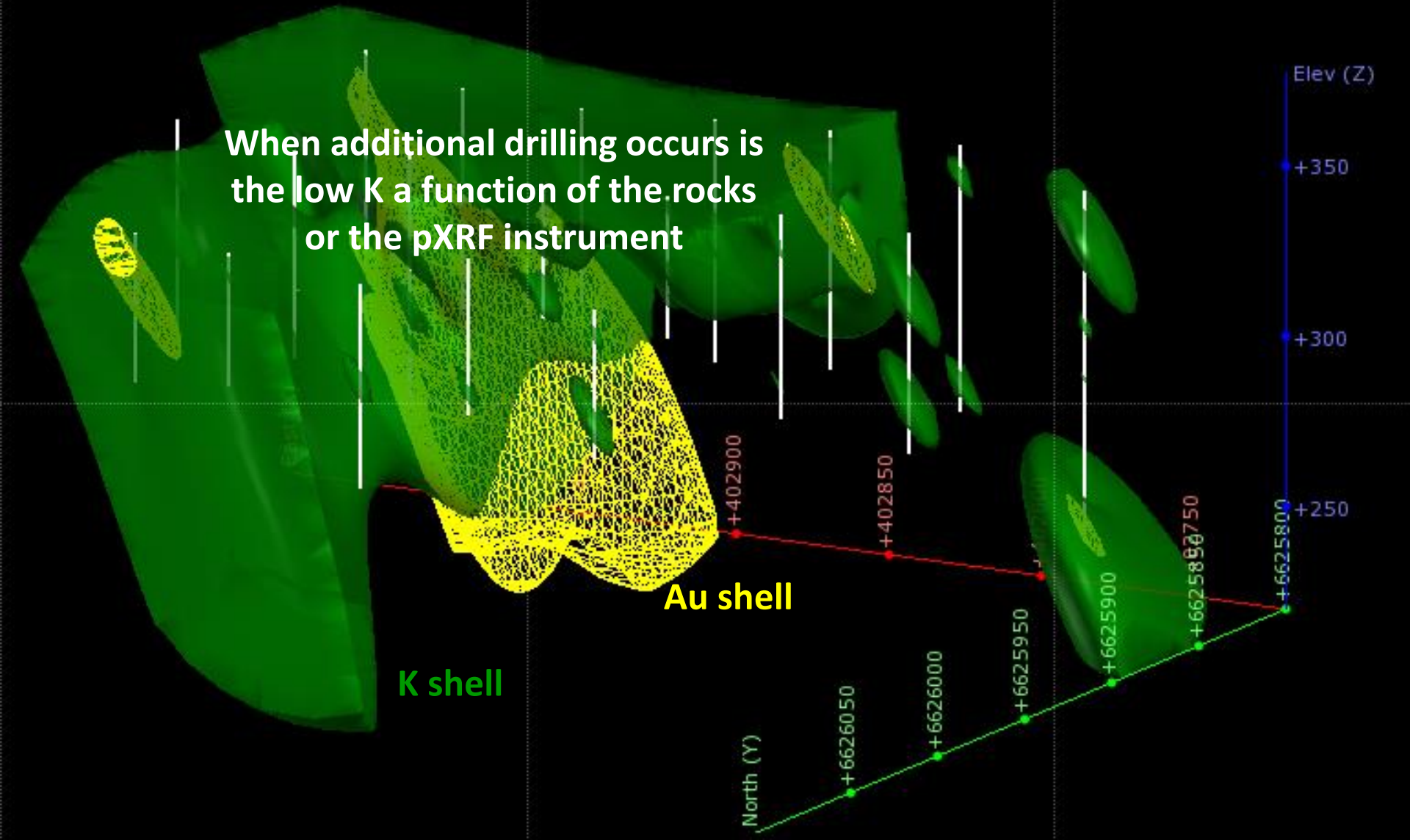


- Standard - NIST2709a in plastic cup
- Instruments set up in stand
- Instruments run on battery power
- Continuously run over 5 hour period
- Beams set for a 120sec cycle for 150 readings
- Symmetrical beam times
- **Repeat analysis within 6 months of initial test**

significant decrease in light elements (Si and Al) from both manufactures

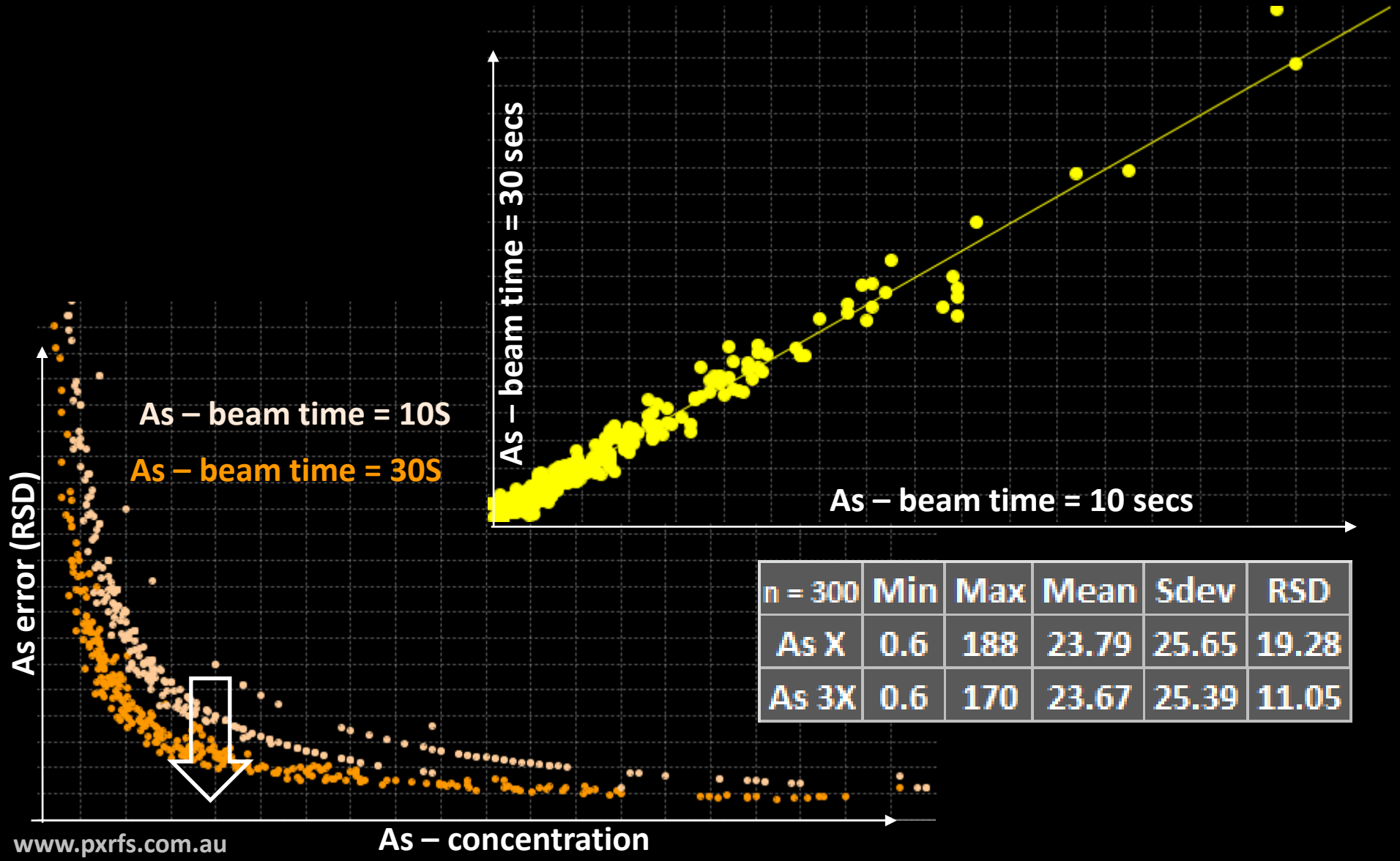
3D Model of Drill Data

Integration of pXRF data with conventional Au (AR) analysis



Beam Times

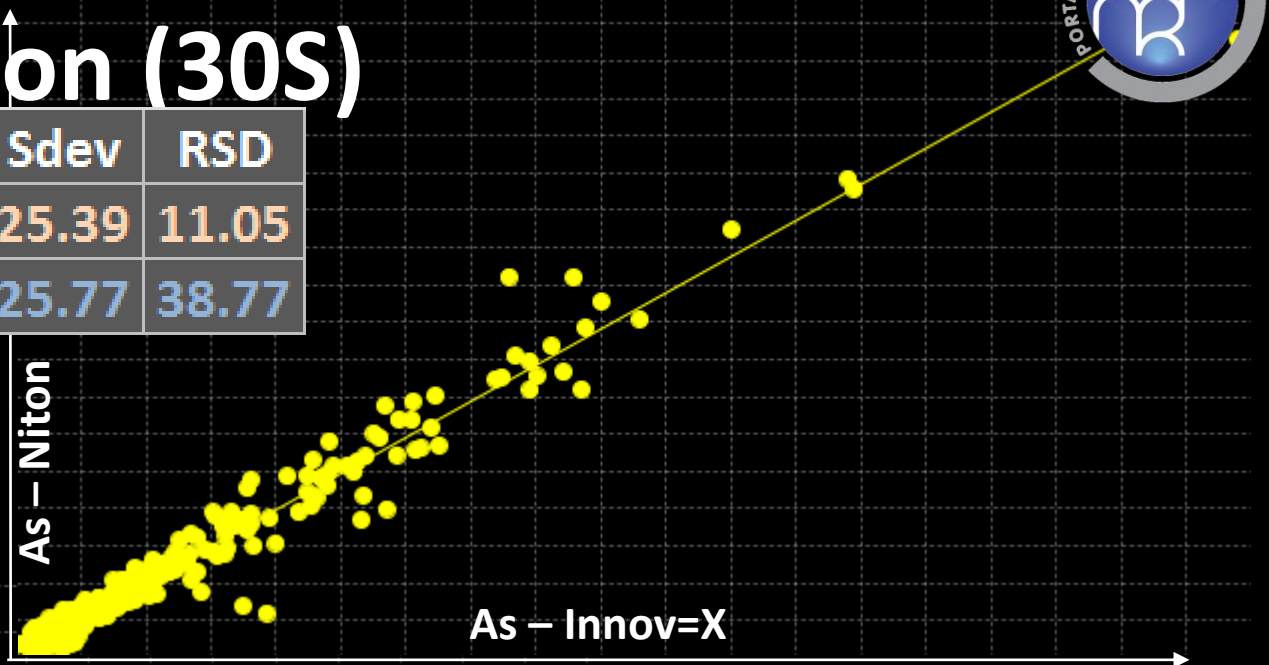
Influence of Beam Times

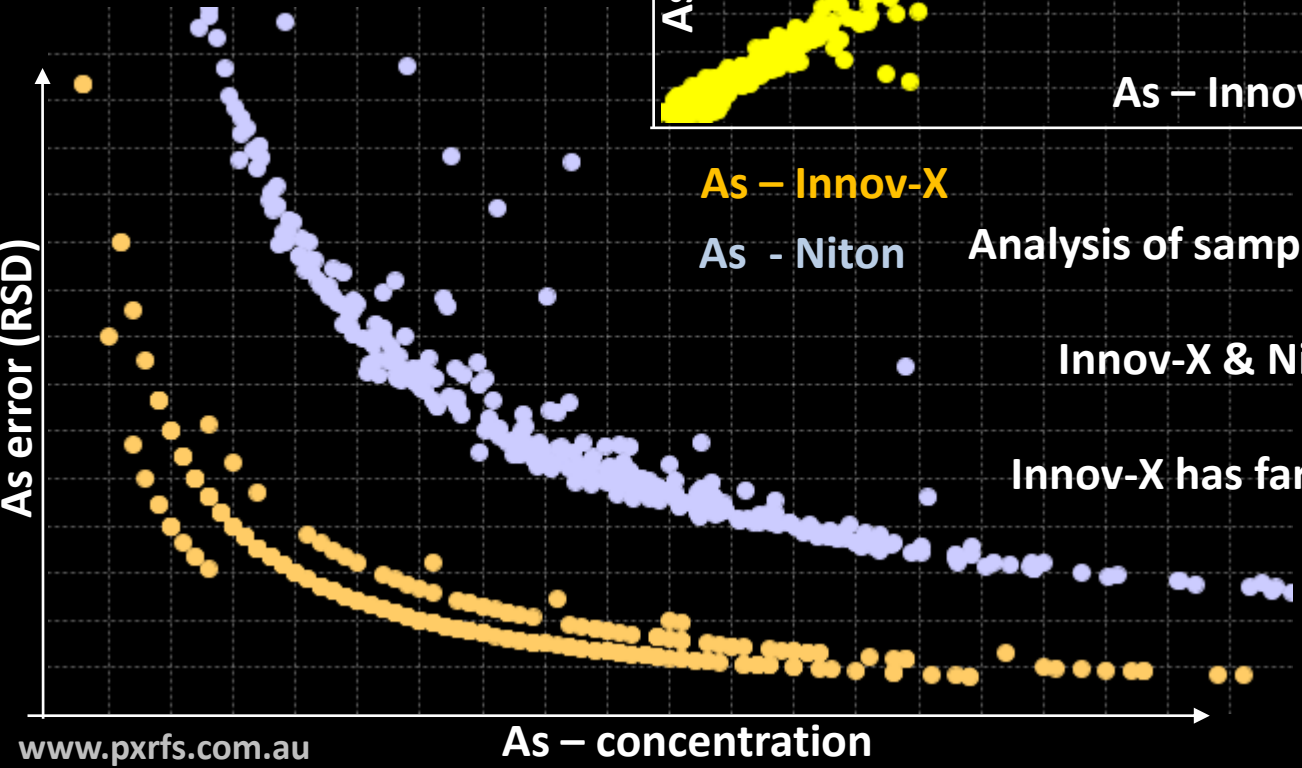


n = 300	Min	Max	Mean	Sdev	RSD
As X	0.6	188	23.79	25.65	19.28
As 3X	0.6	170	23.67	25.39	11.05

Instrument comparison
Innov-X vs Niton (30S)

n = 300	Min	Max	Mean	Sdev	RSD
As_OI	0.6	170	23.67	25.39	11.05
As_TN	LOD	168	24.22	25.77	38.77





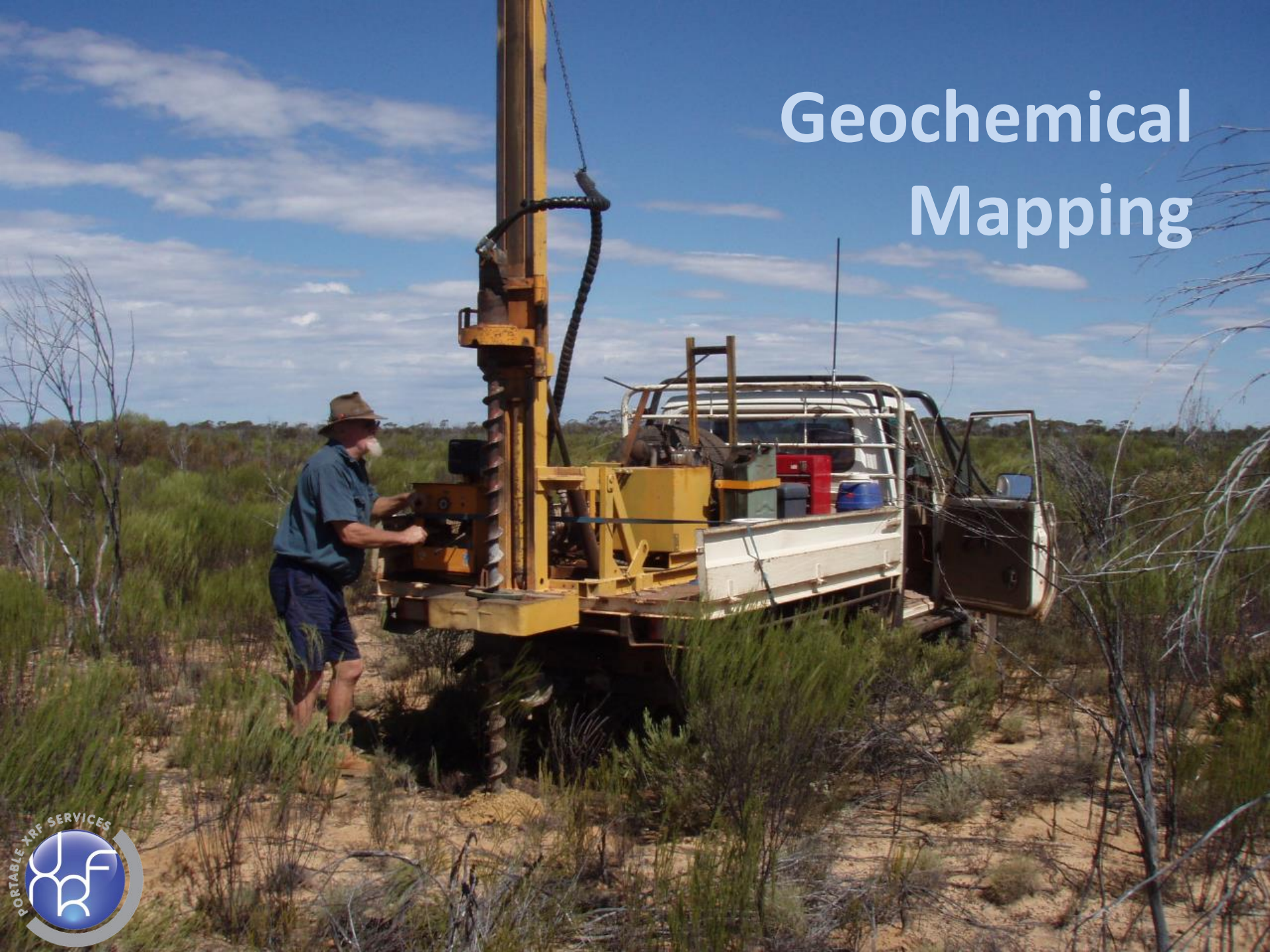
As – Innov-X

As - Niton

Analysis of samples were conducted identically

Innov-X & Niton have similar accuracy

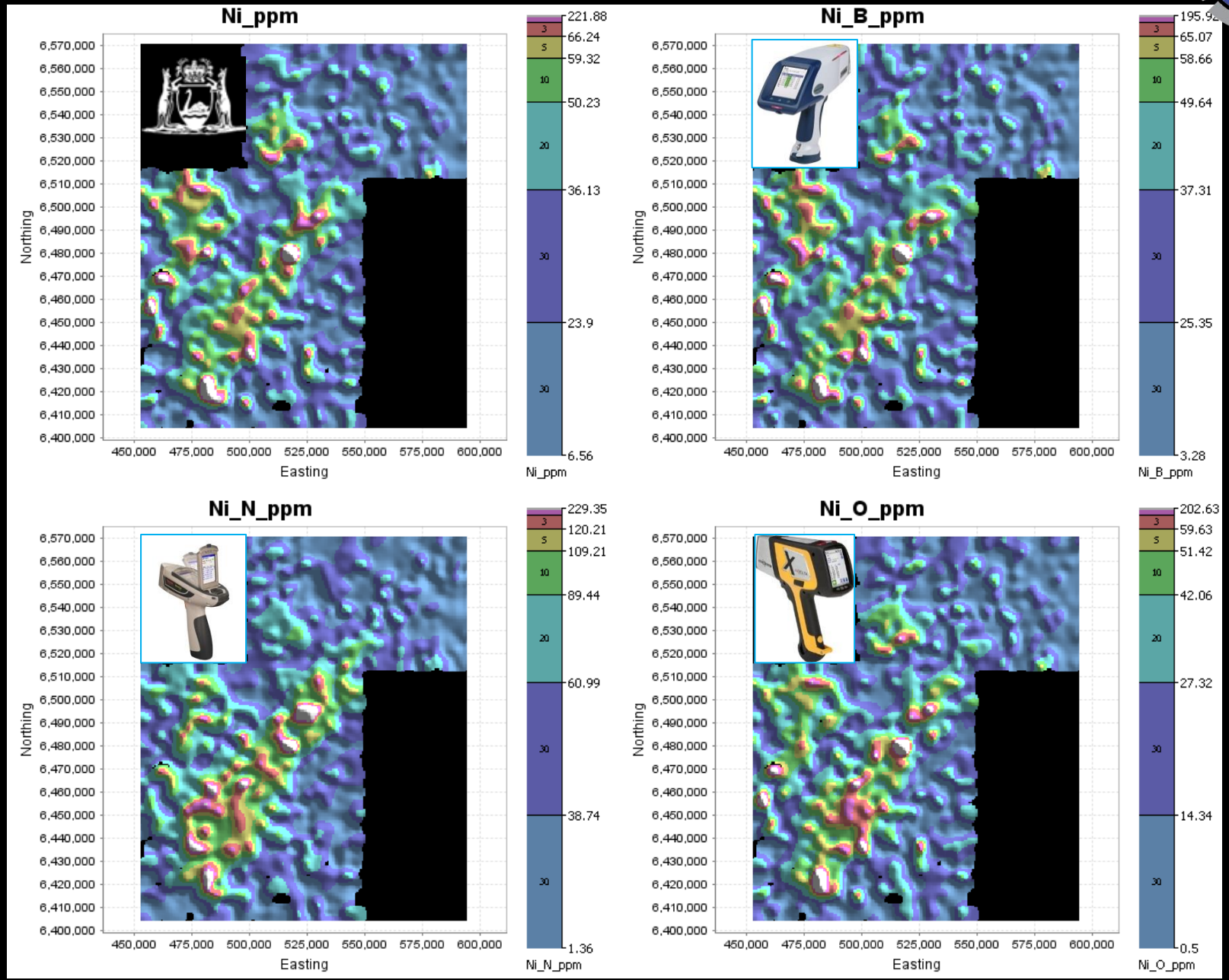
Innov-X has far better precision than Niton


Geochemical
Mapping
PORTABLE XRF SERVICES

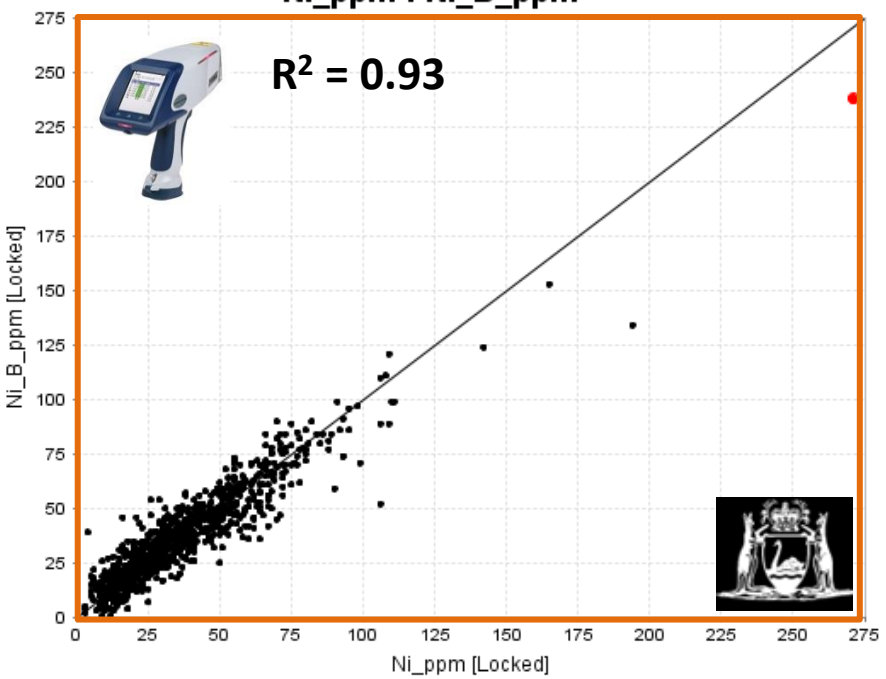
Geochemcial Mapping

- Commercial laboratories take weeks to months for results especially when shipping from remote locations
- pXRF allows for real time “fit for purpose” data to be collected.
- Using samples collected by Geological Survey of Western Australia (GSWA) we reanalyzed 14 year old samples with BR, OI and TN pXRF.

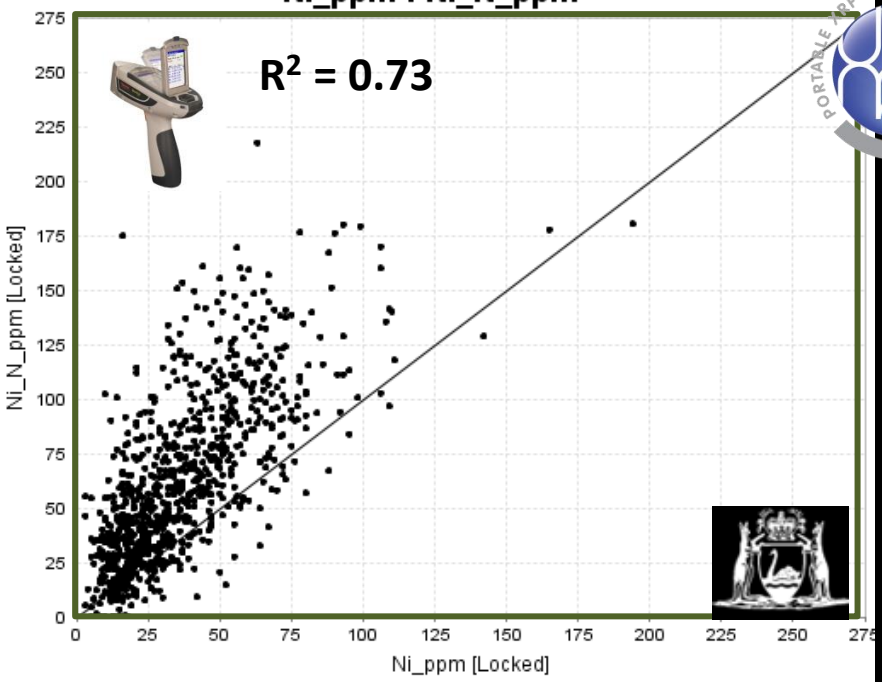
Nickel Response



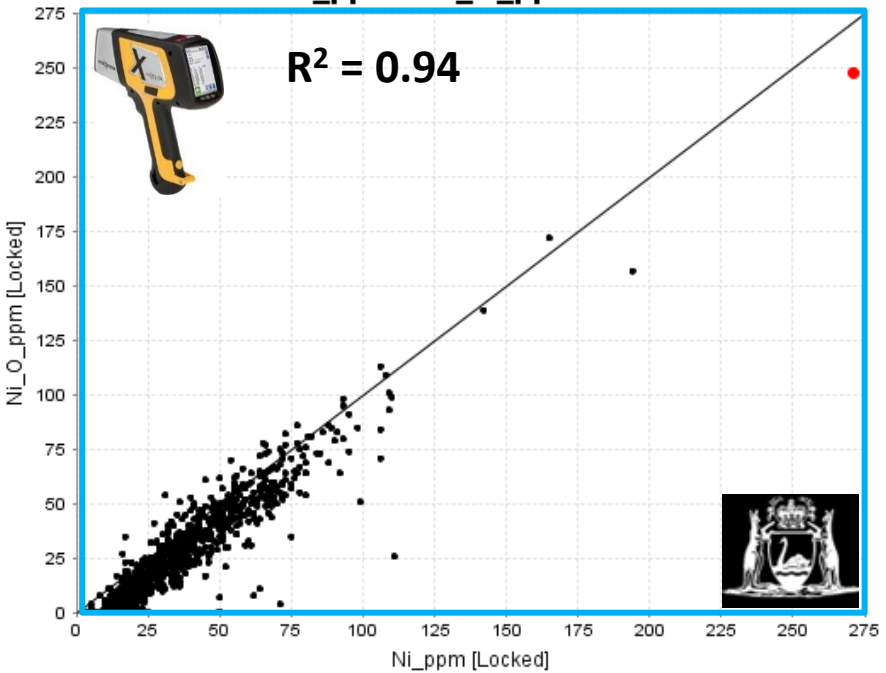
Ni_ppm : Ni_B_ppm



Ni_ppm : Ni_N_ppm

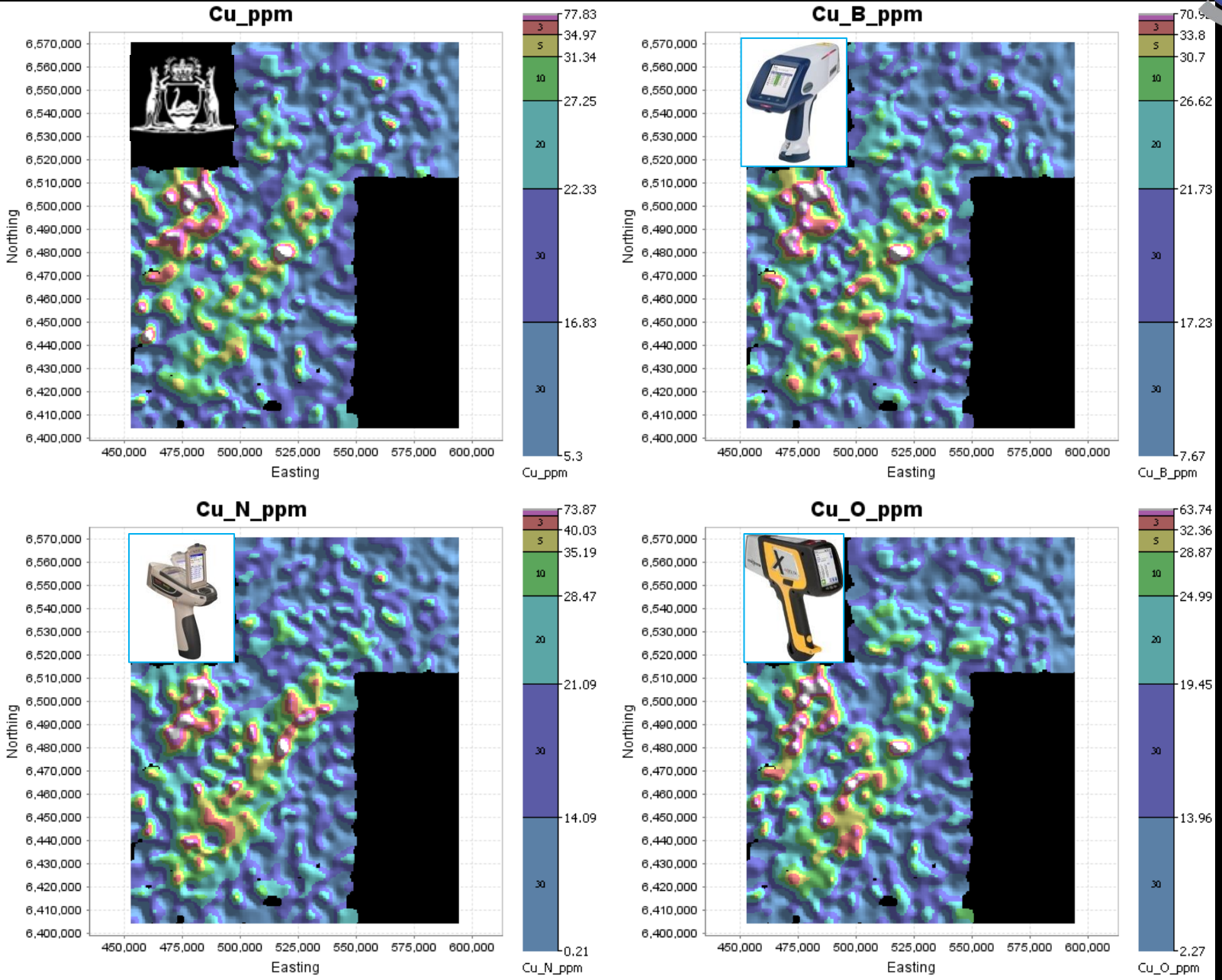


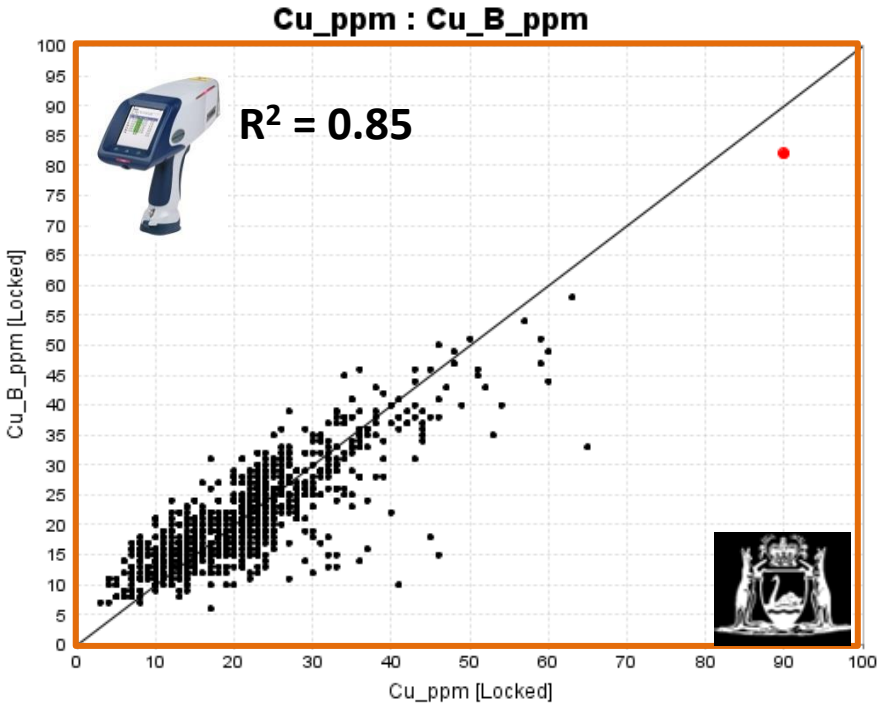
Ni_ppm : Ni_O_ppm

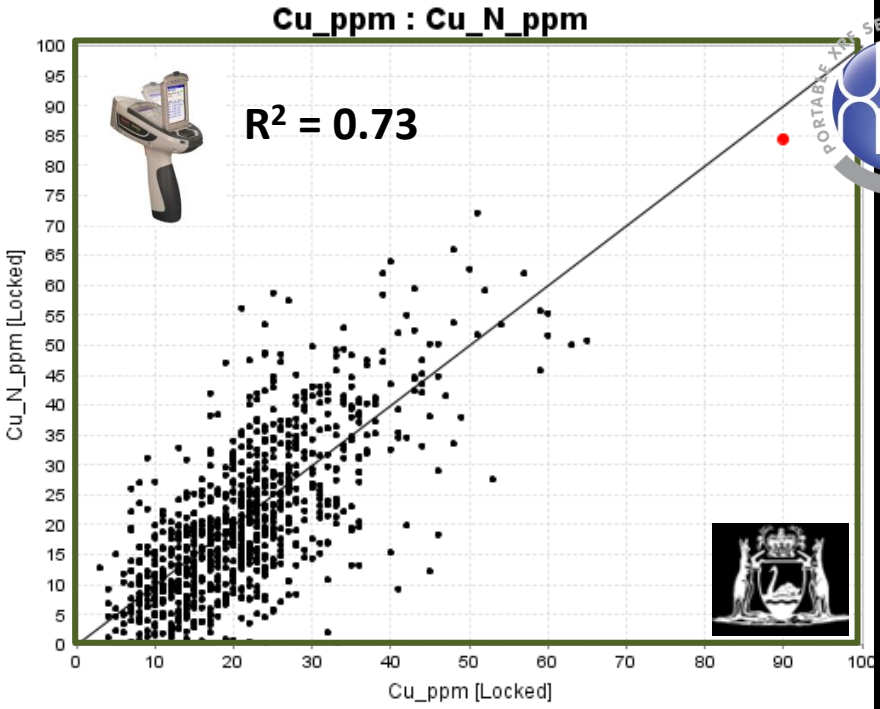


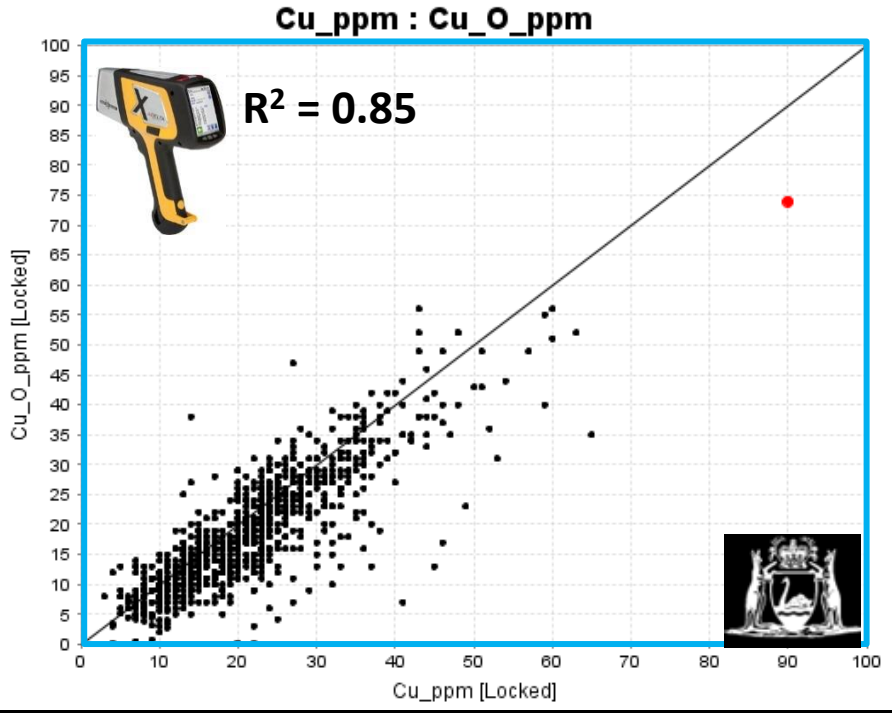
	Ni_ppm	Ni_B_ppm	Ni_N_ppm	Ni_O_ppm
Min	3	1	0.055	0.5
Max	271	238	267.56	248
Mean	35.48	35.84	60.69	26.52
Sdev	23.58	22.22	38.84	24.23
RSD	66.48	62.00	64.00	91.38

Copper Response









	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

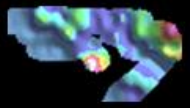
Geochemical Mapping

Weekly Time Slices (2 year)

Images of Ni

~48,000 samples collected over 100 strike Km on a 1000 x 100m grid

Nickel Time Slices



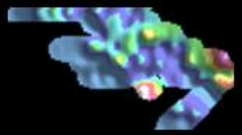
0 25

kilometres

n = 314

B01

10/02/13



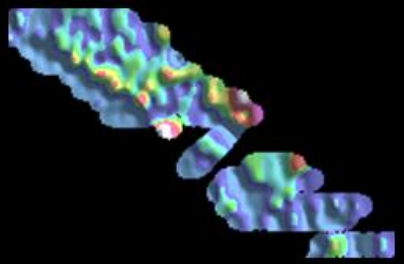
0 25

kilometres

n = 568

B02

17/02/13



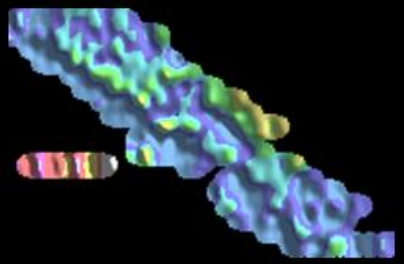
0 25

kilometres

n = 1280

B03

24/02/13



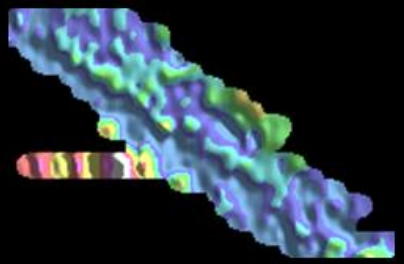
0 25

kilometres

n = 1655

B04

03/03/13



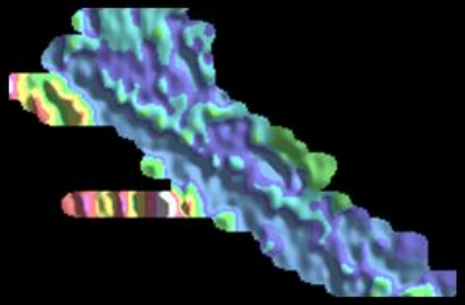
0 25

kilometres

n = 2030

B05

10/03/13



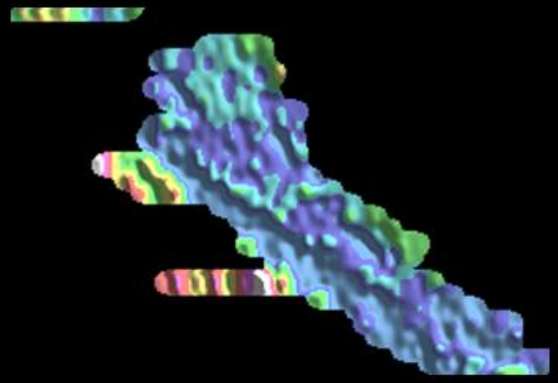
0 25

kilometres

n = 2588

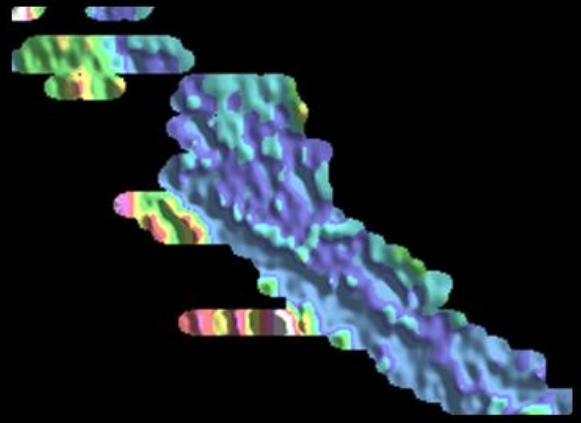
B06

10703/13



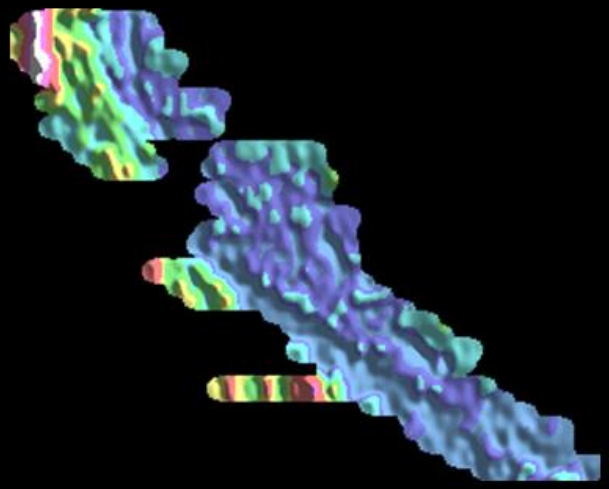
0 25
kilometres

n = 2897
B07
24/03/13



0 25
kilometres

n = 3168
B08
31/03/13



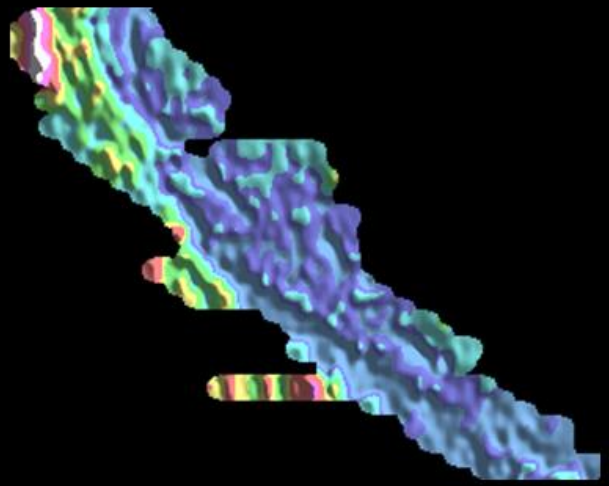
0 25

kilometres

n = 3937

B09

07/04/13



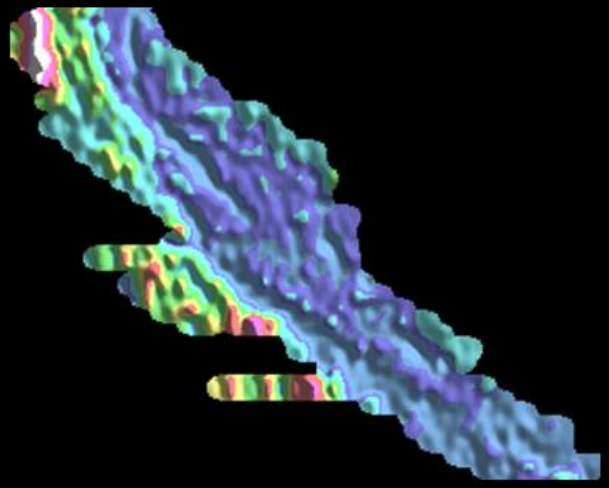
0 25

kilometres

n = 4473

B10

14/04/13



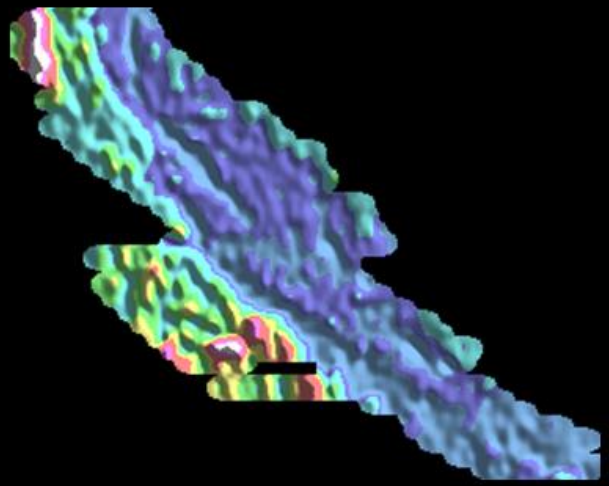
0 25

kilometres

n = 5330

B11

21/04/13



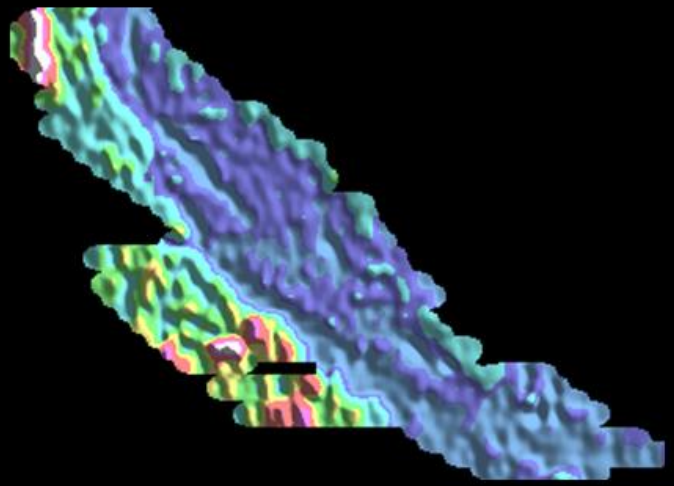
0 25

kilometres

n = 6134

B12

28/04/13



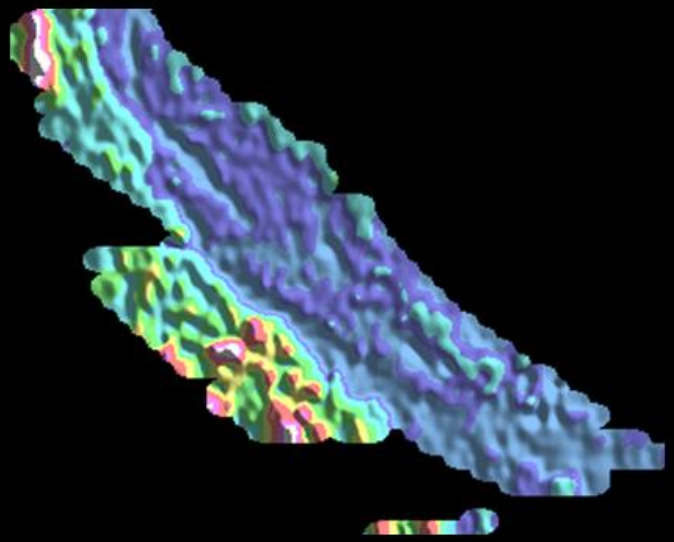
0 25

kilometres

n = 6804

B13

05/05/13



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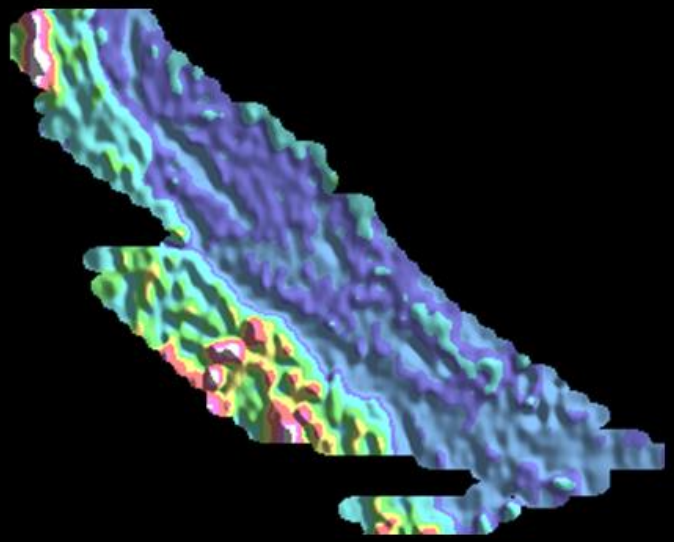
kilometres

n = 7382
B14
12/05/13



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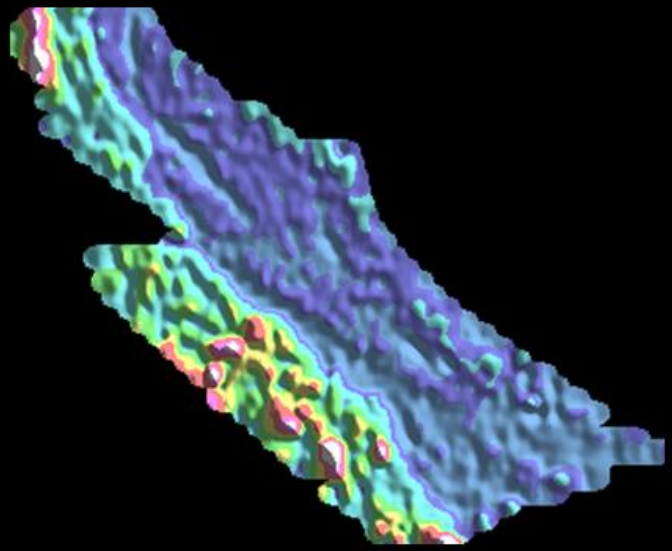
kilometres

n = 8183

B15

19/05/13



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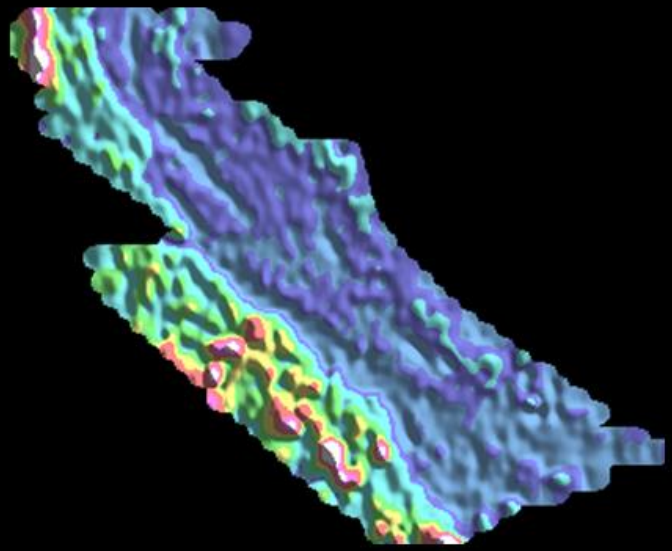
kilometres

n = 9233

B16

26/05/13



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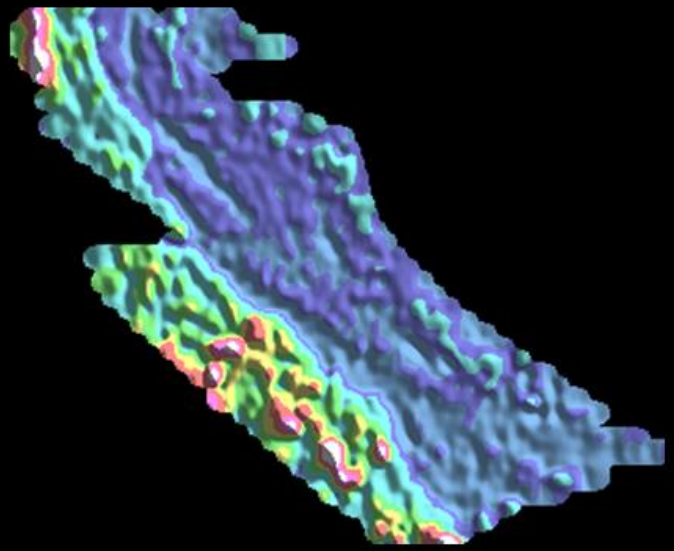
kilometres

n = 9908

B17

02/06/13



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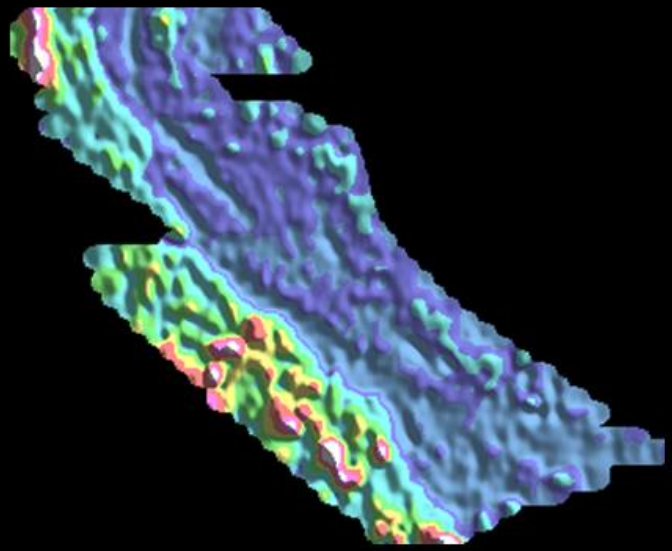
kilometres

n = 10614

B18

09/06/13



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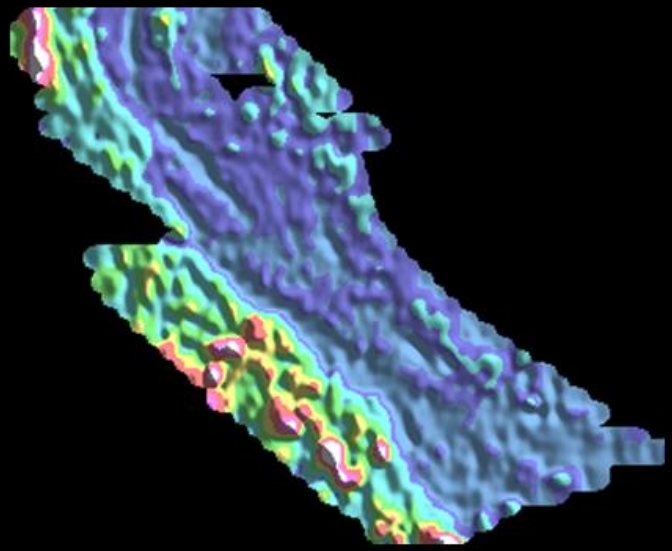
kilometres

n = 11326
B19
16/06/13



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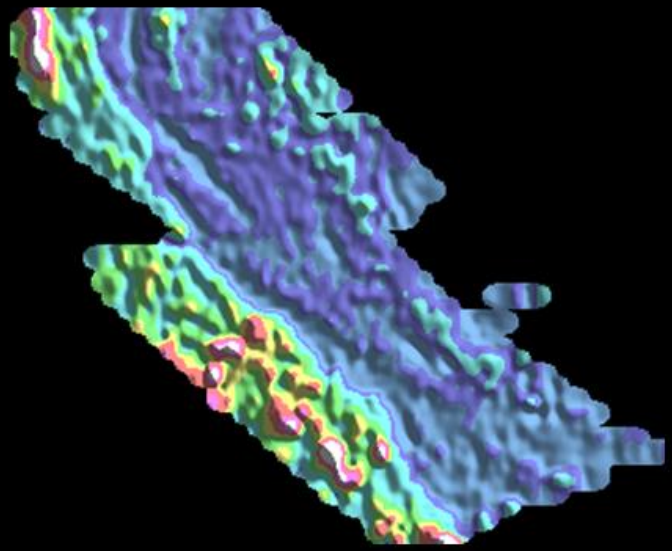
kilometres

n = 11813

B20

23/06/13



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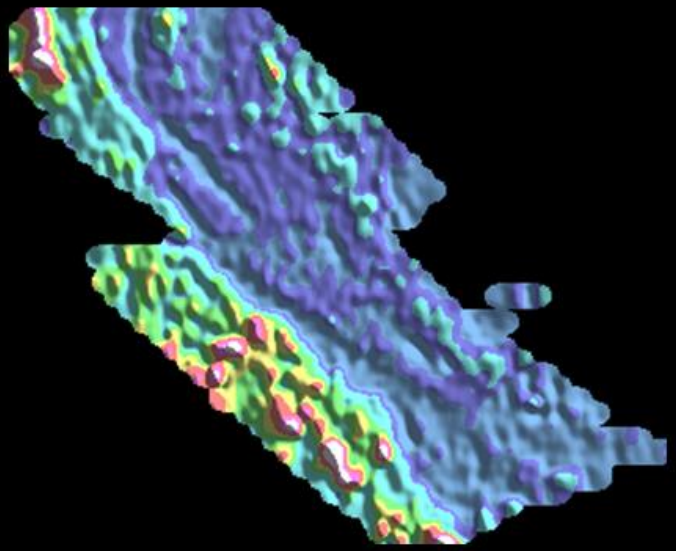
kilometres

n = 12493

B21

30/06/13



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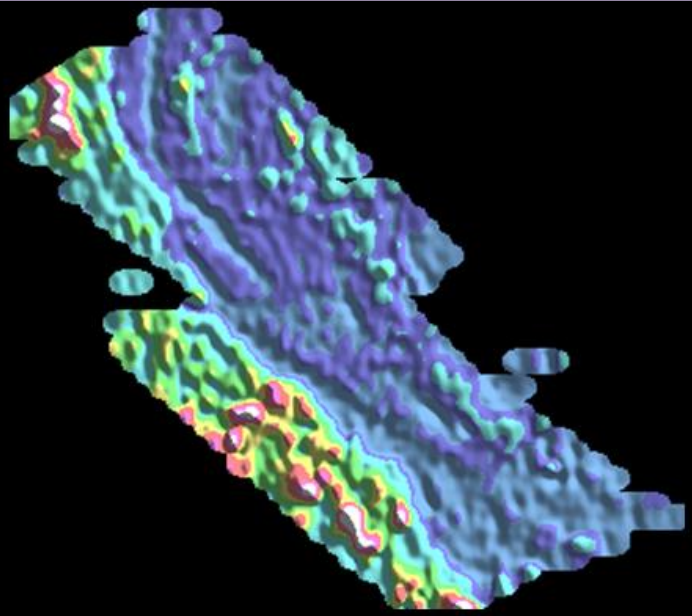
kilometres

n = 13833
B22
07/07/13



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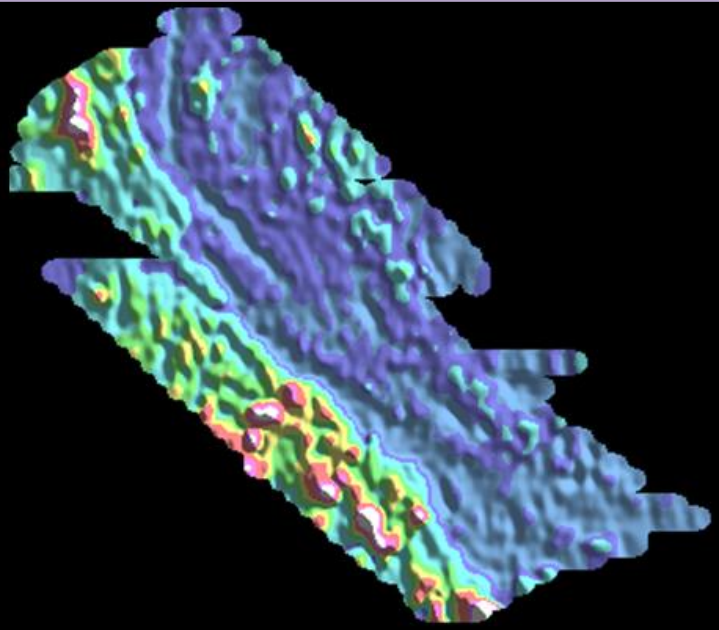
kilometres

n = 15133

B23

14/07/13



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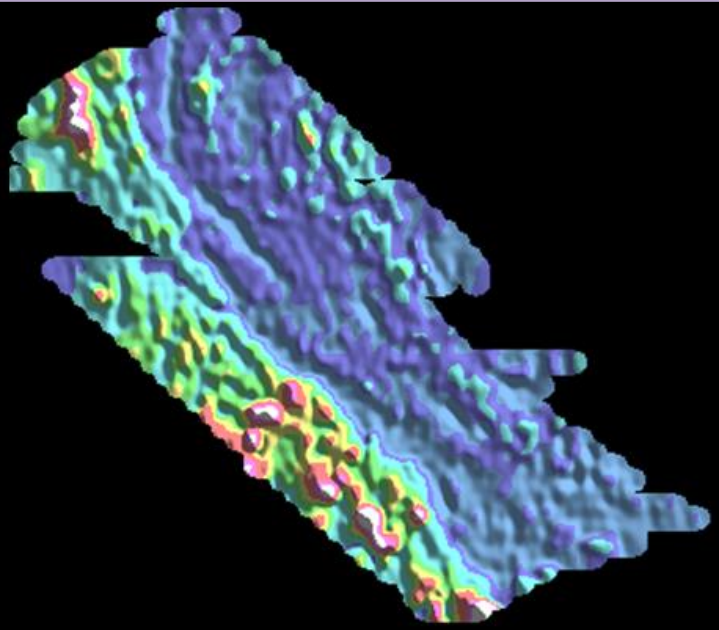
kilometres

n = 16082
B24
21/07/13



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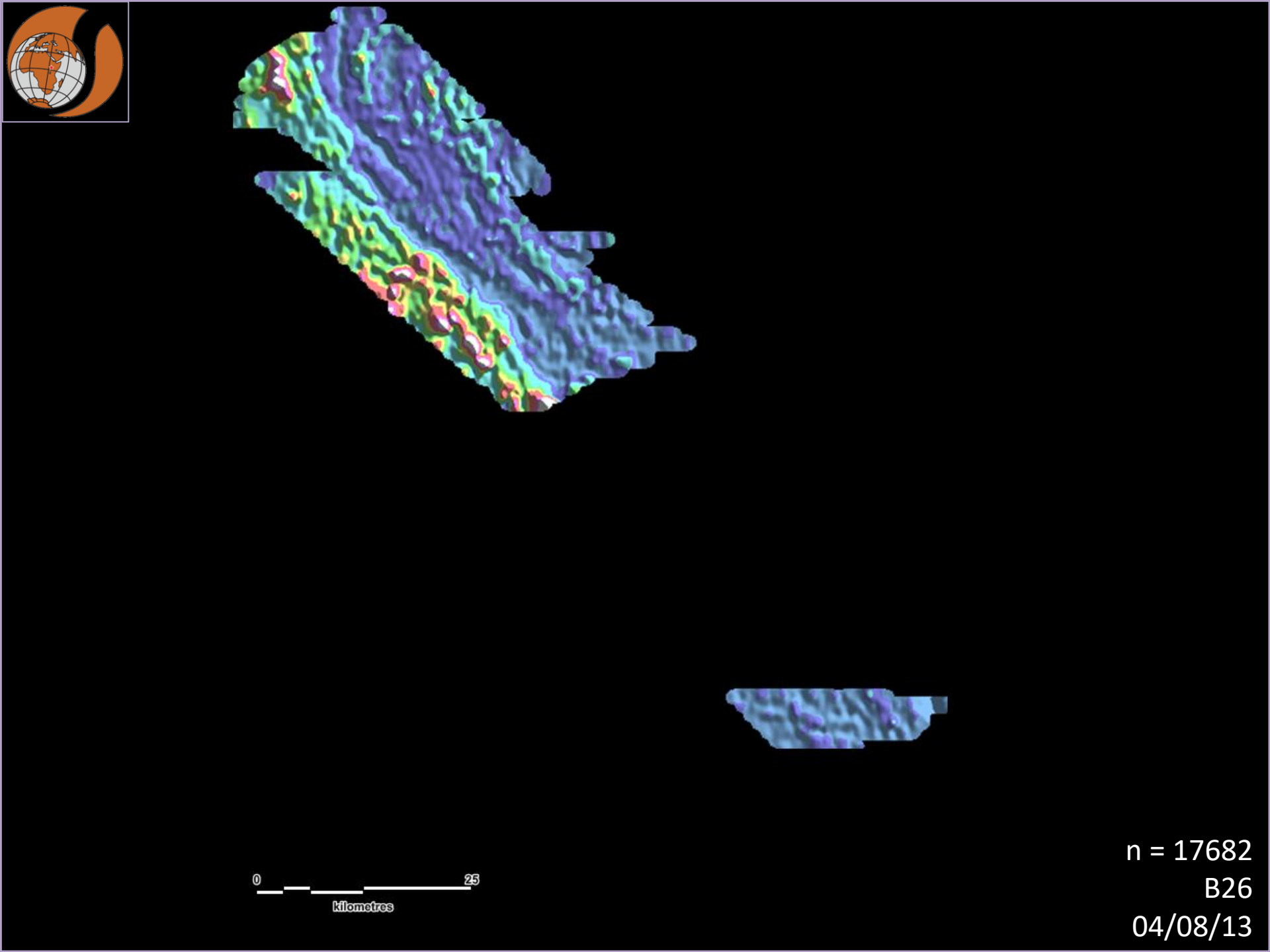
kilometres

n = 16382
B25
28/07/13



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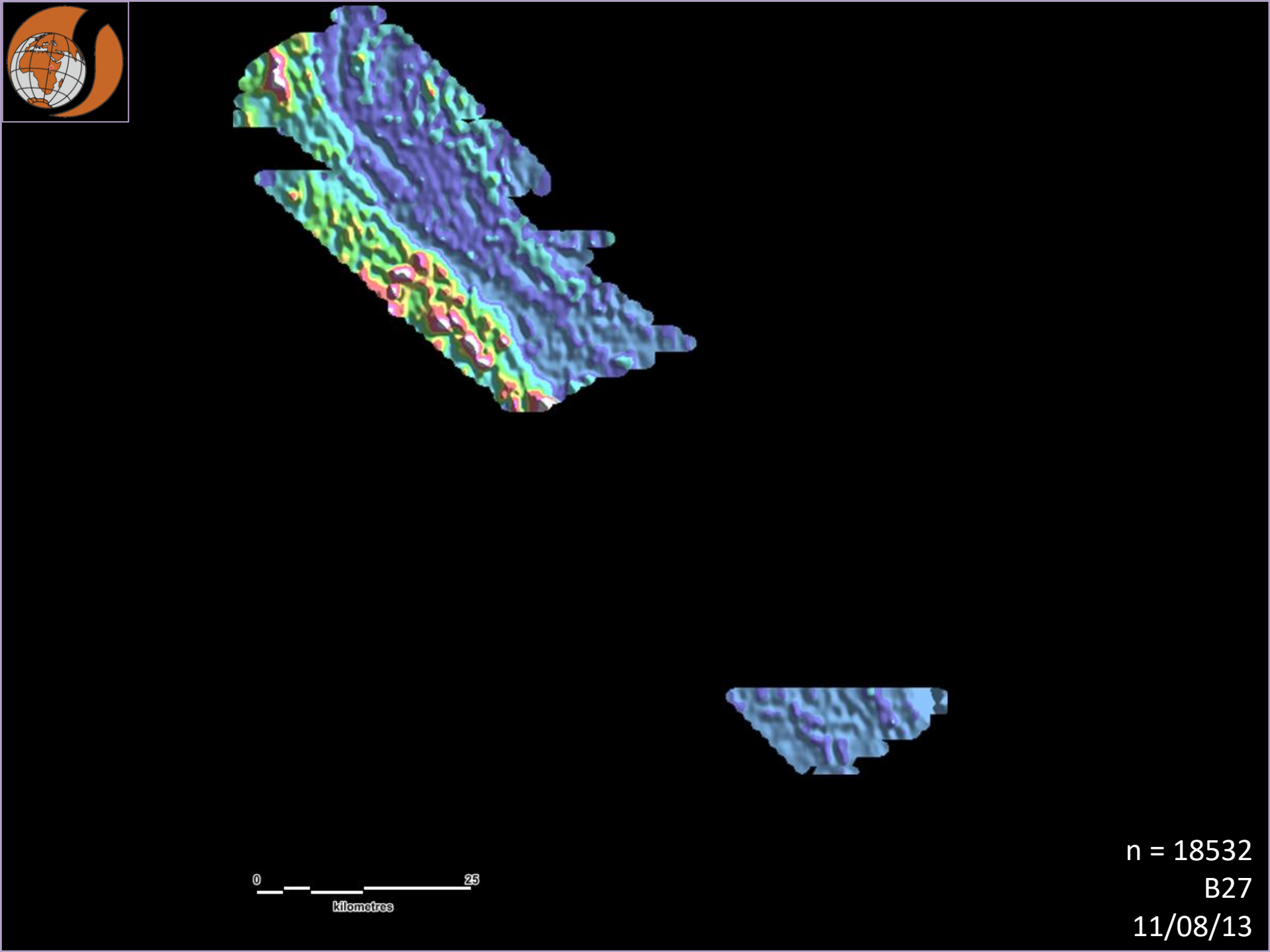
B26
04/08/13



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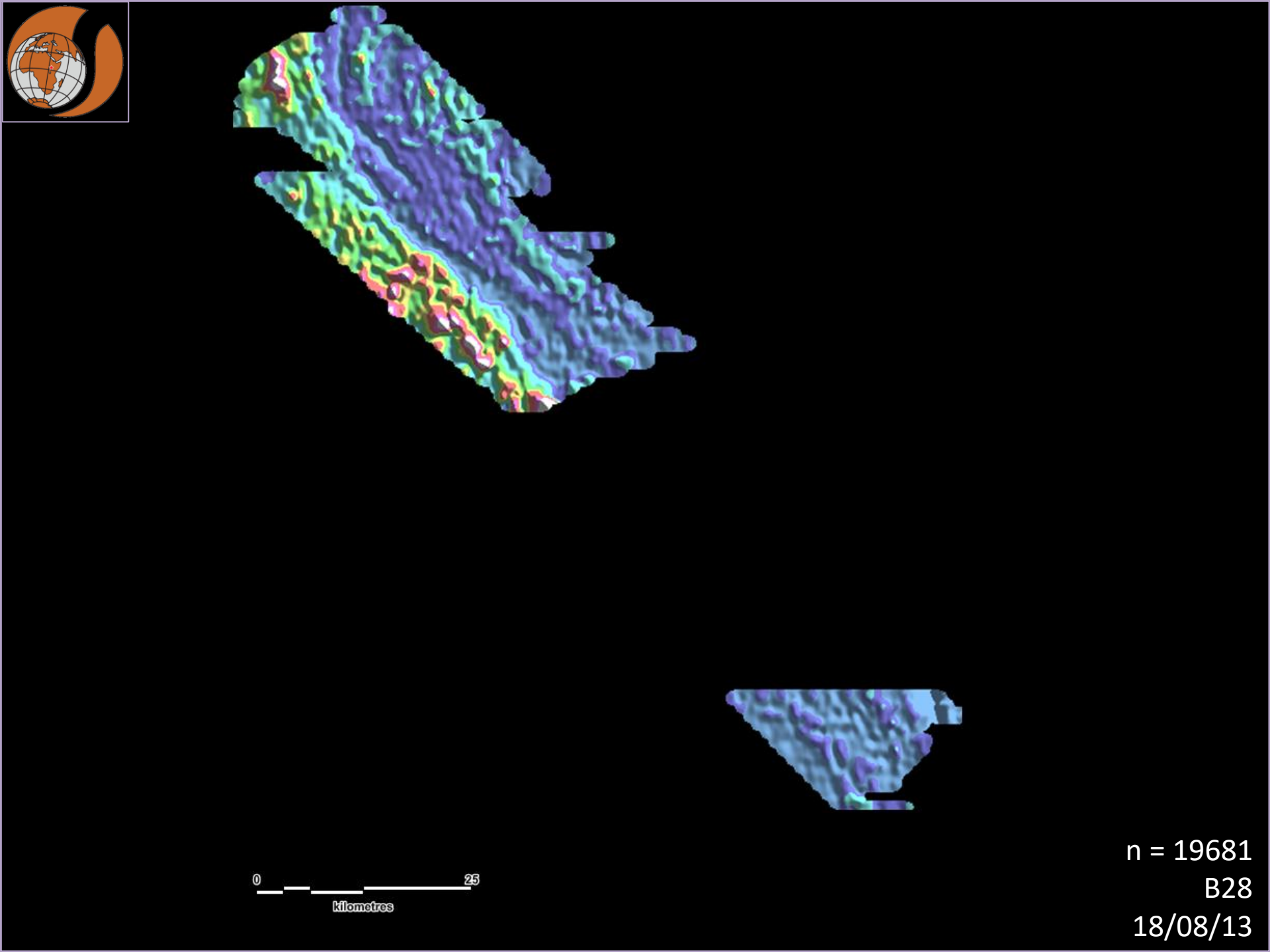
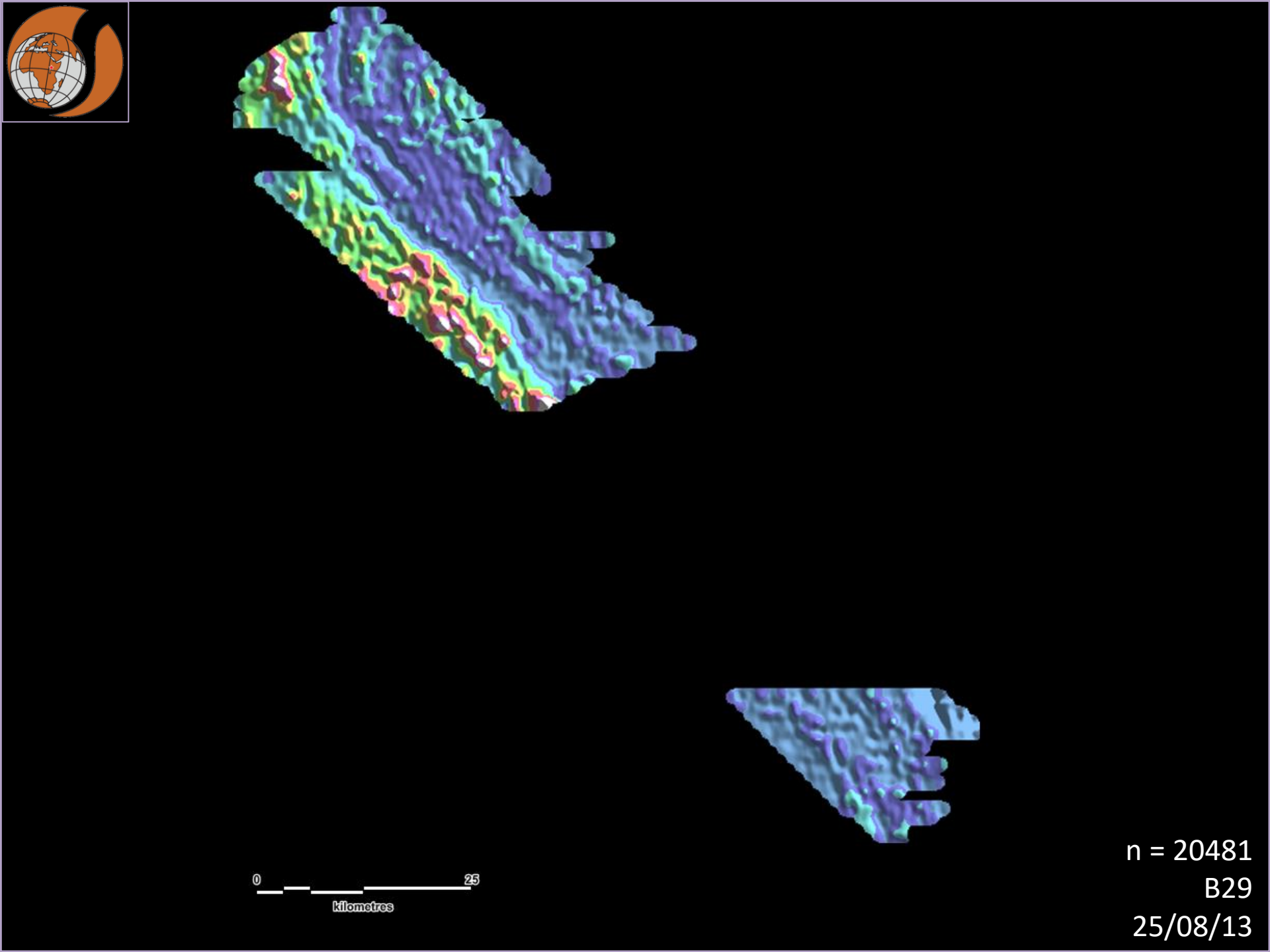
B27
11/08/13



n = 19681
B28
18/08/13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kilometres
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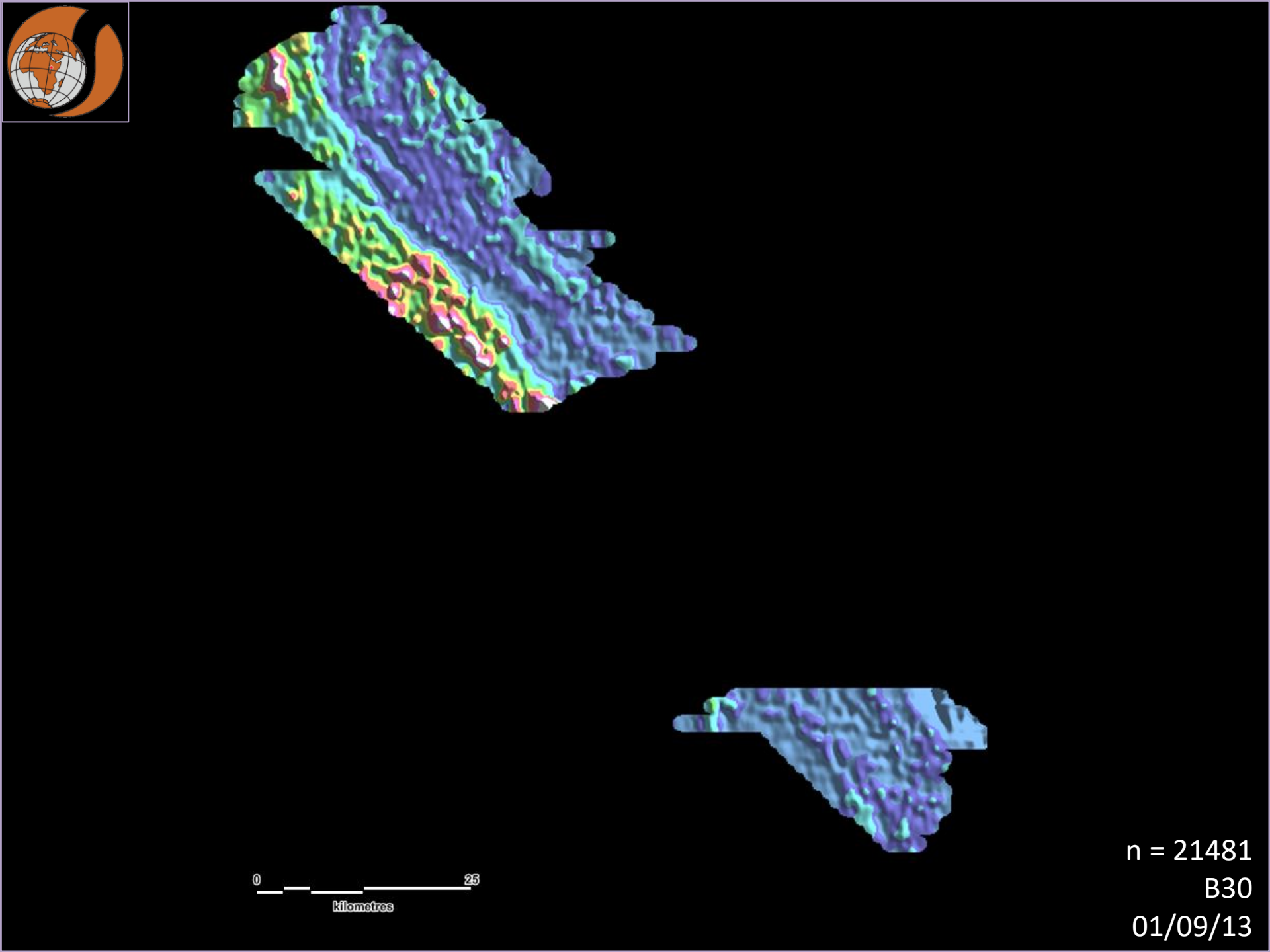
B29
25/08/13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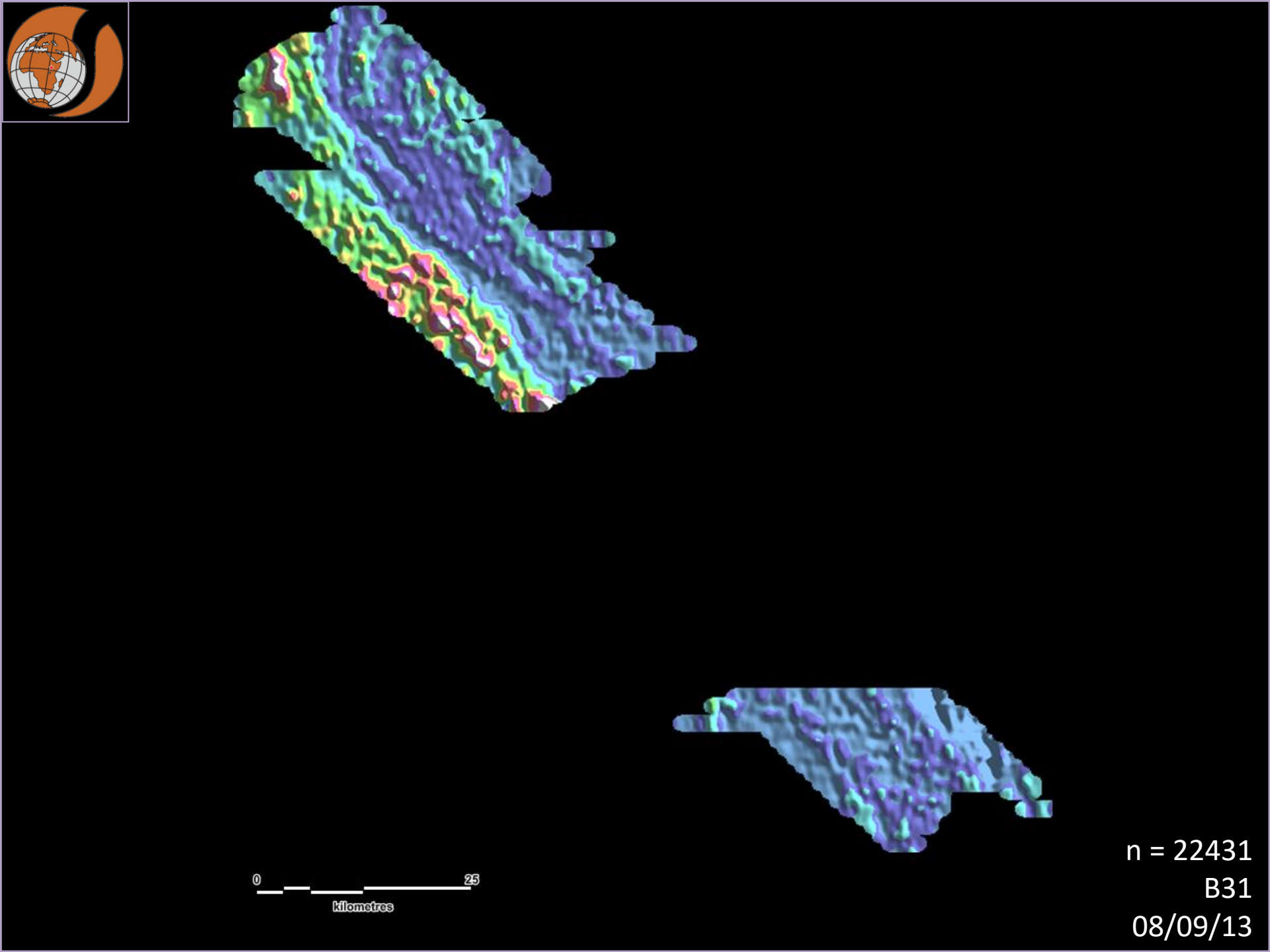
kilometres
n = 21481
B30
01/09/13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kilometres
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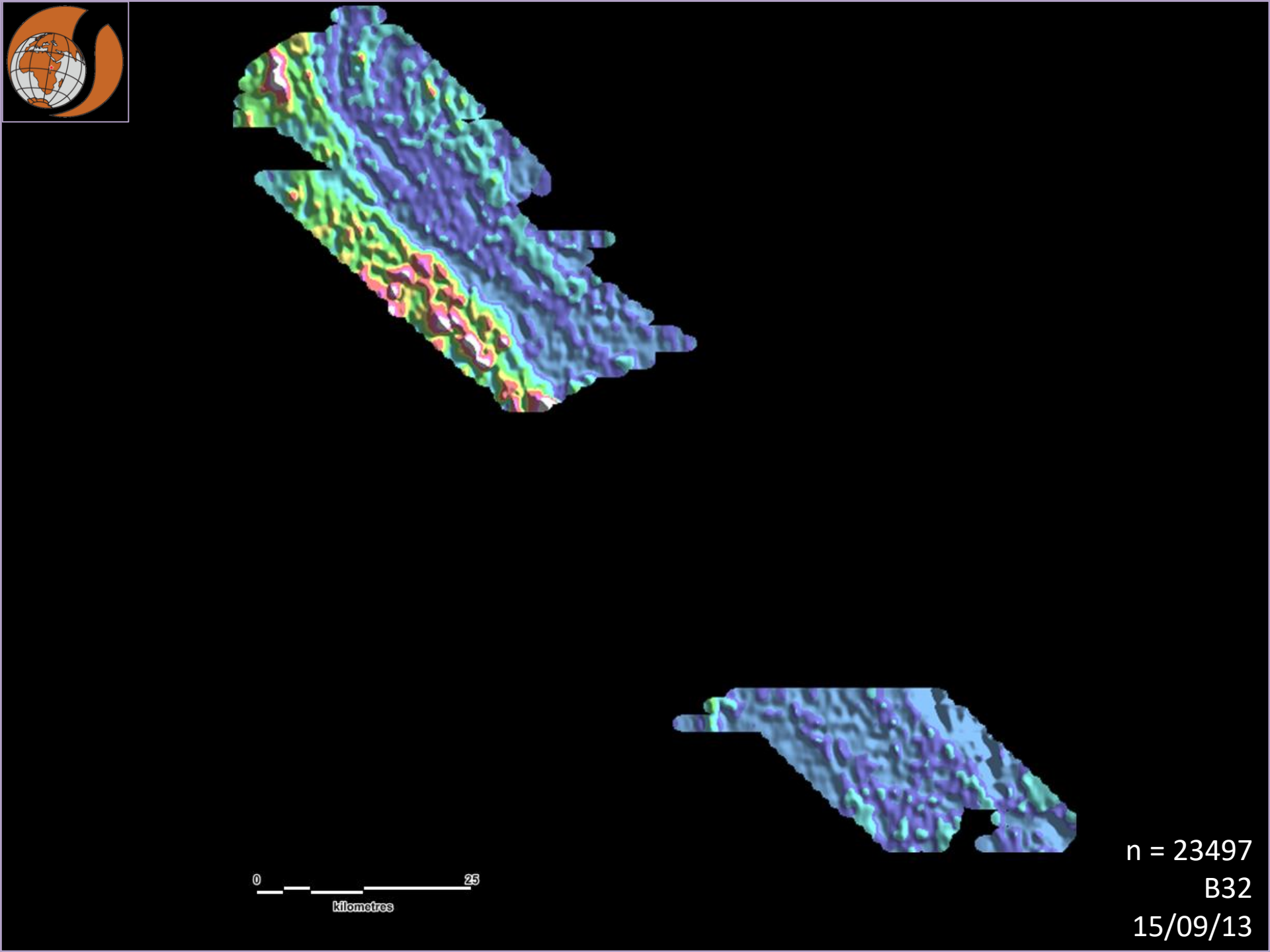
B31
08/09/13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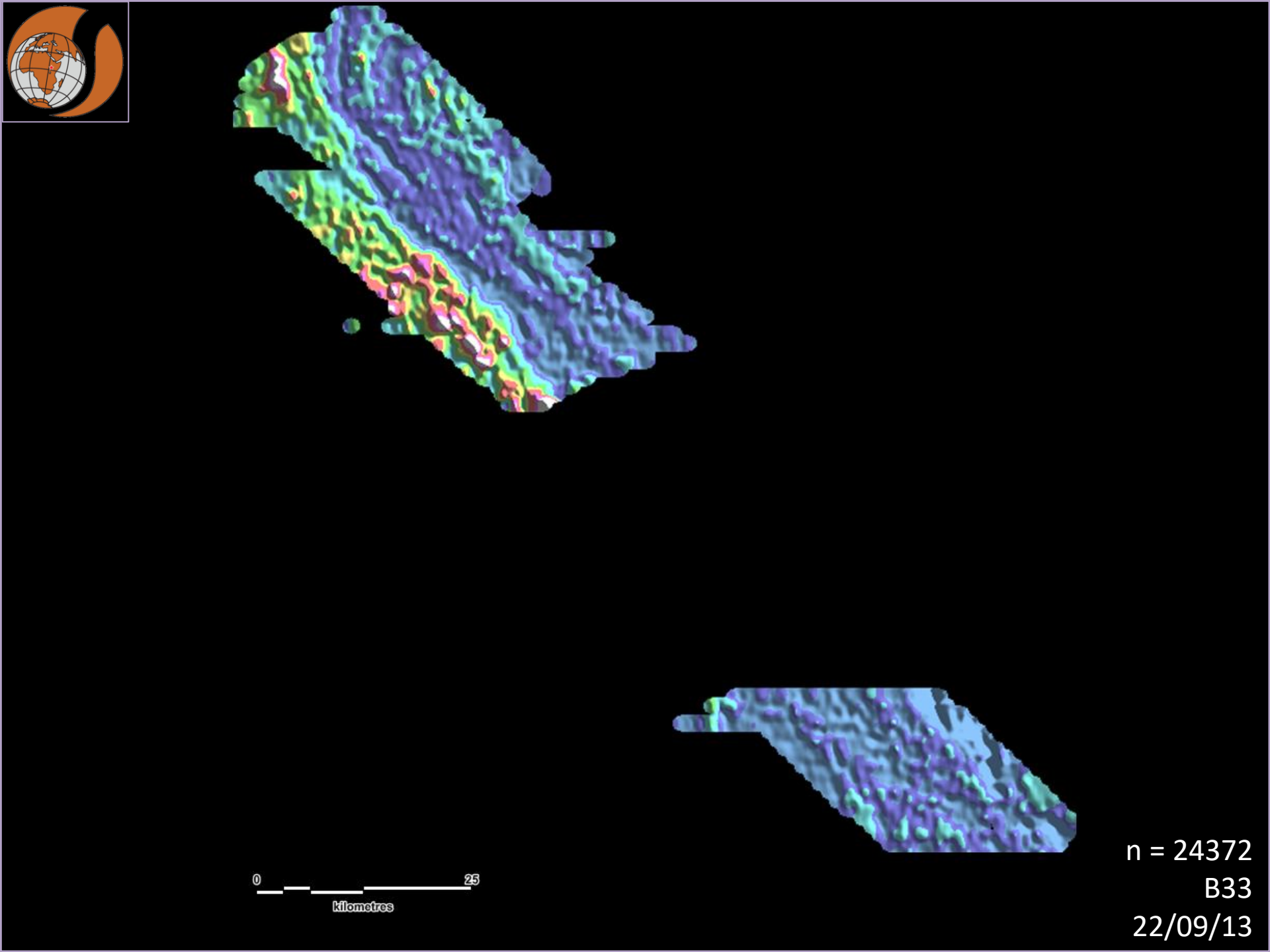
kilometres
n = 23497
B32
15/09/13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kilometres
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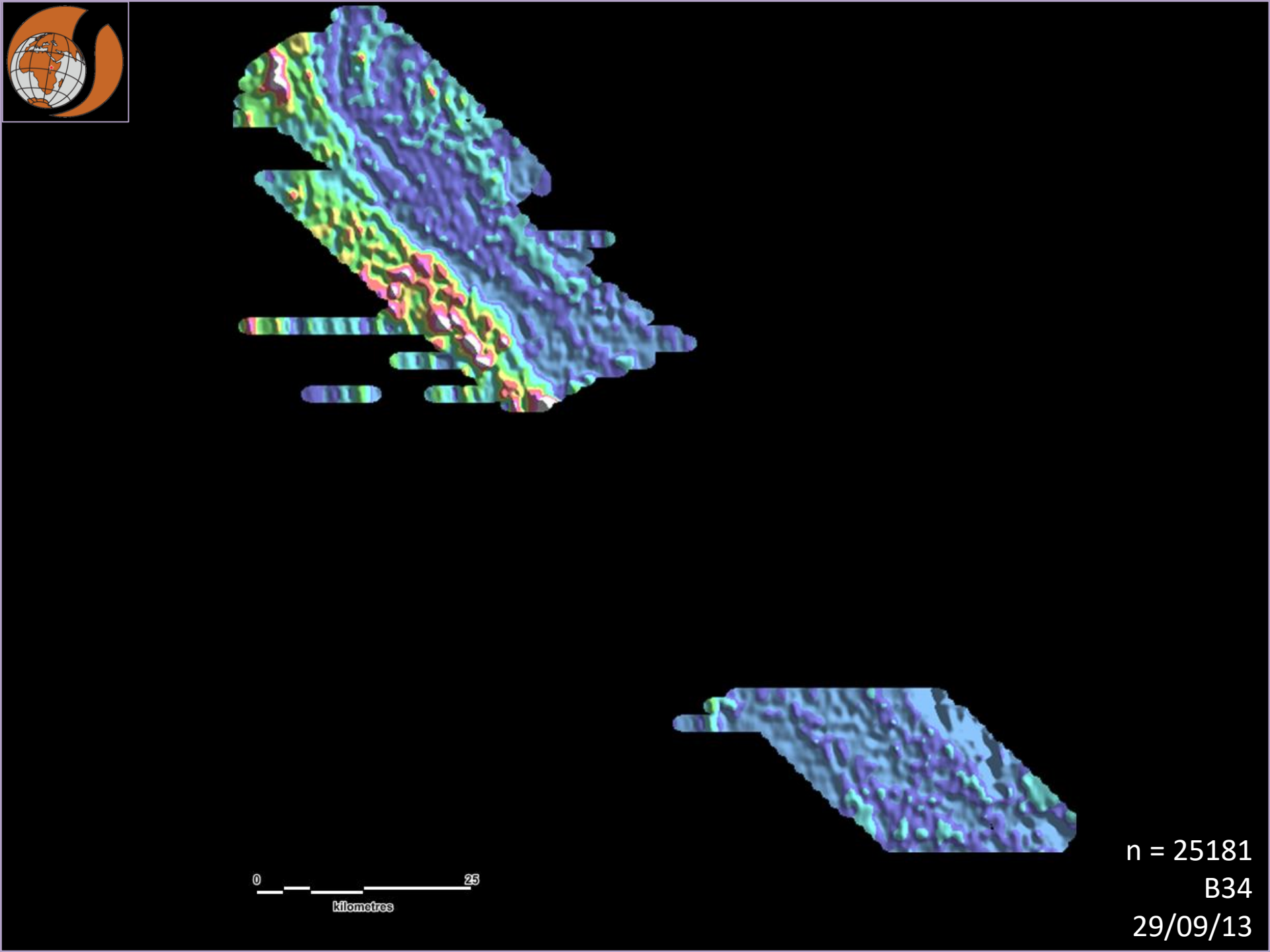
B33
22/09/13



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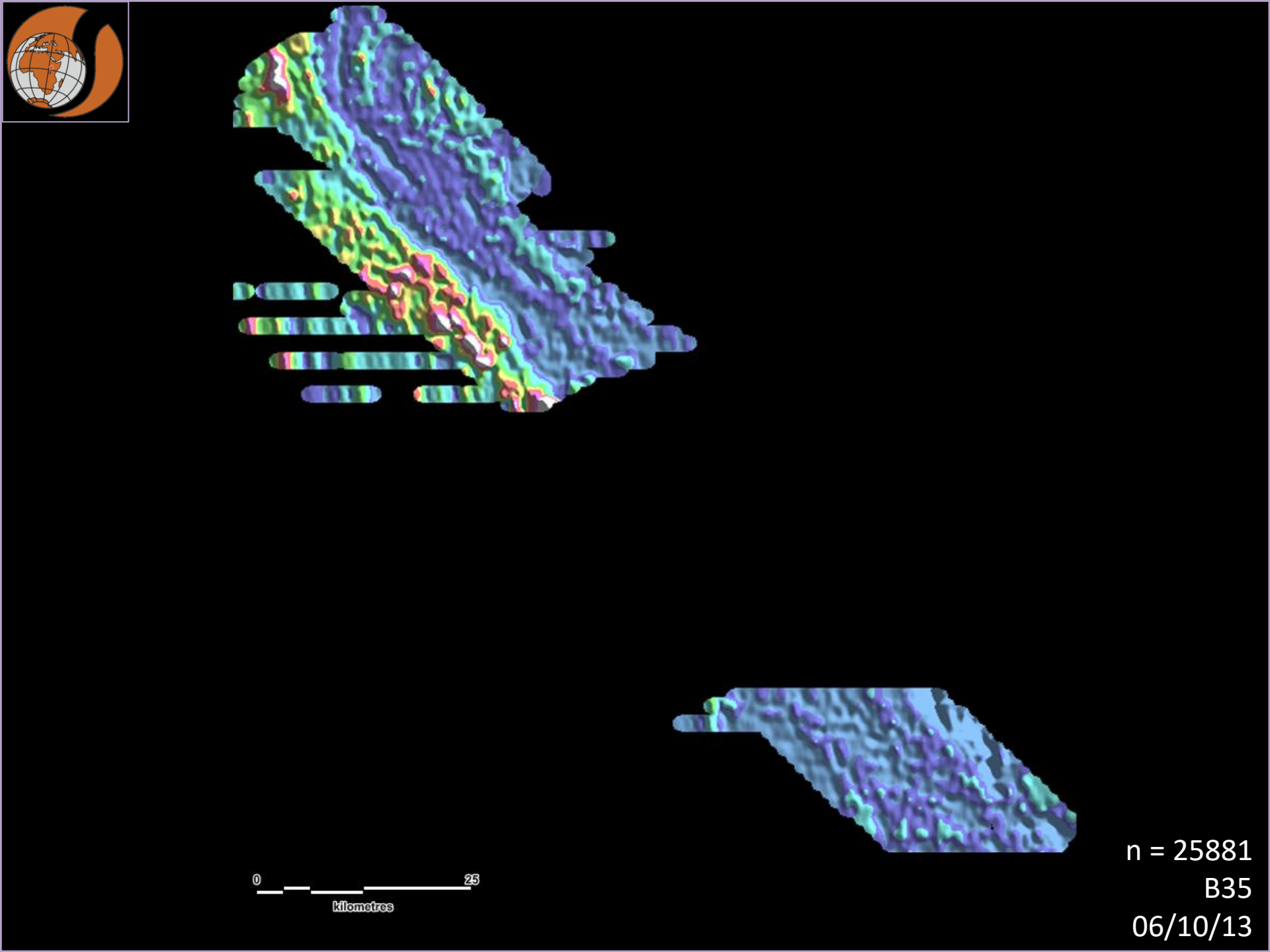
B34
29/09/13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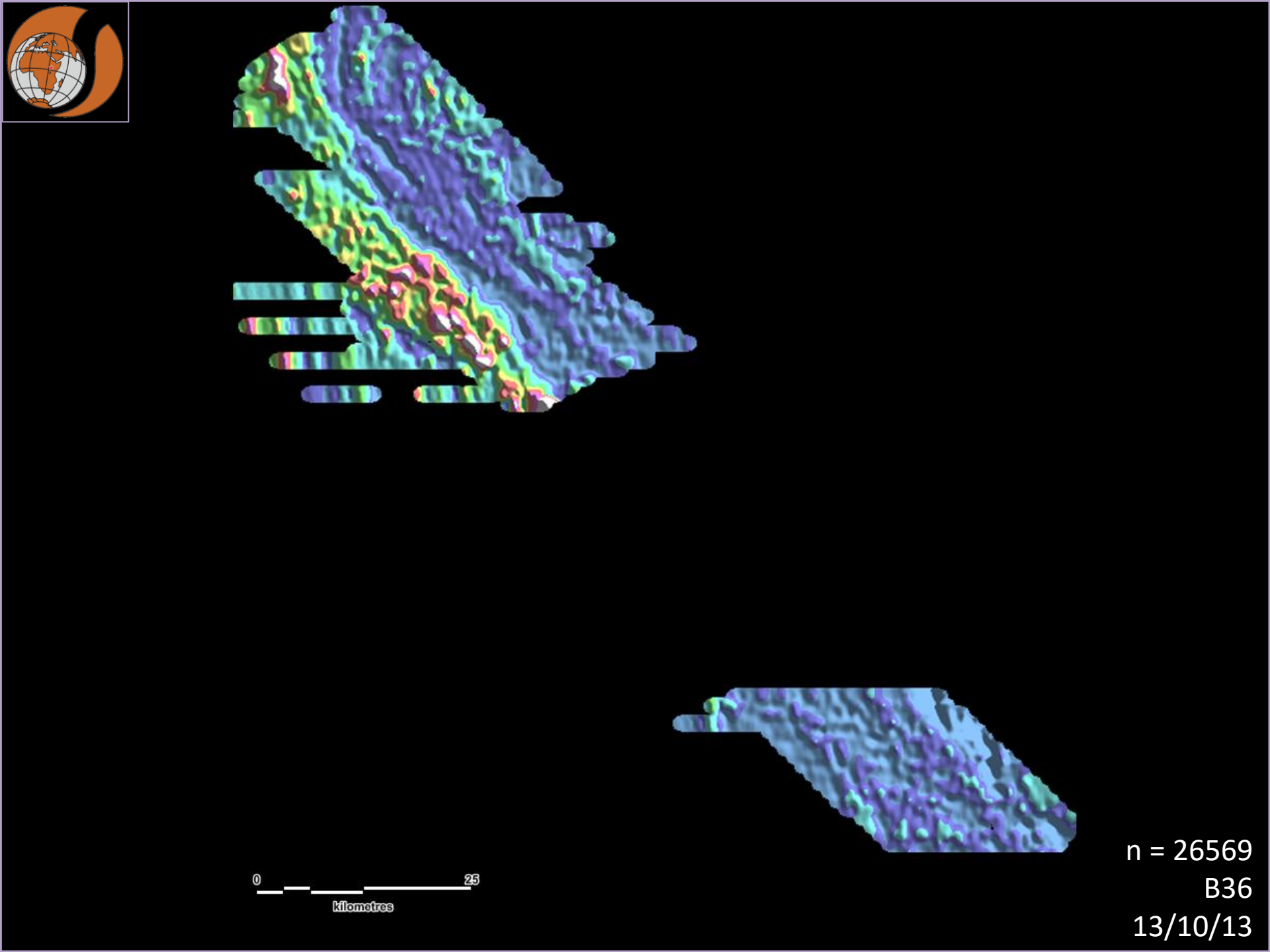
kilometres
n = 25881
B35
06/10/13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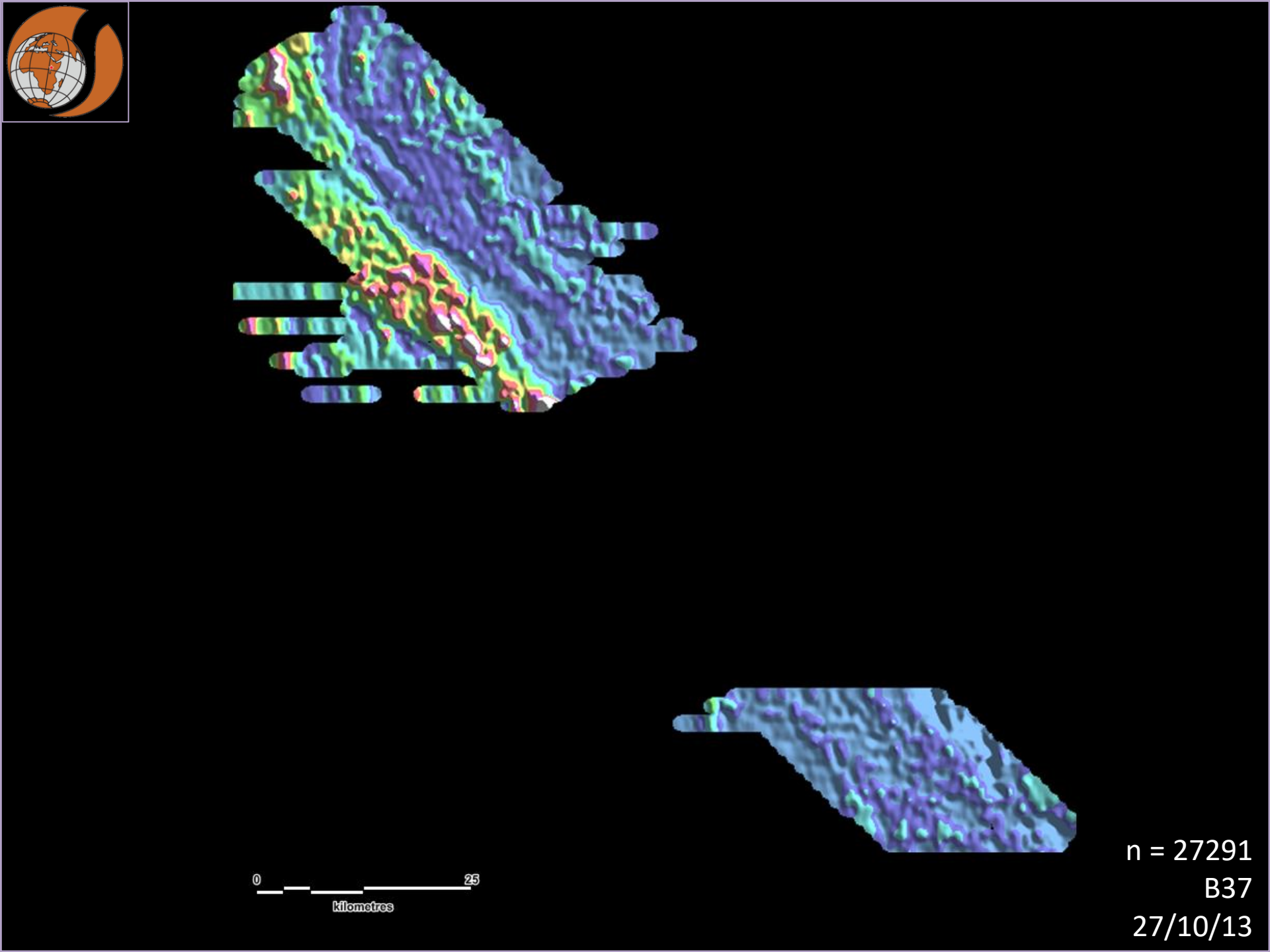
B36
13/10/13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kilometres
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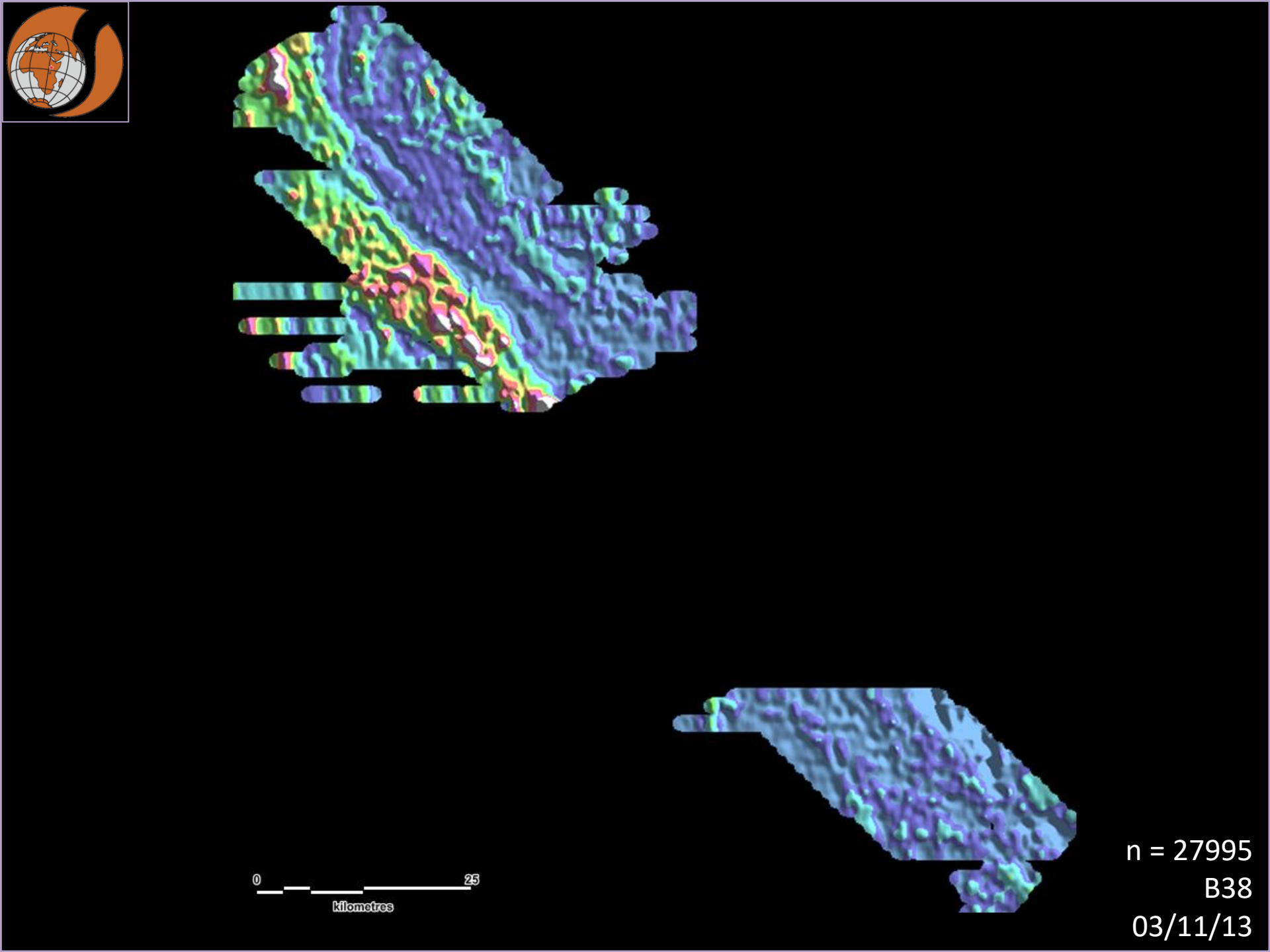
B37
27/10/13



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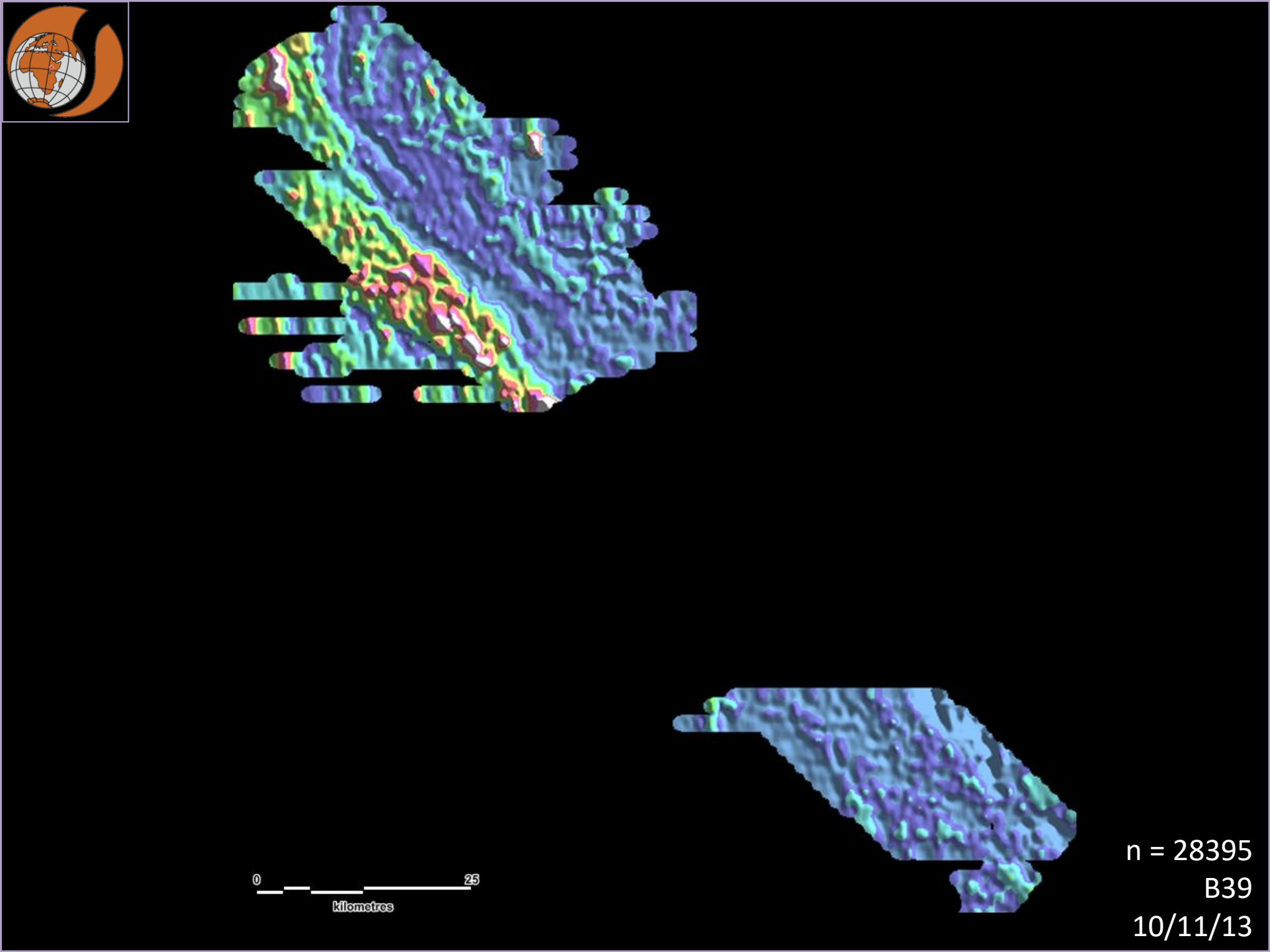
B38
03/11/13



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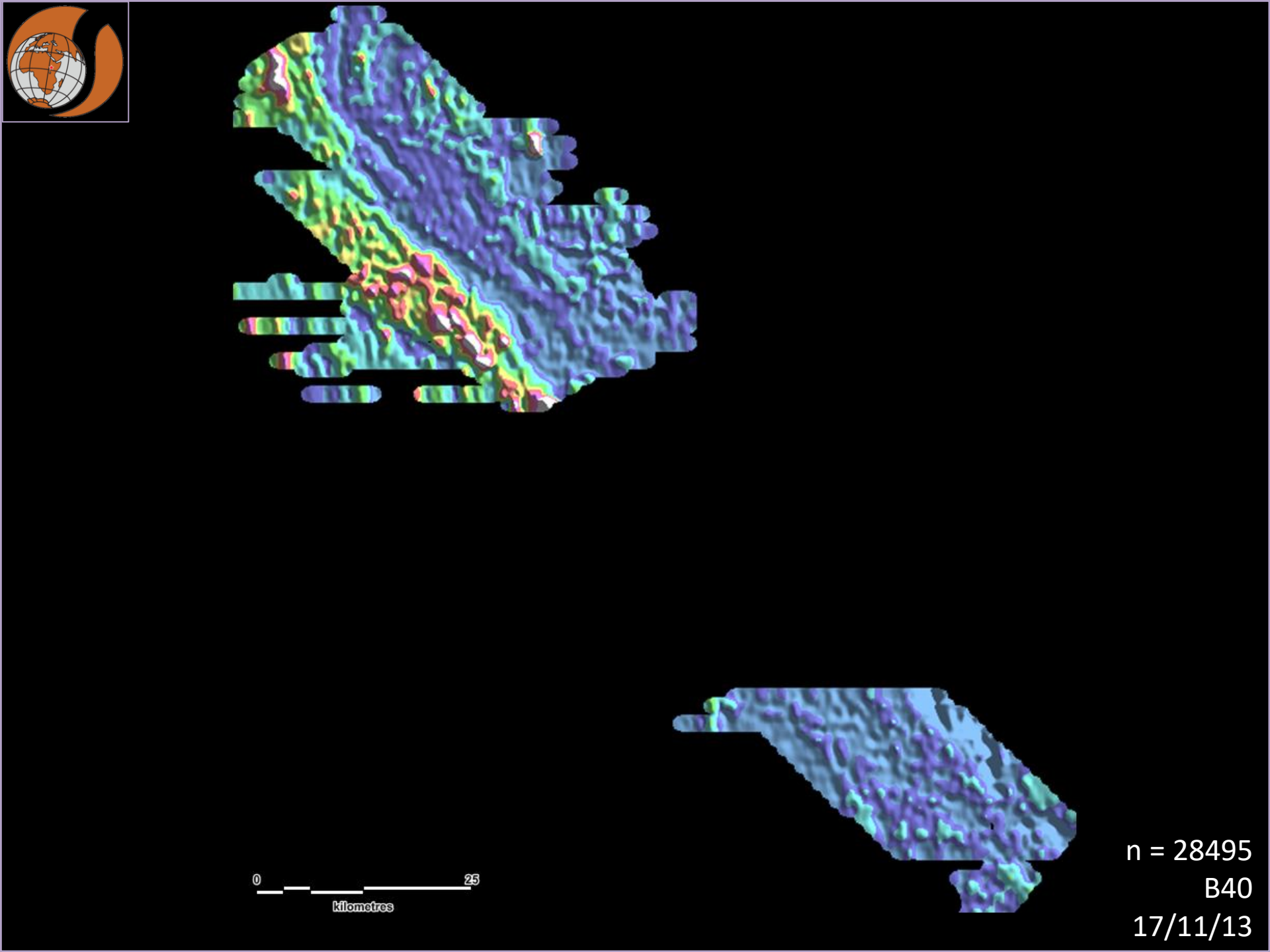
B39
10/11/13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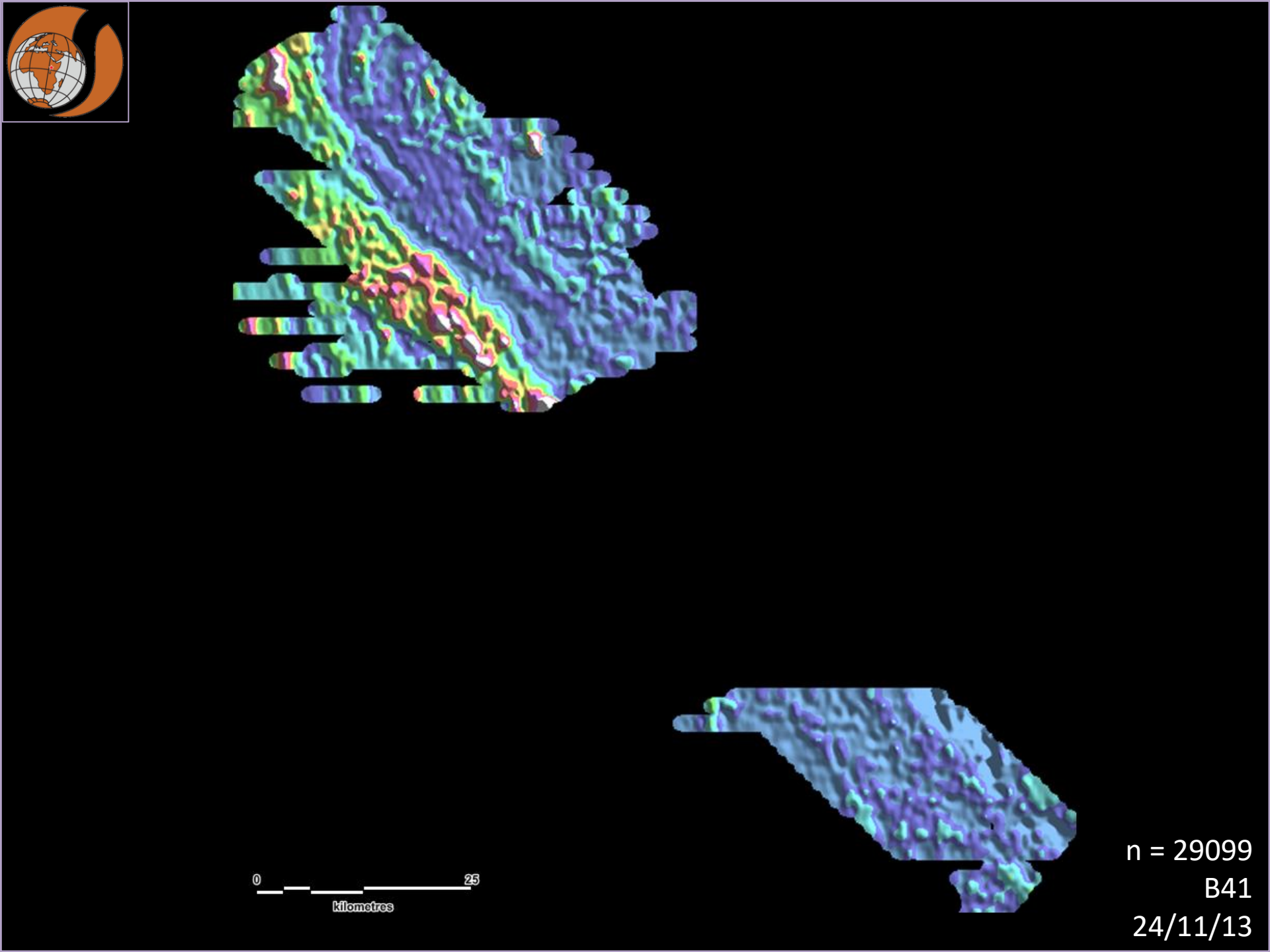
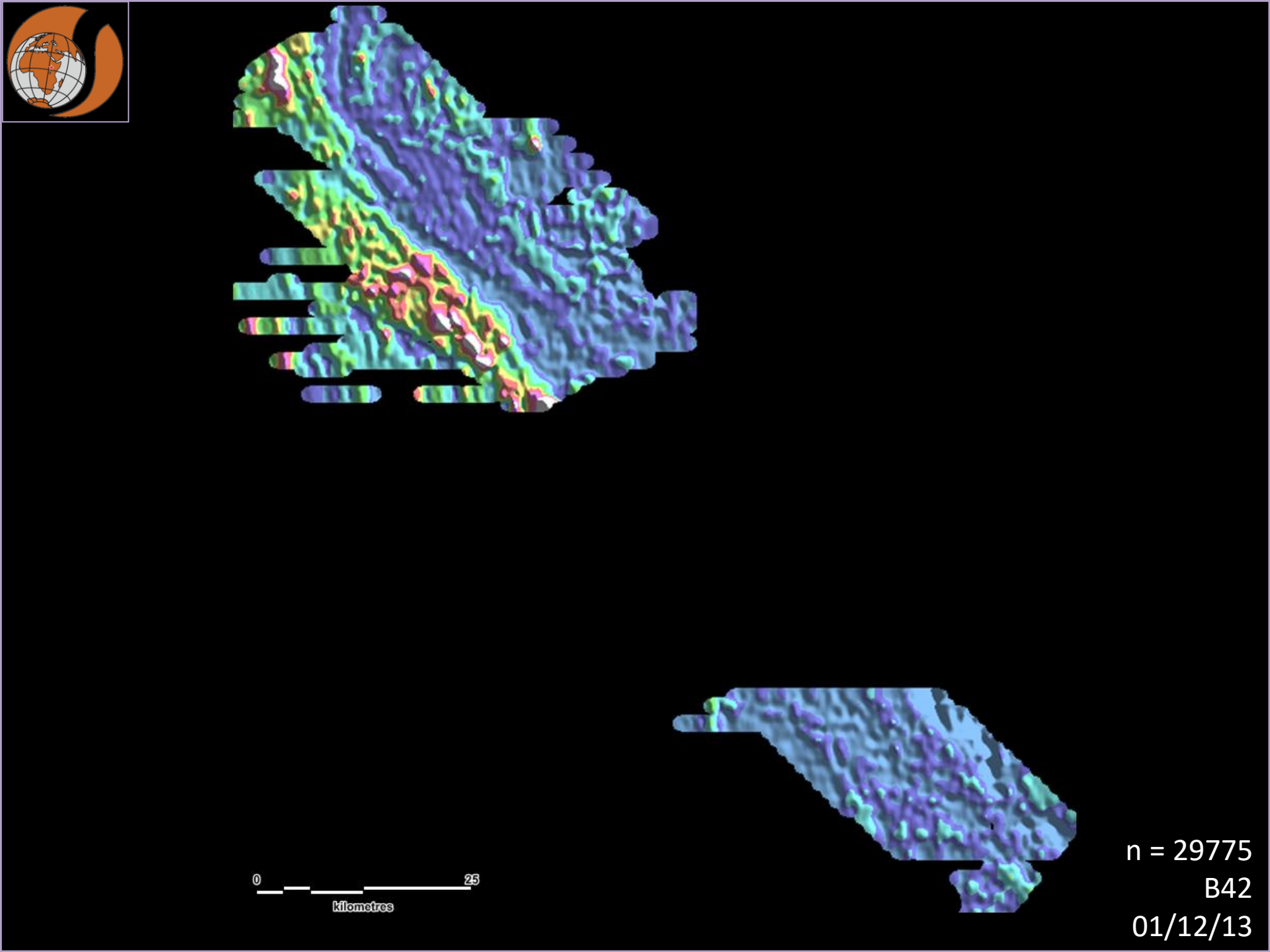
B40
17/11/13



n = 29099
B41
24/11/13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kilometres
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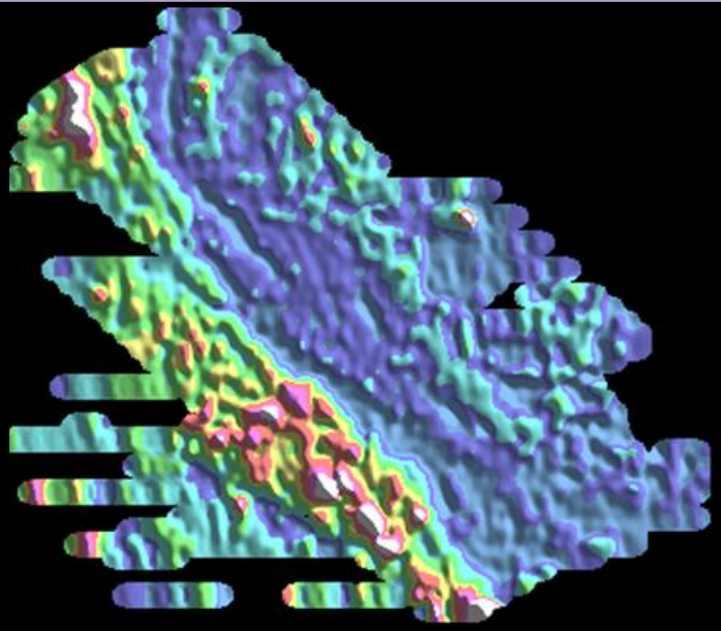
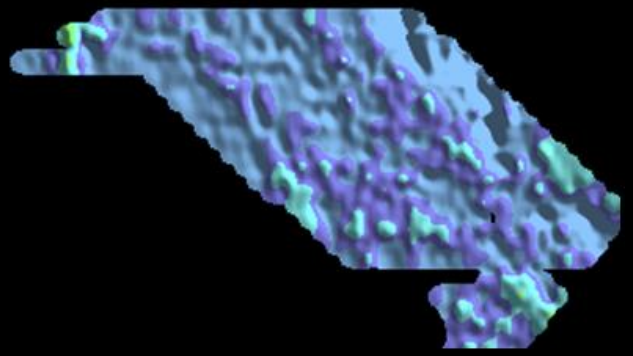
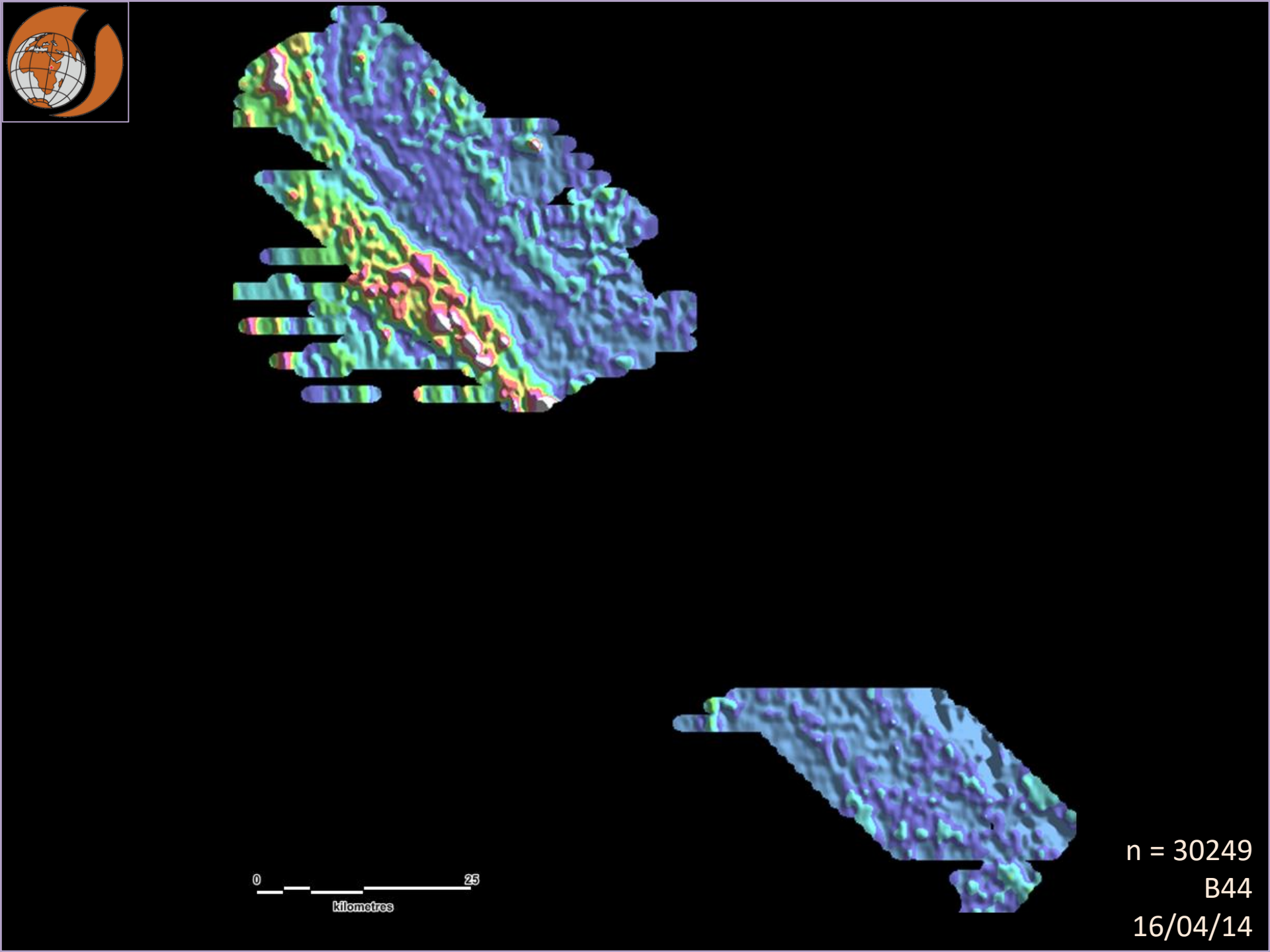
B42
01/12/13



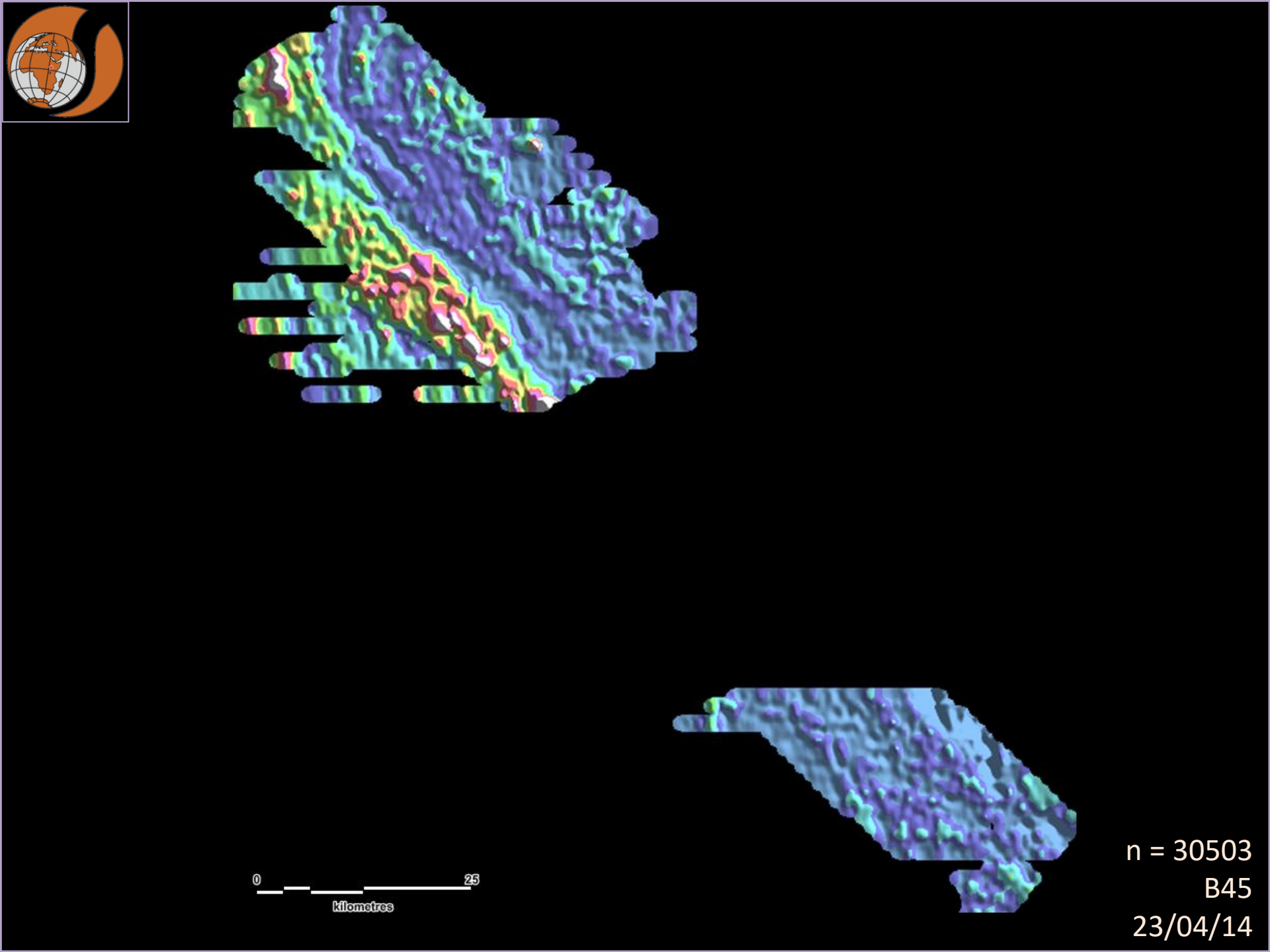
NOTE 4 month field break



n = 29968
B43
08/12/13



n = 30249
B44
16/04/14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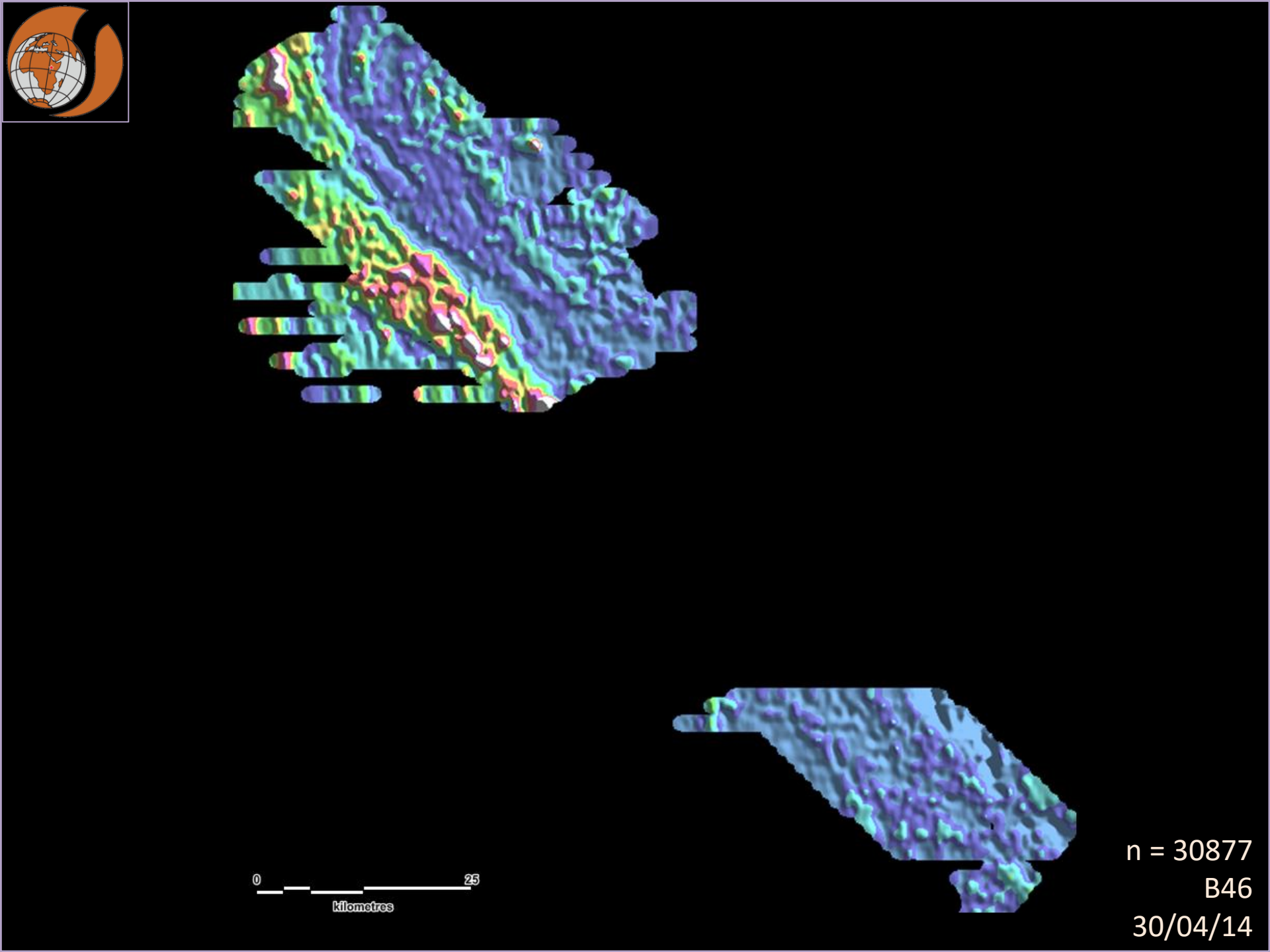
B45
23/04/14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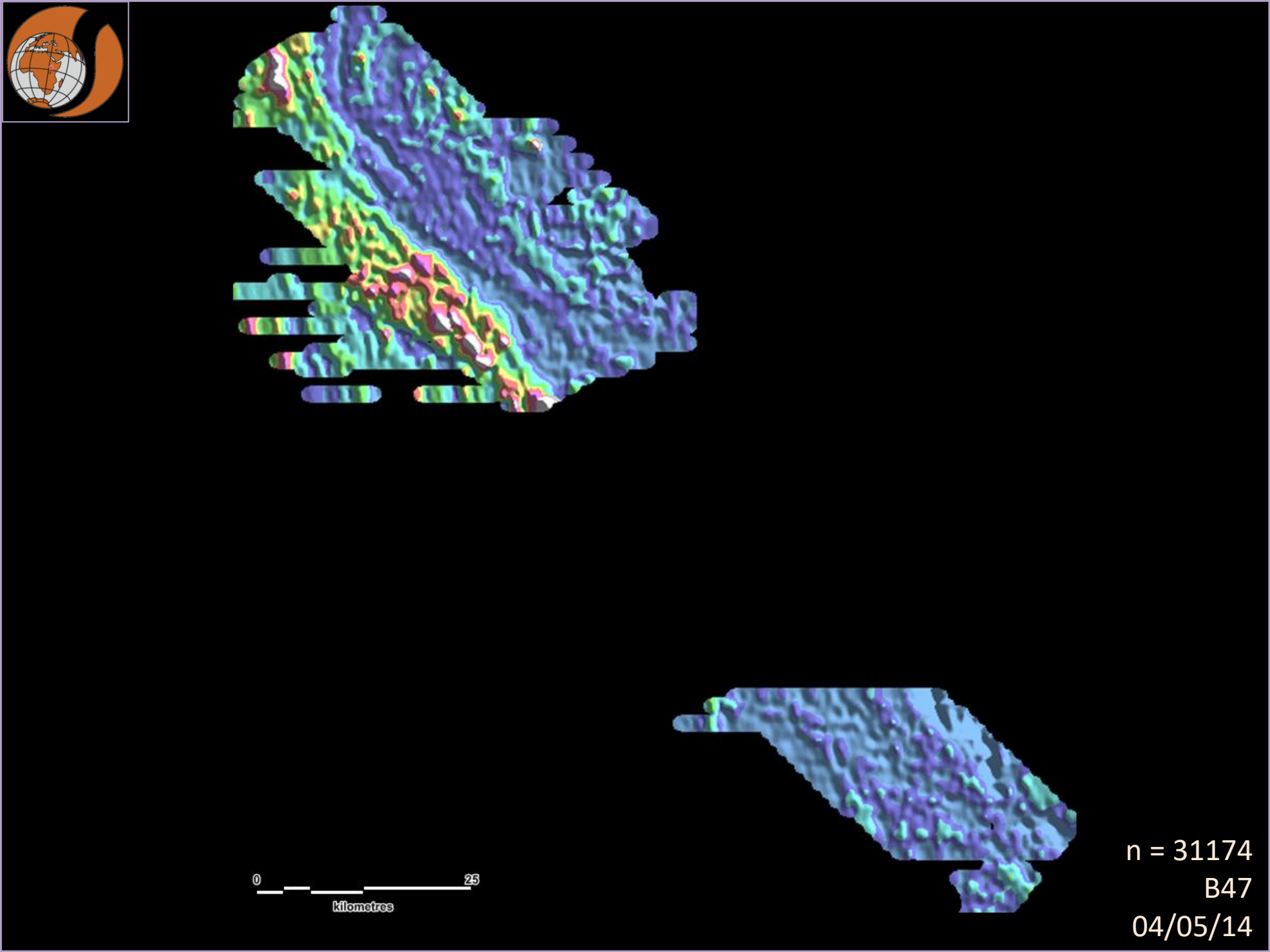
n = 30877
B46
30/04/14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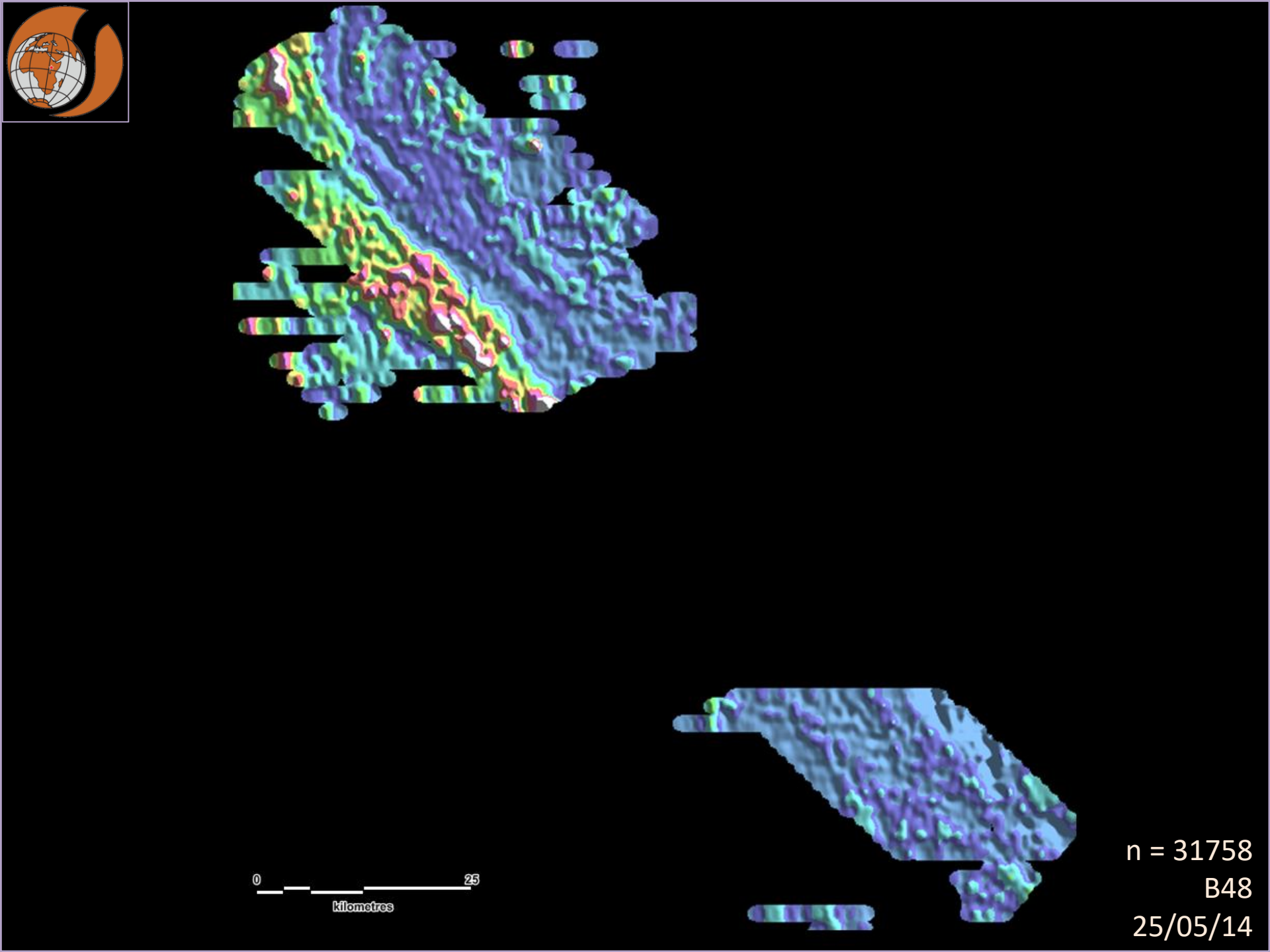
B47
04/05/14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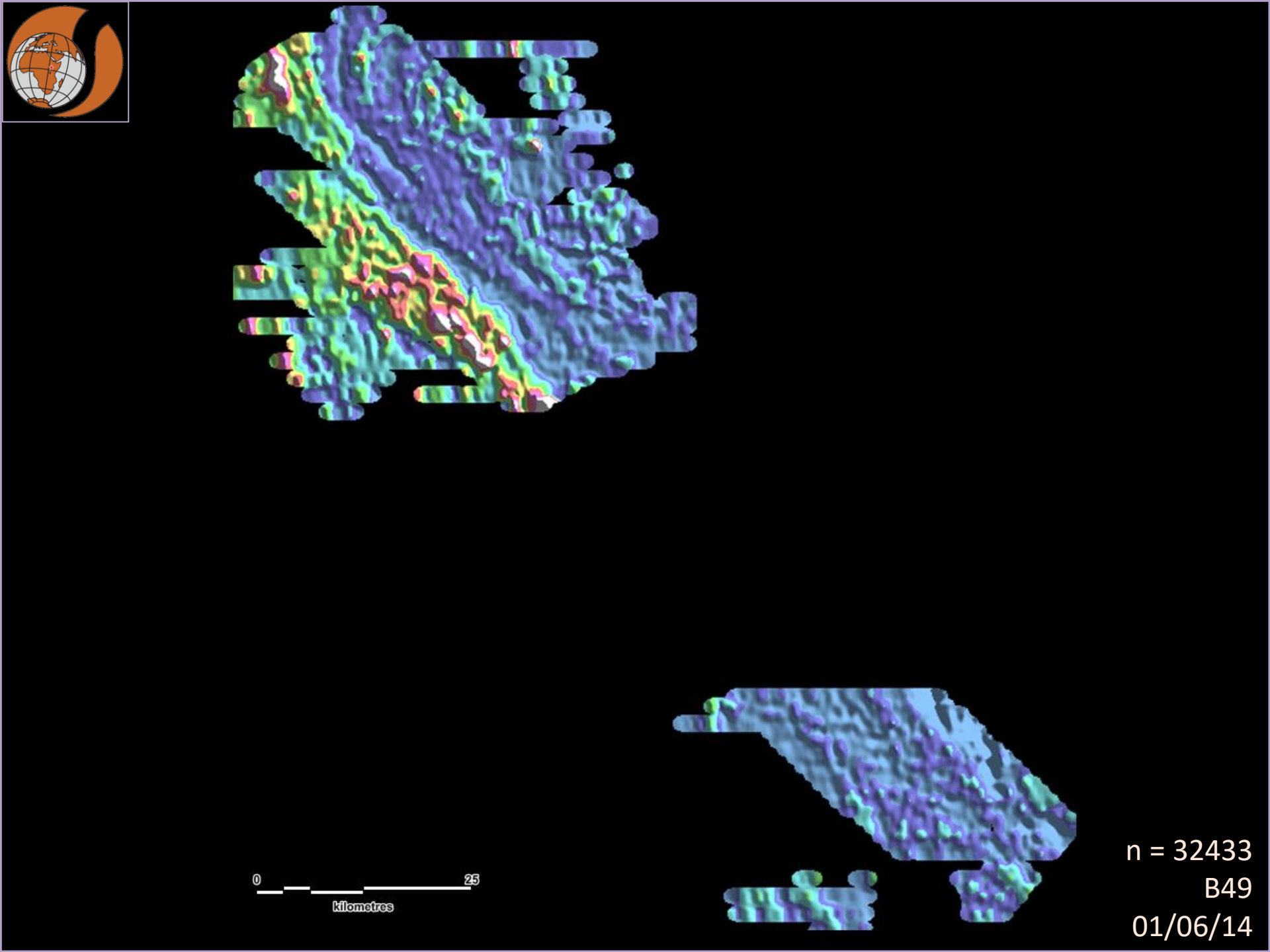
n = 31758
B48
25/05/14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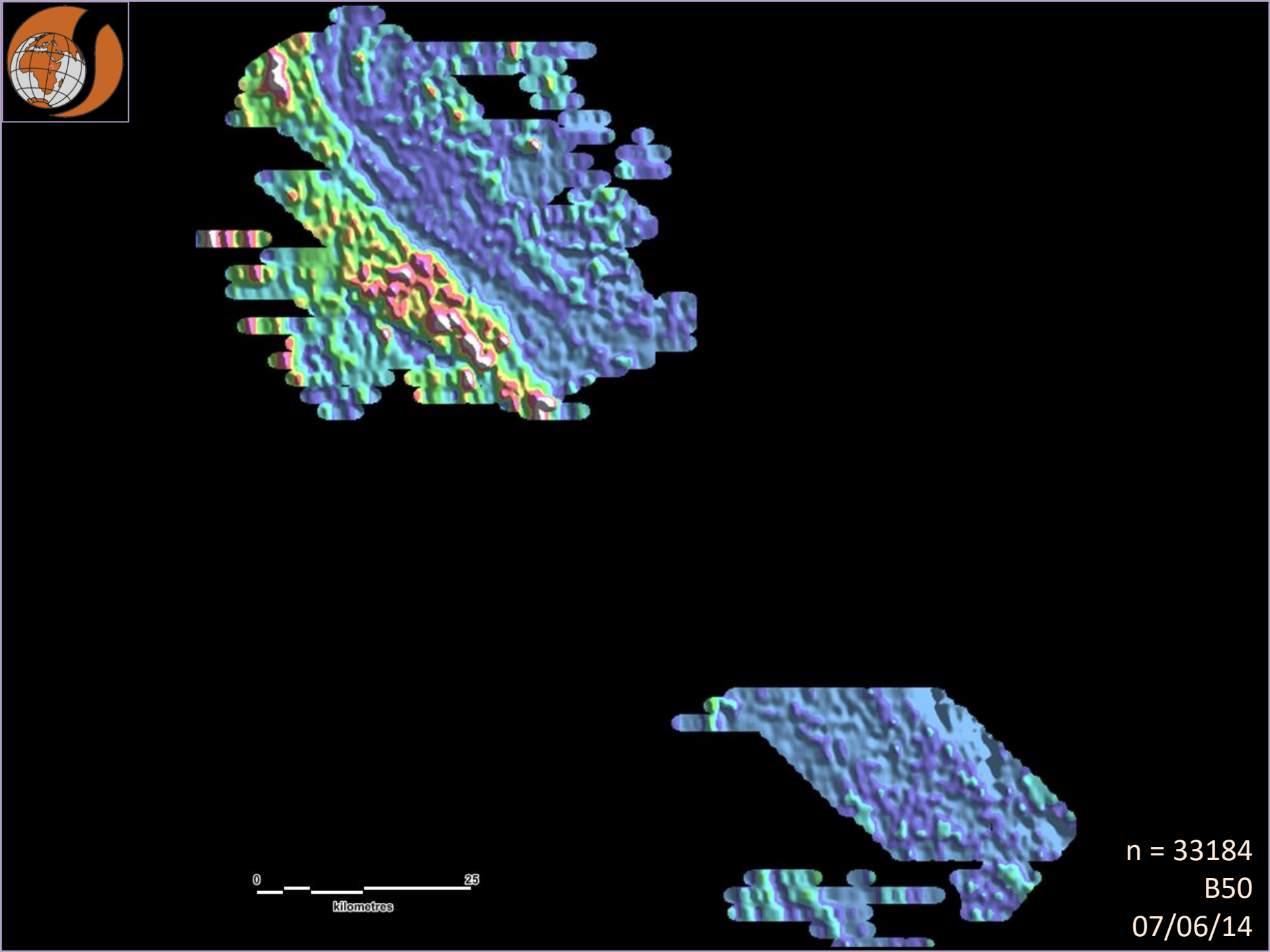
B49
01/06/14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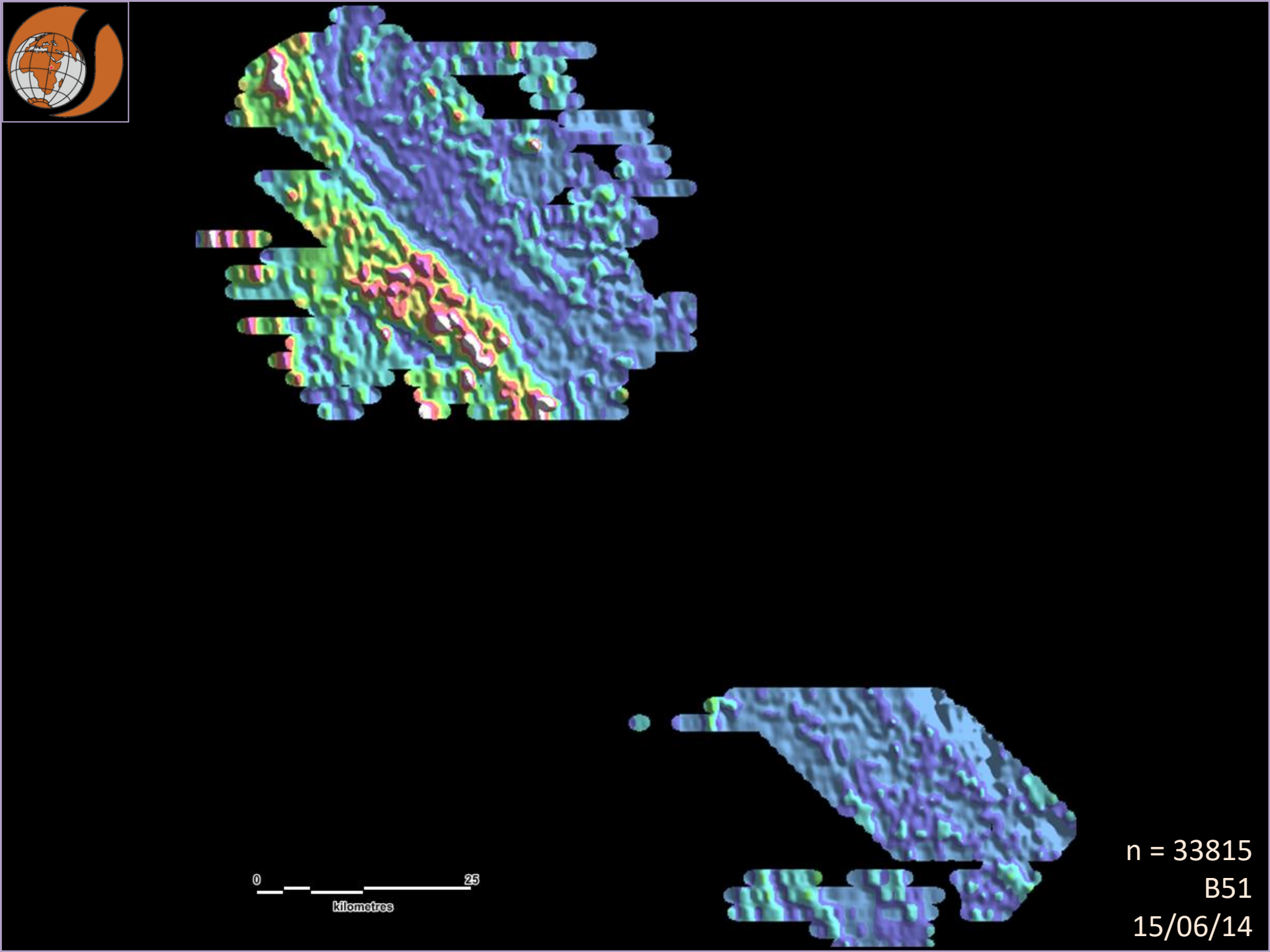
kilometres
n = 33184
B50
07/06/14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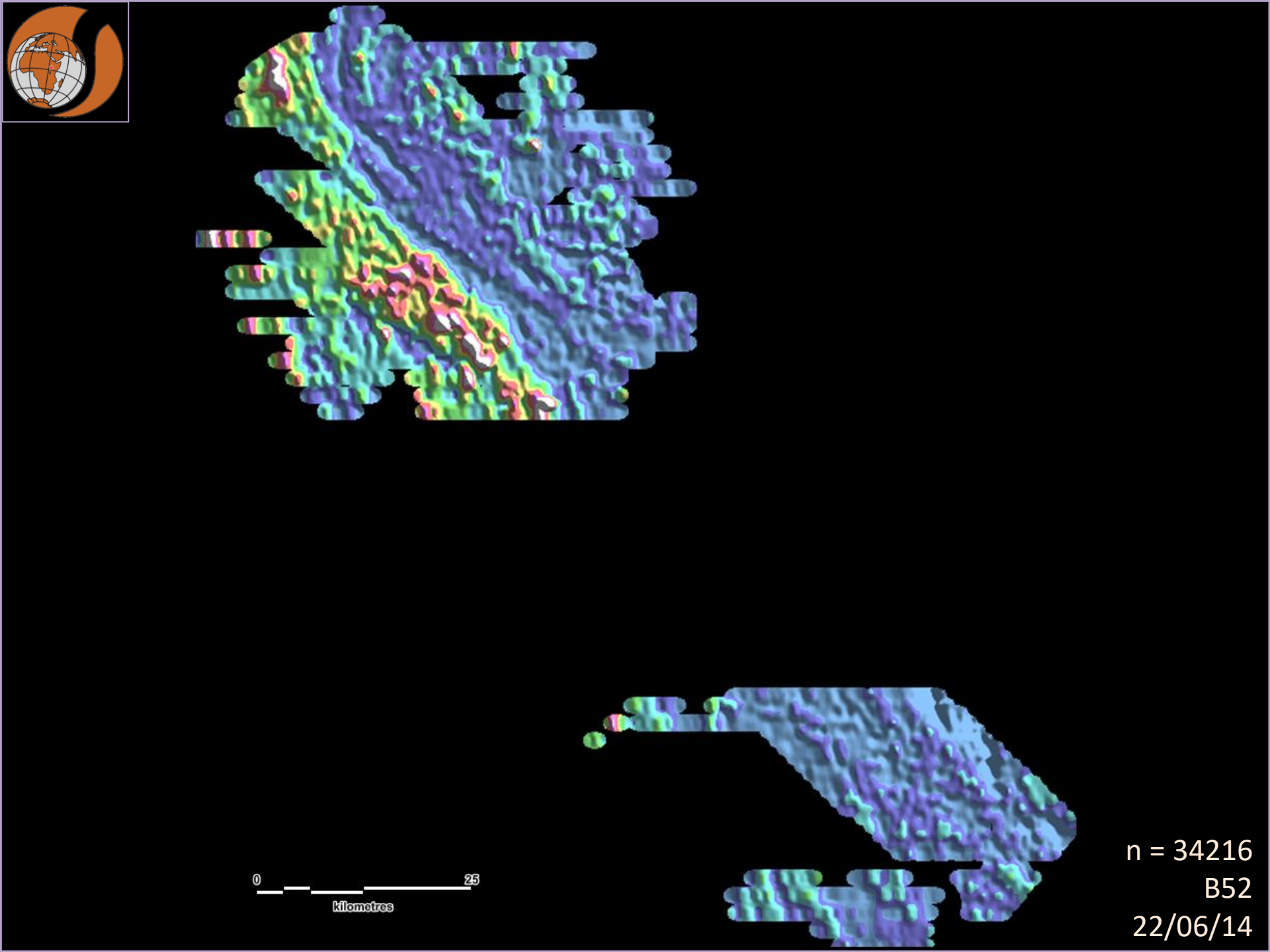
kilometres
n = 33815
B51
15/06/14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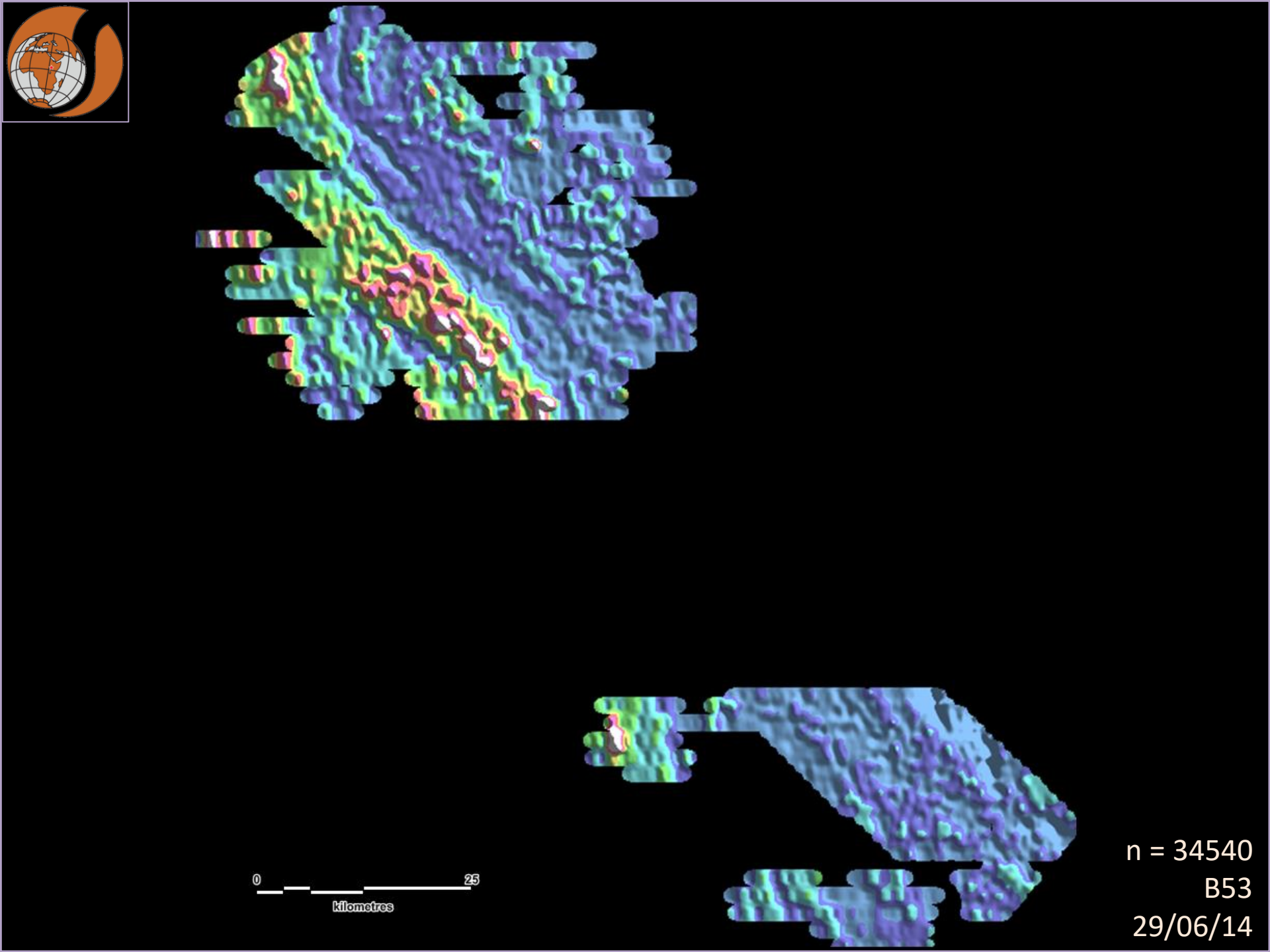
B52
22/06/14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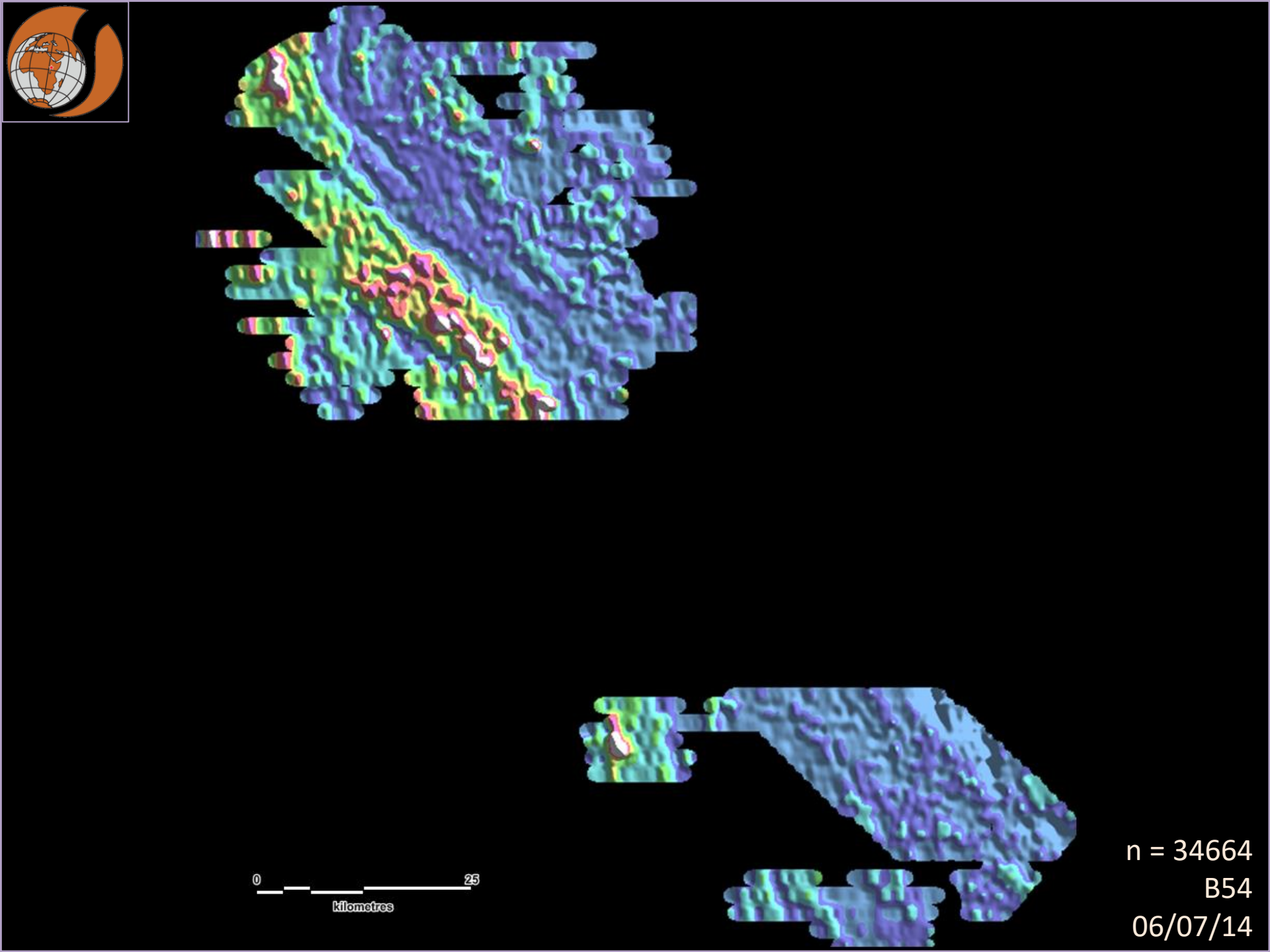
B53
29/06/14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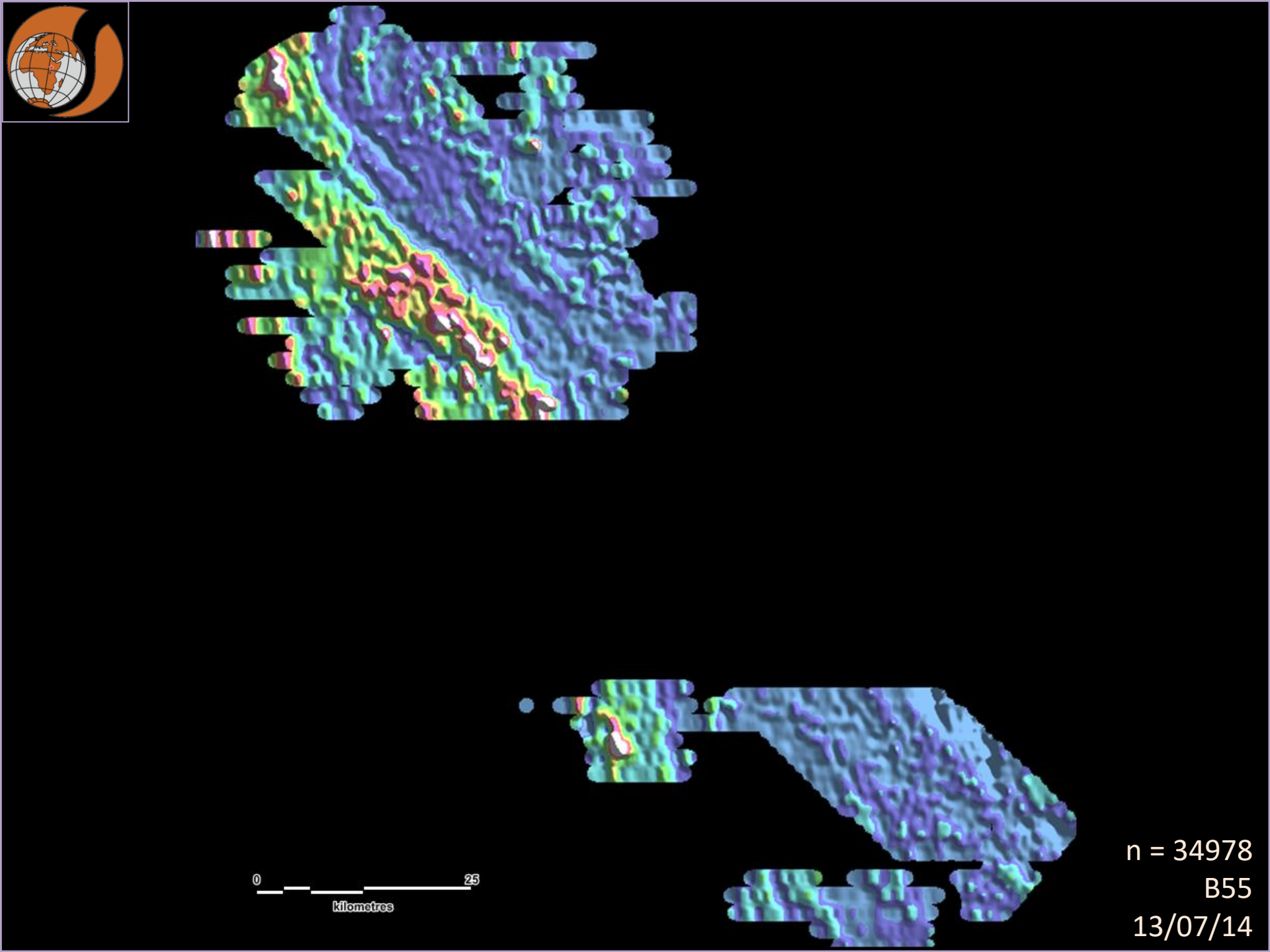
B54
06/07/14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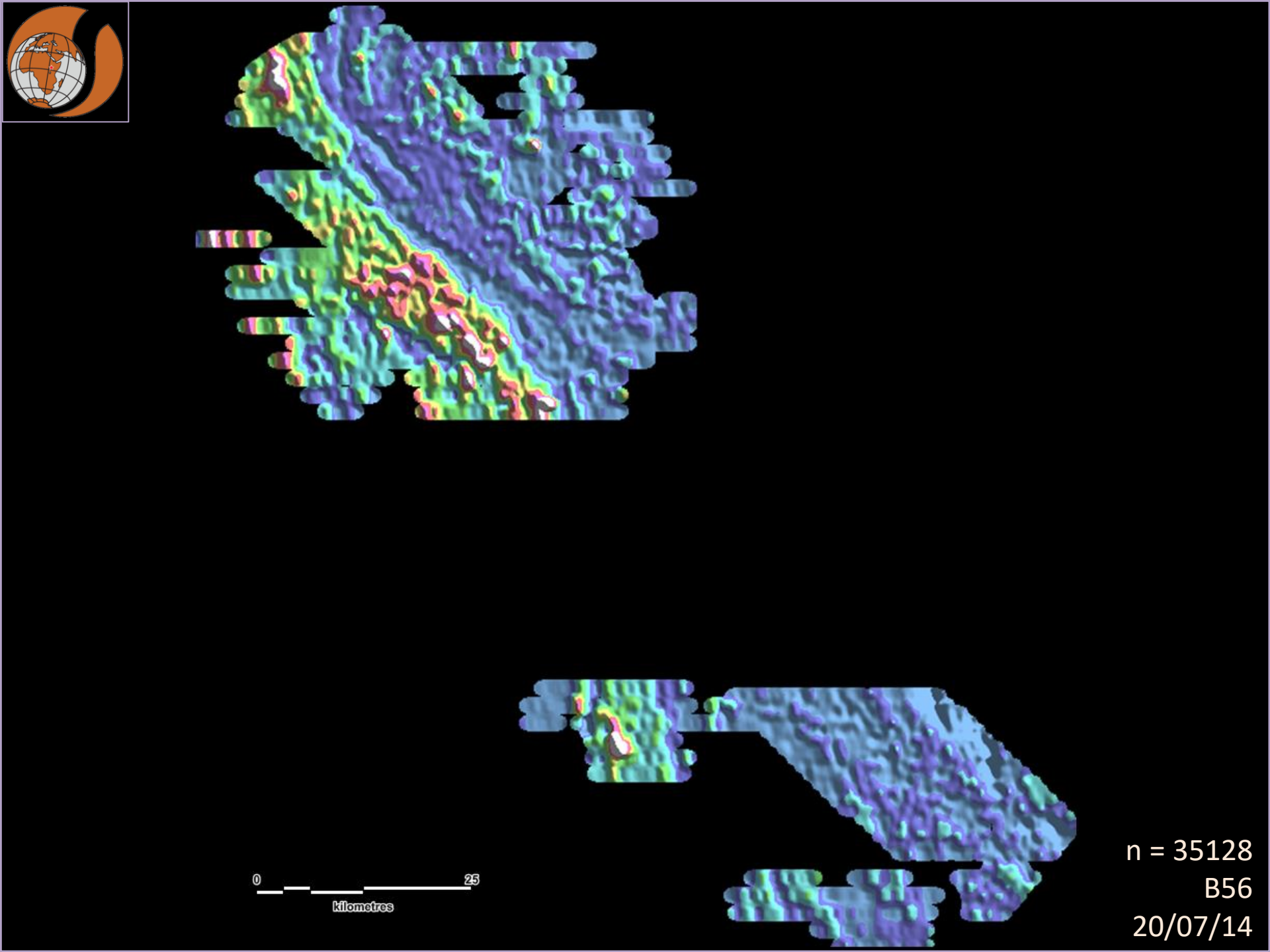
B55
13/07/14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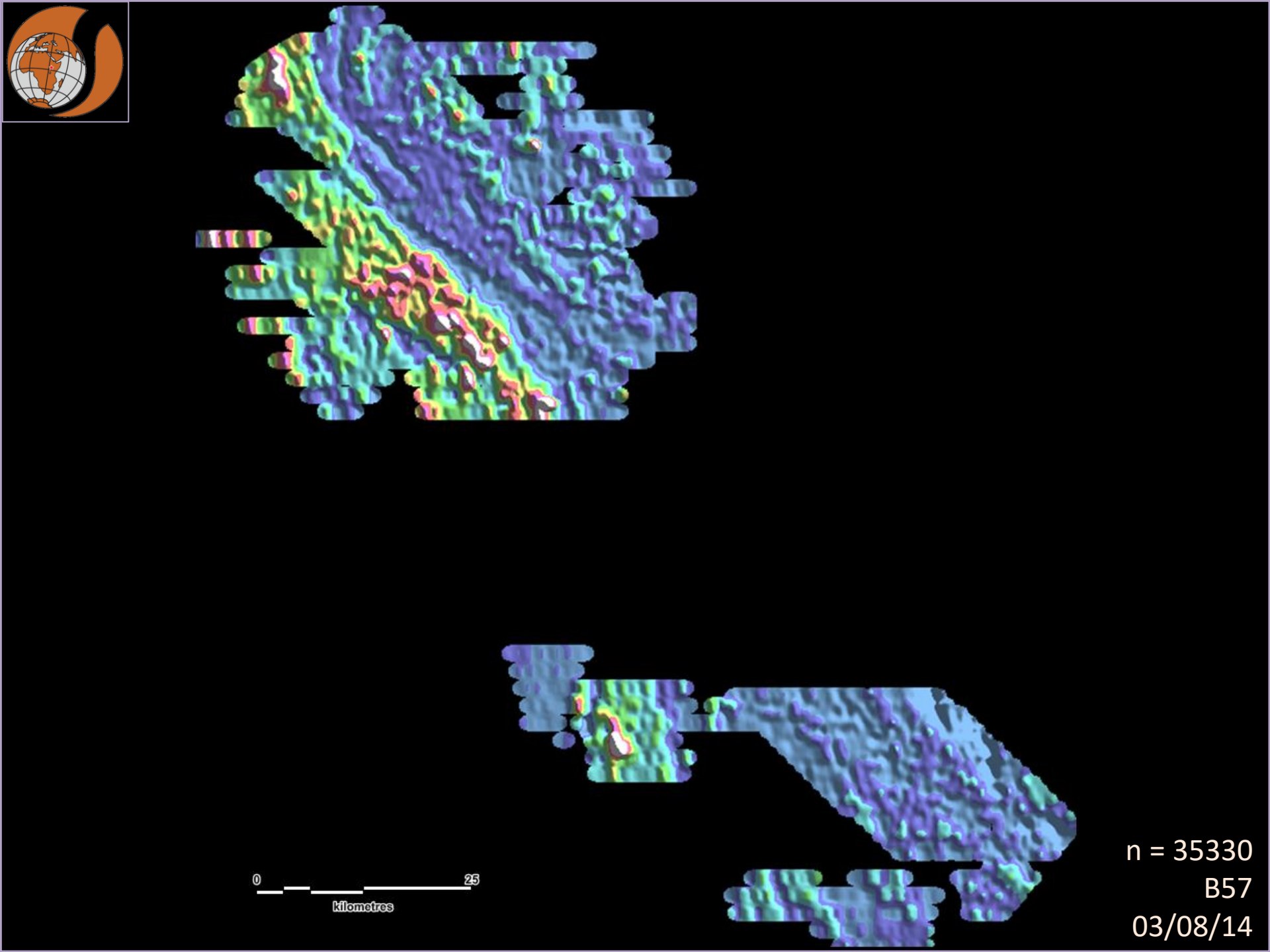
B56
20/07/14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kilometres
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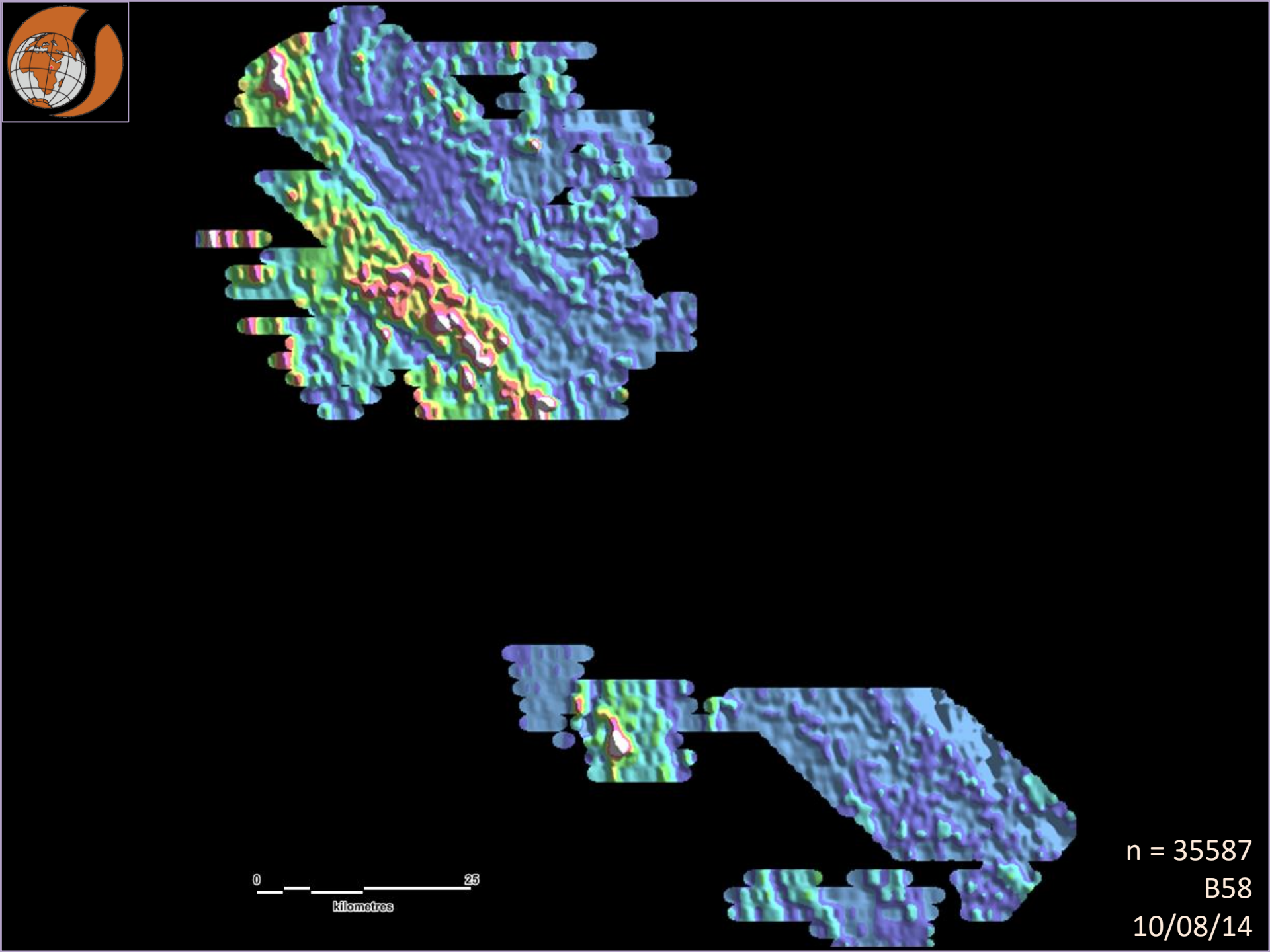
B57
03/08/14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kilometres
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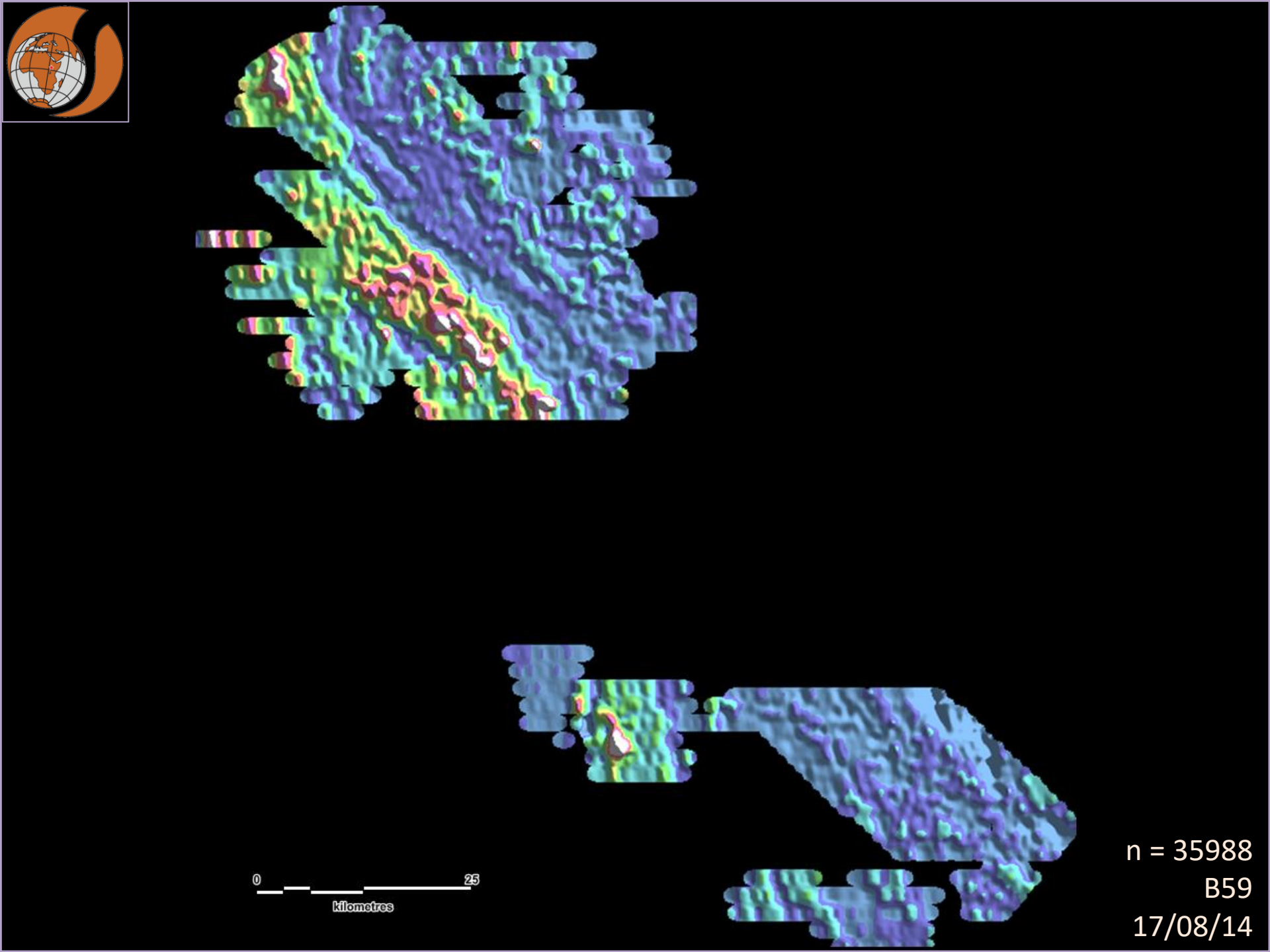
B58
10/08/14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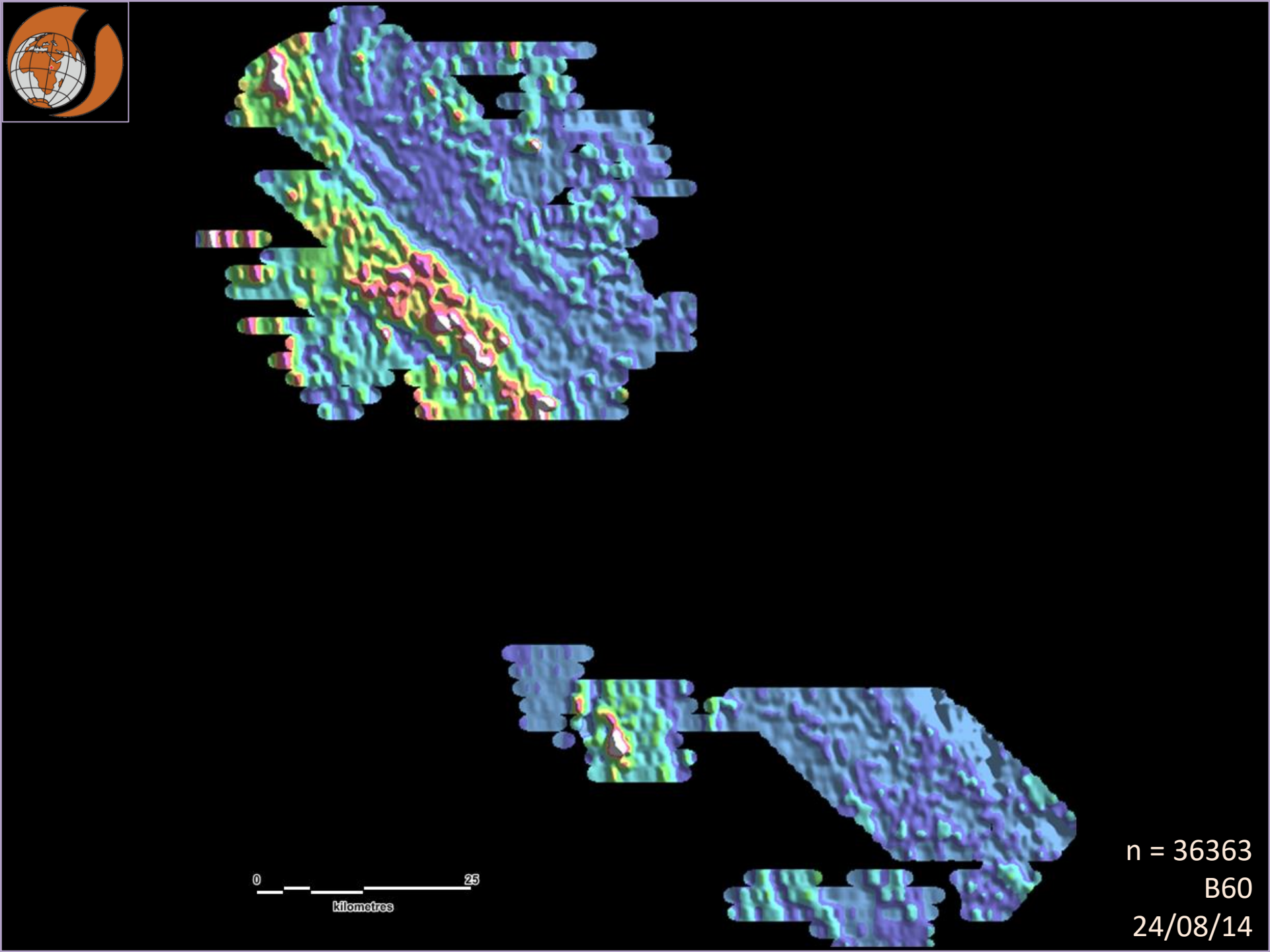
kilometres
n = 35988
B59
17/08/14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kilometres
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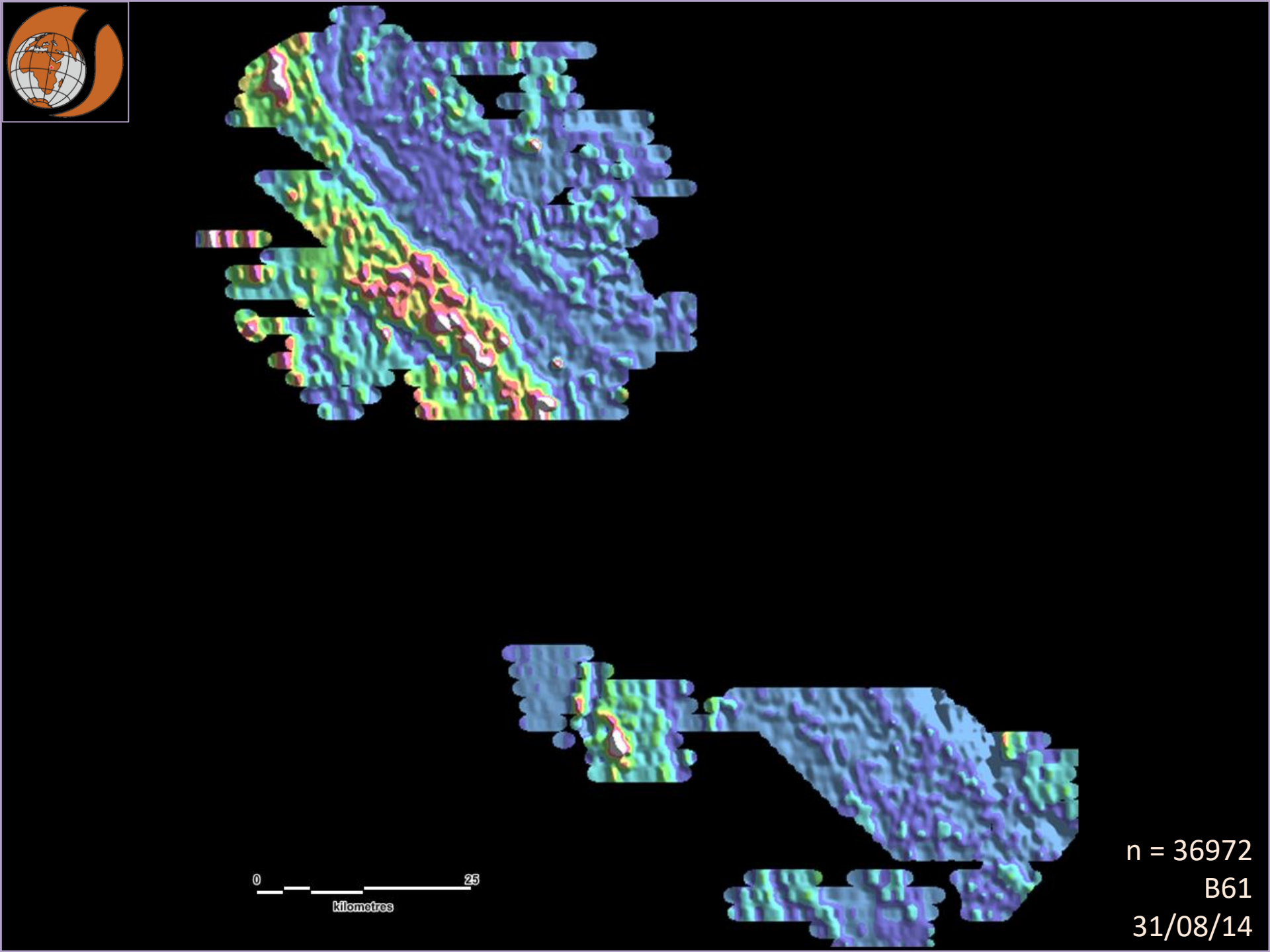
B60
24/08/14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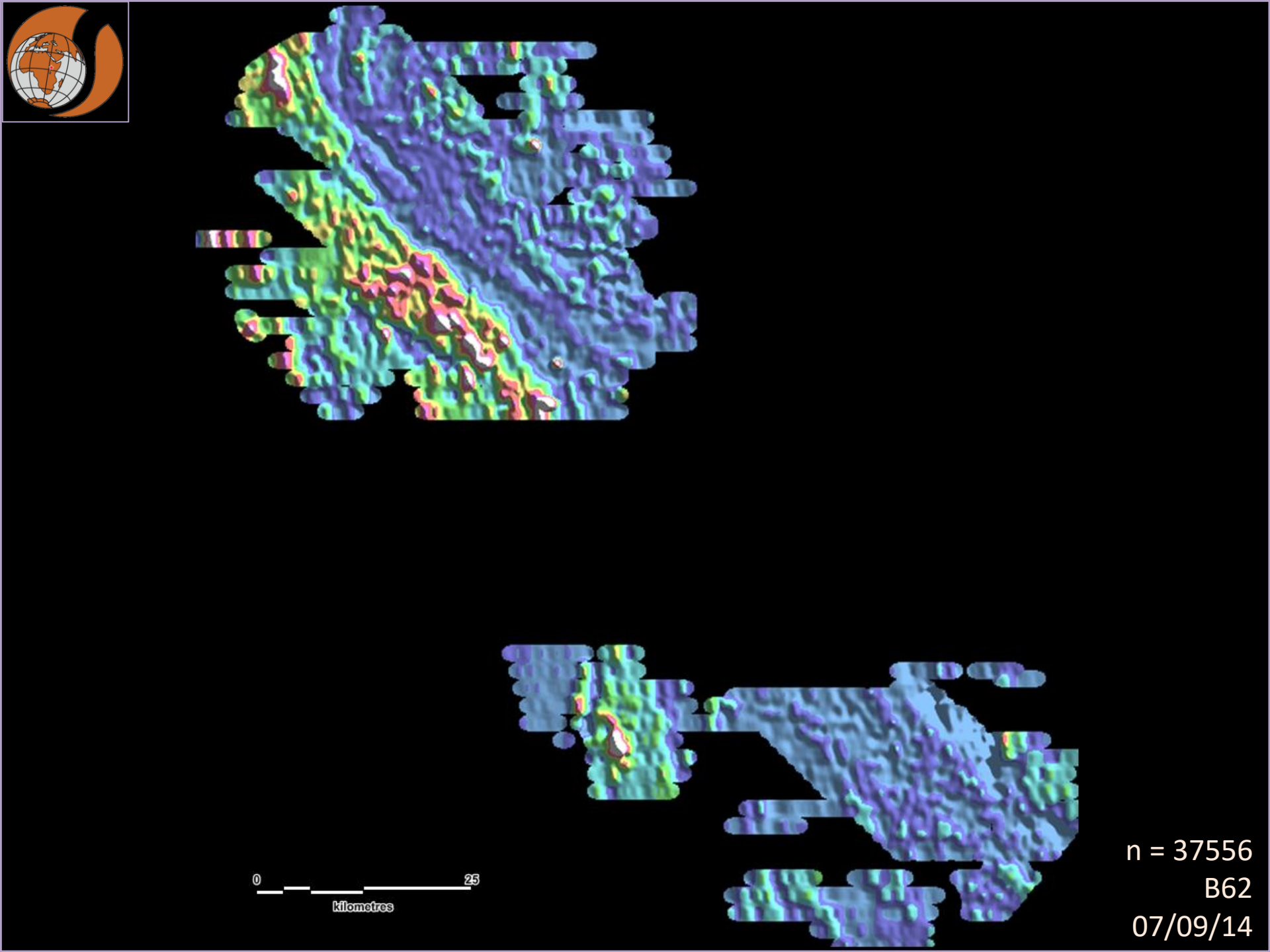
B61
31/08/14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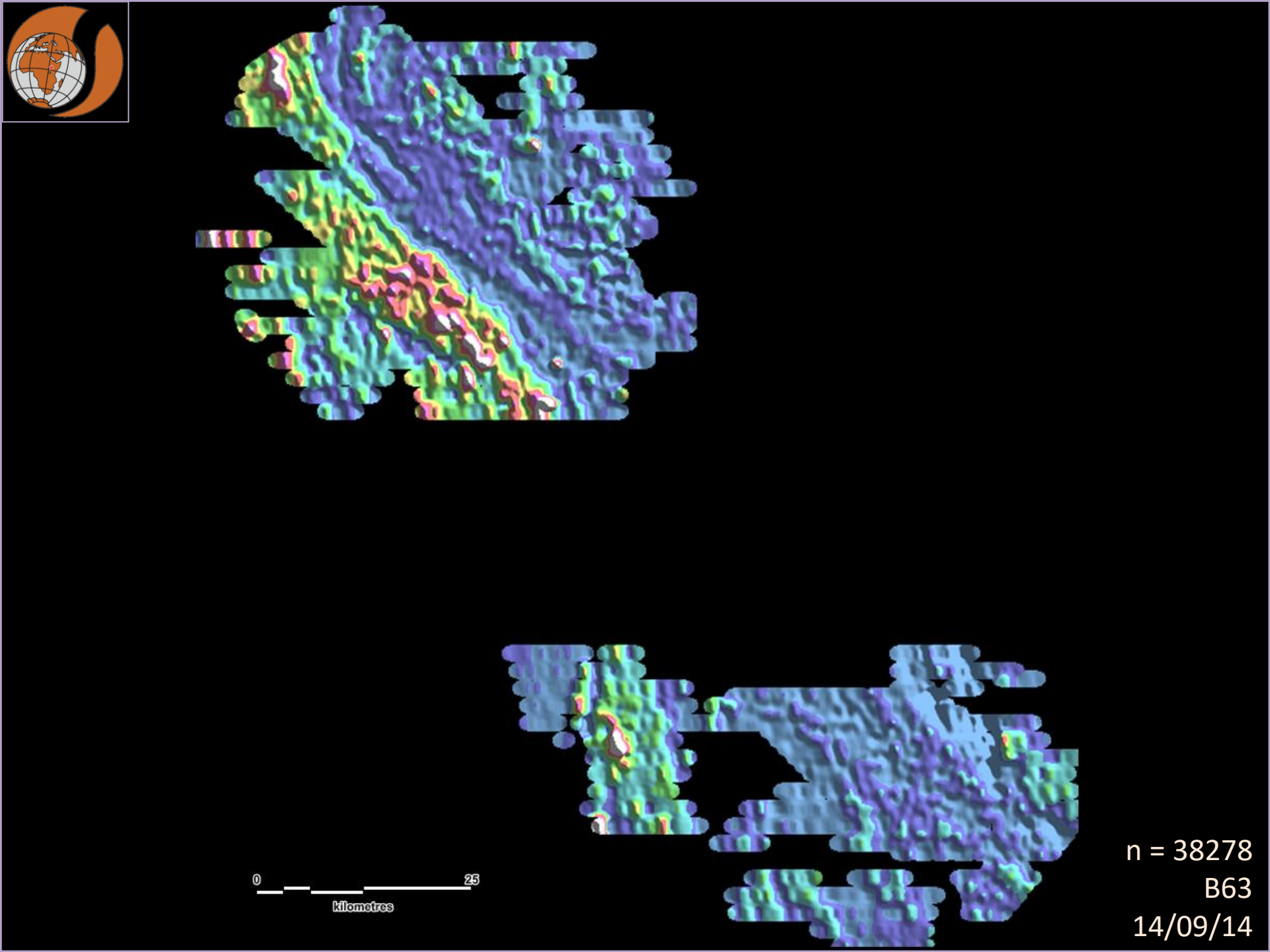
B62
07/09/14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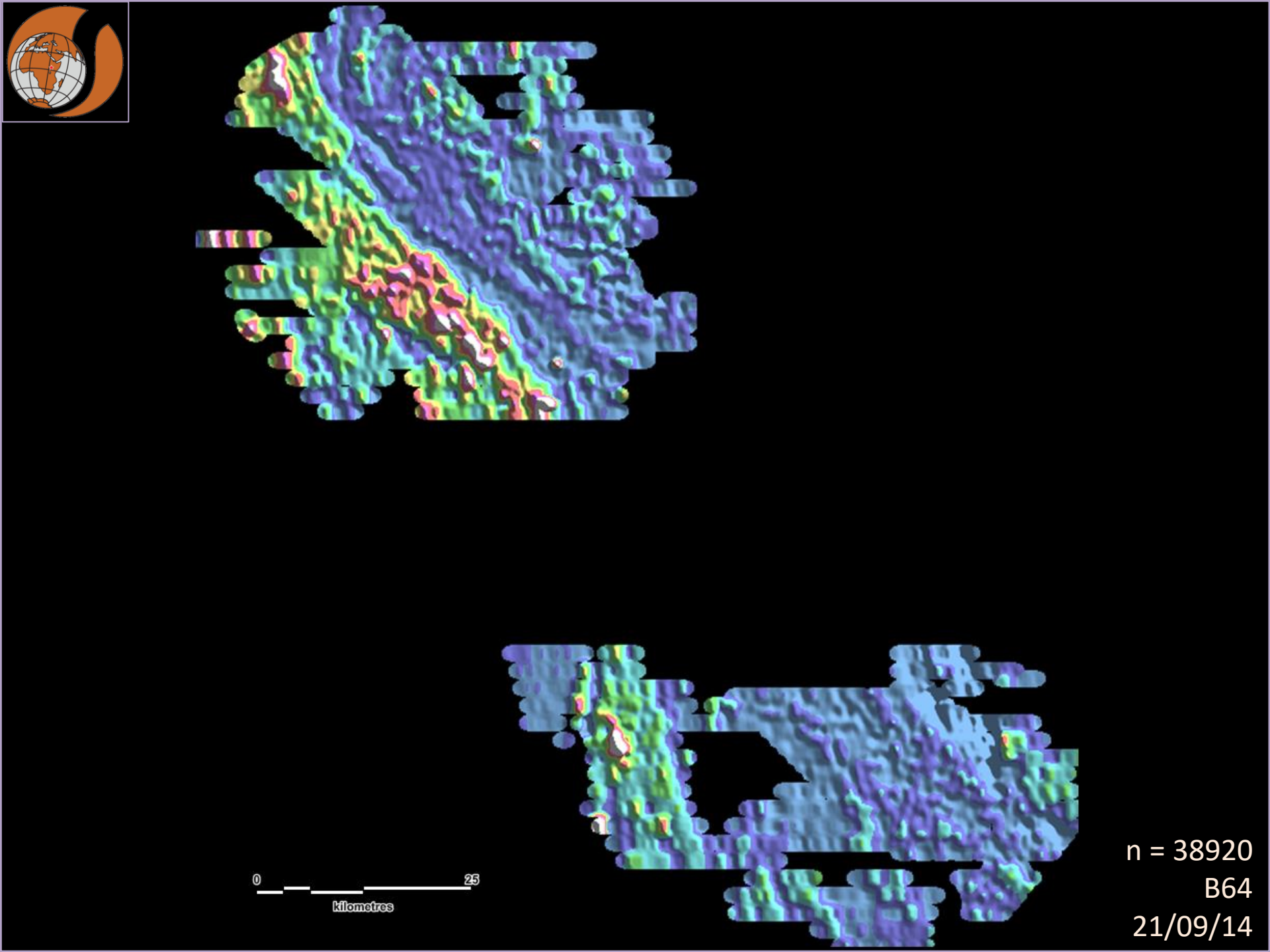
B63
14/09/14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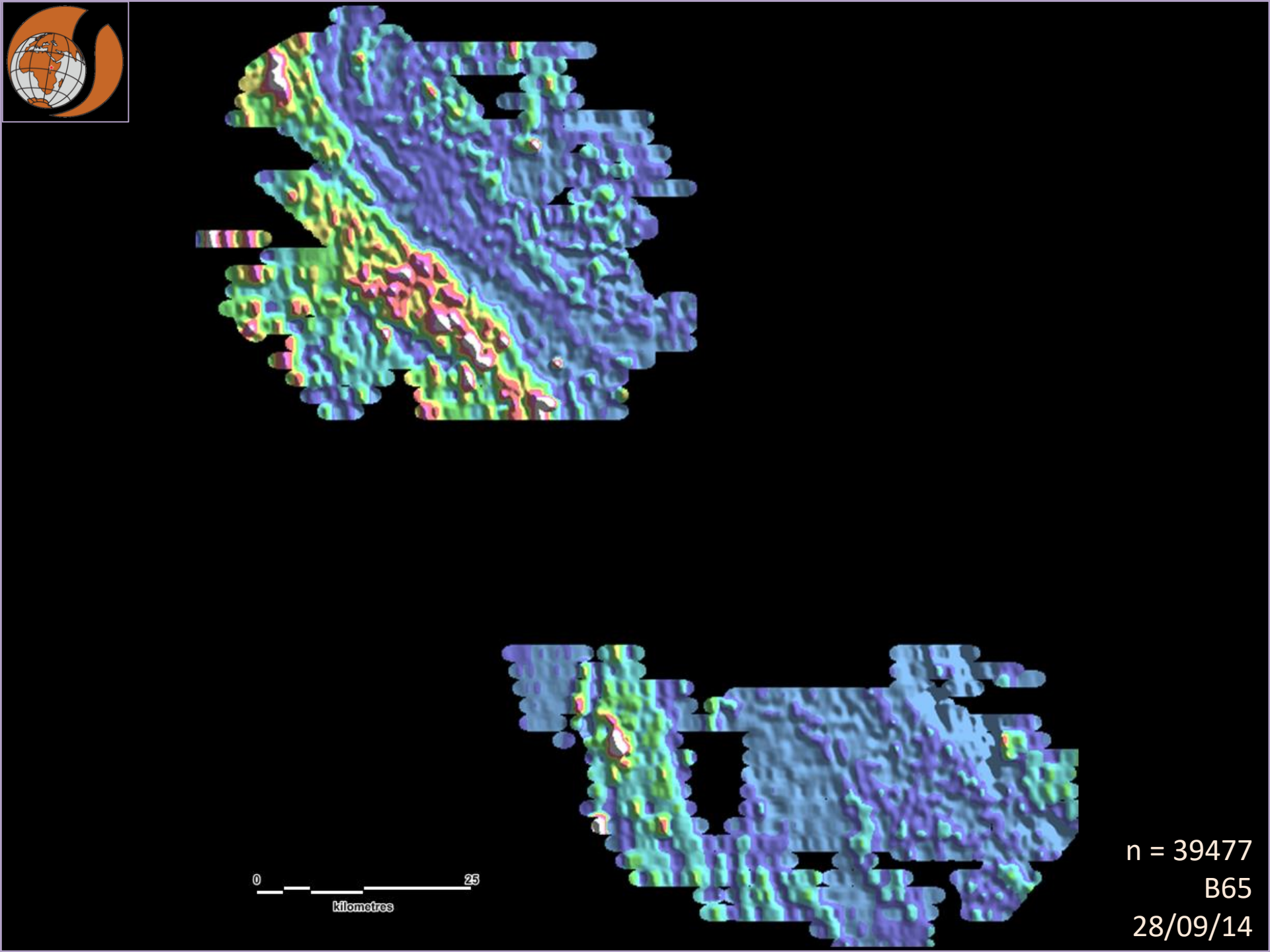
21/09/14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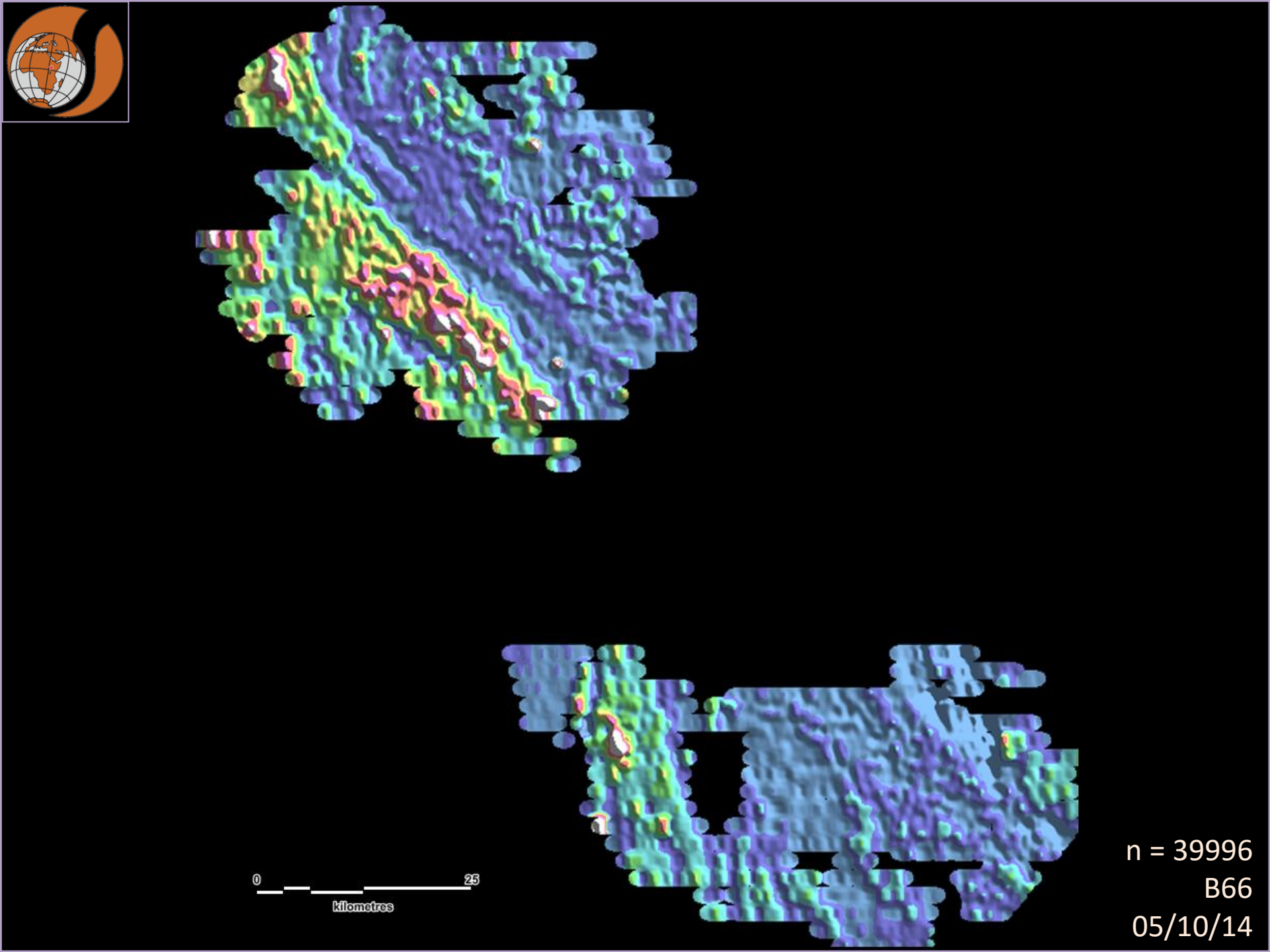
B65
28/09/14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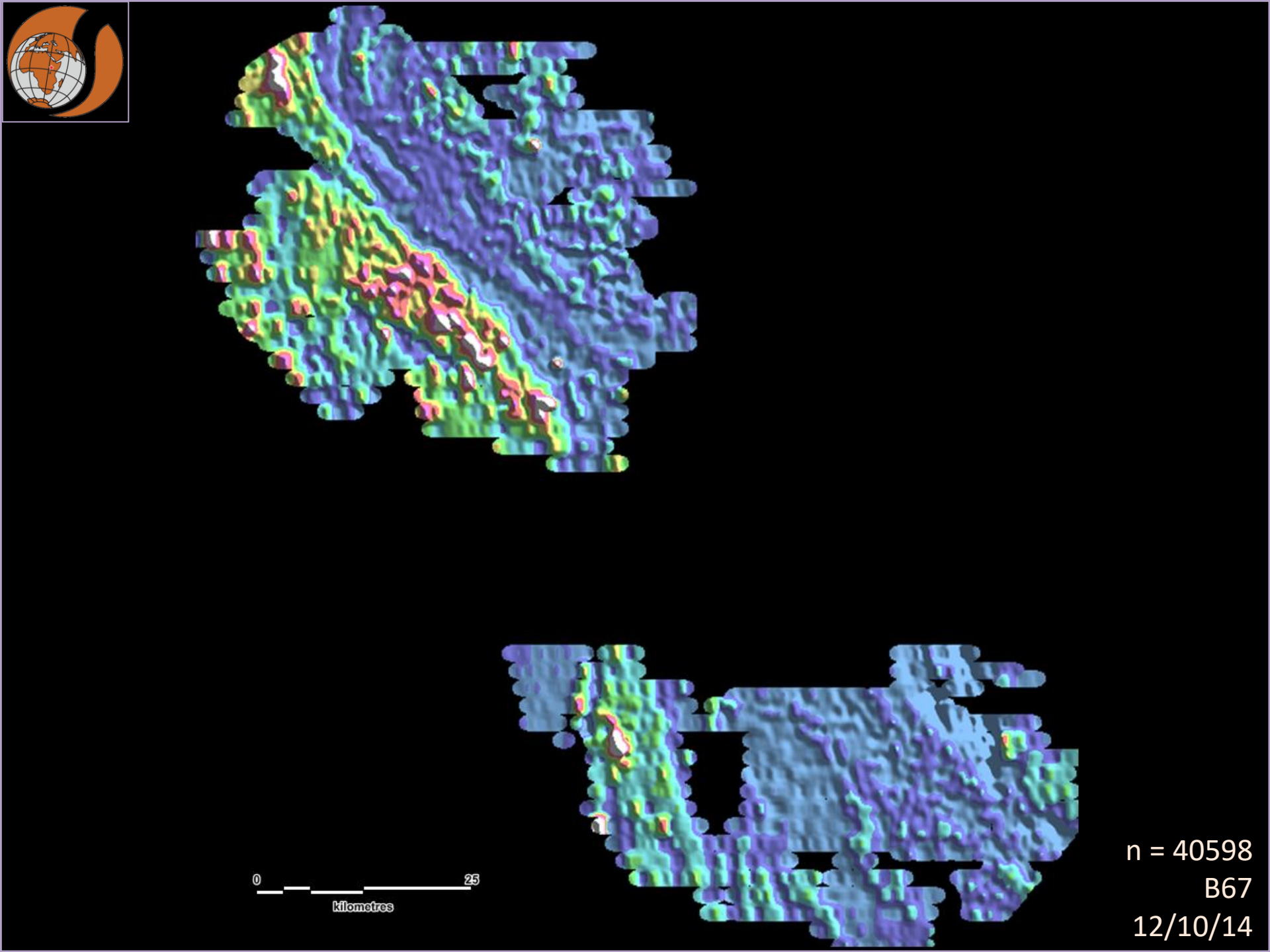
kilometres
n = 39996
B66
05/10/14


0
25
kilometres
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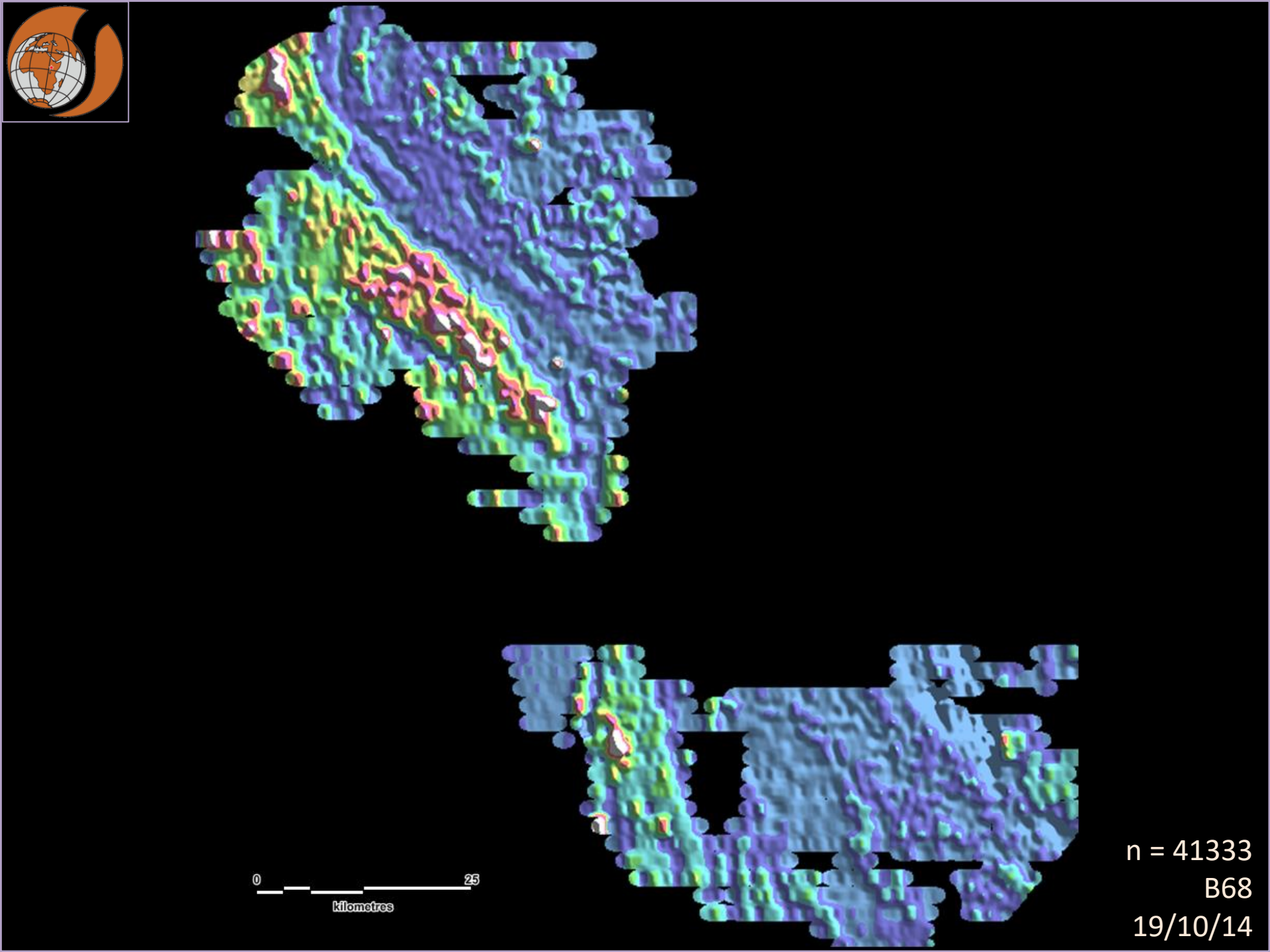
B67
12/10/14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kilometres
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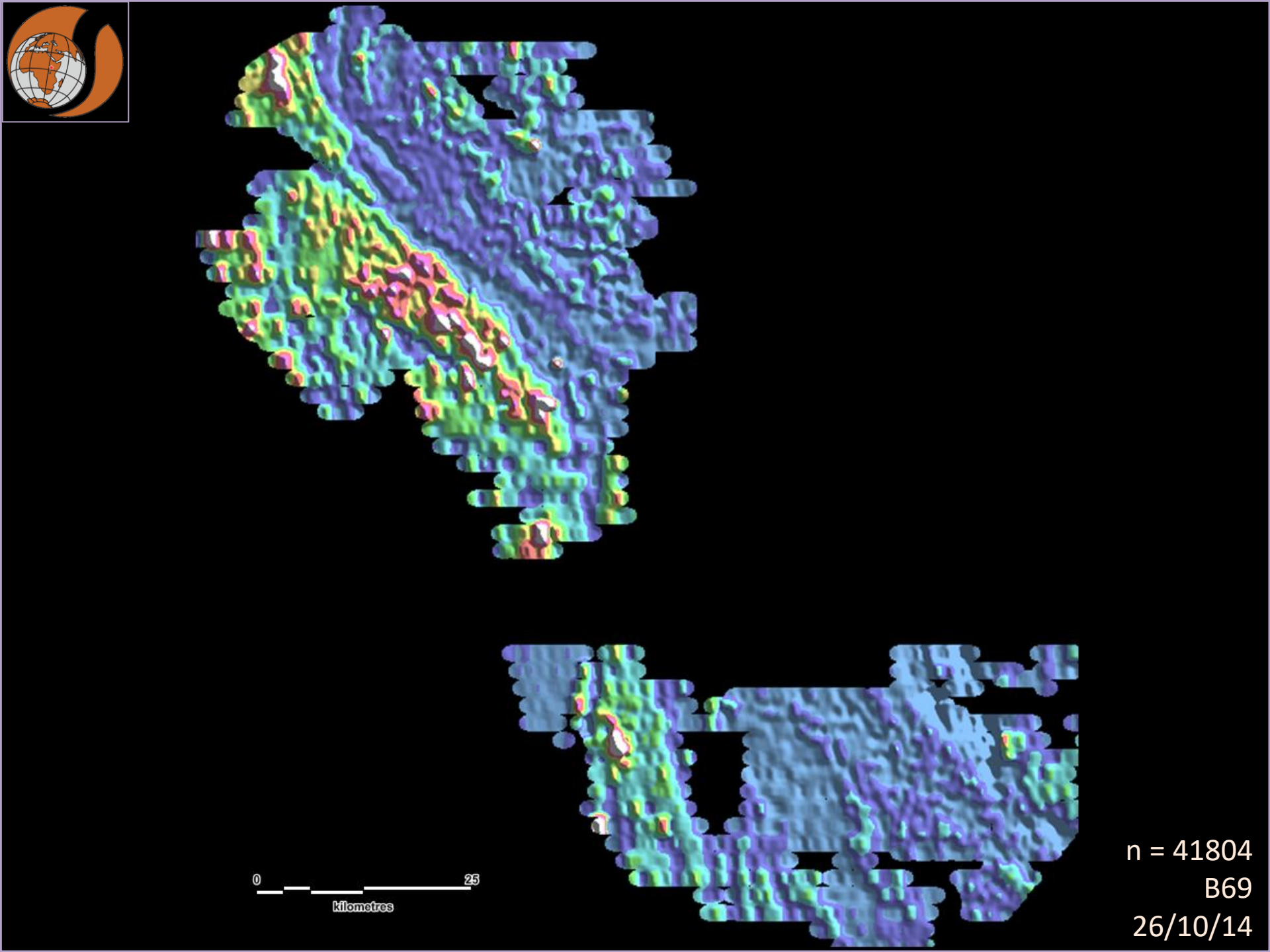
B68
19/10/14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kilometres
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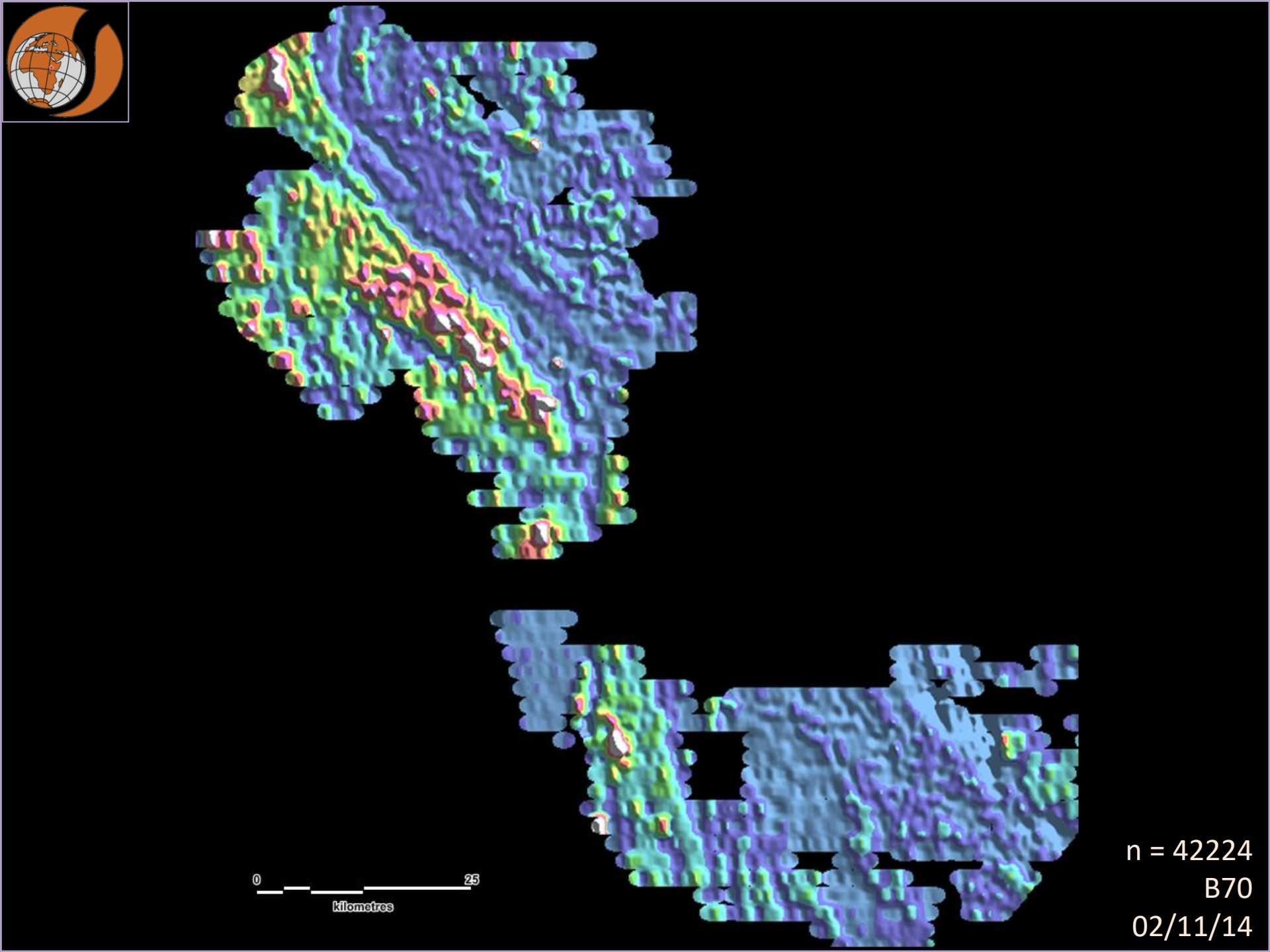
B69
26/10/14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kilometres
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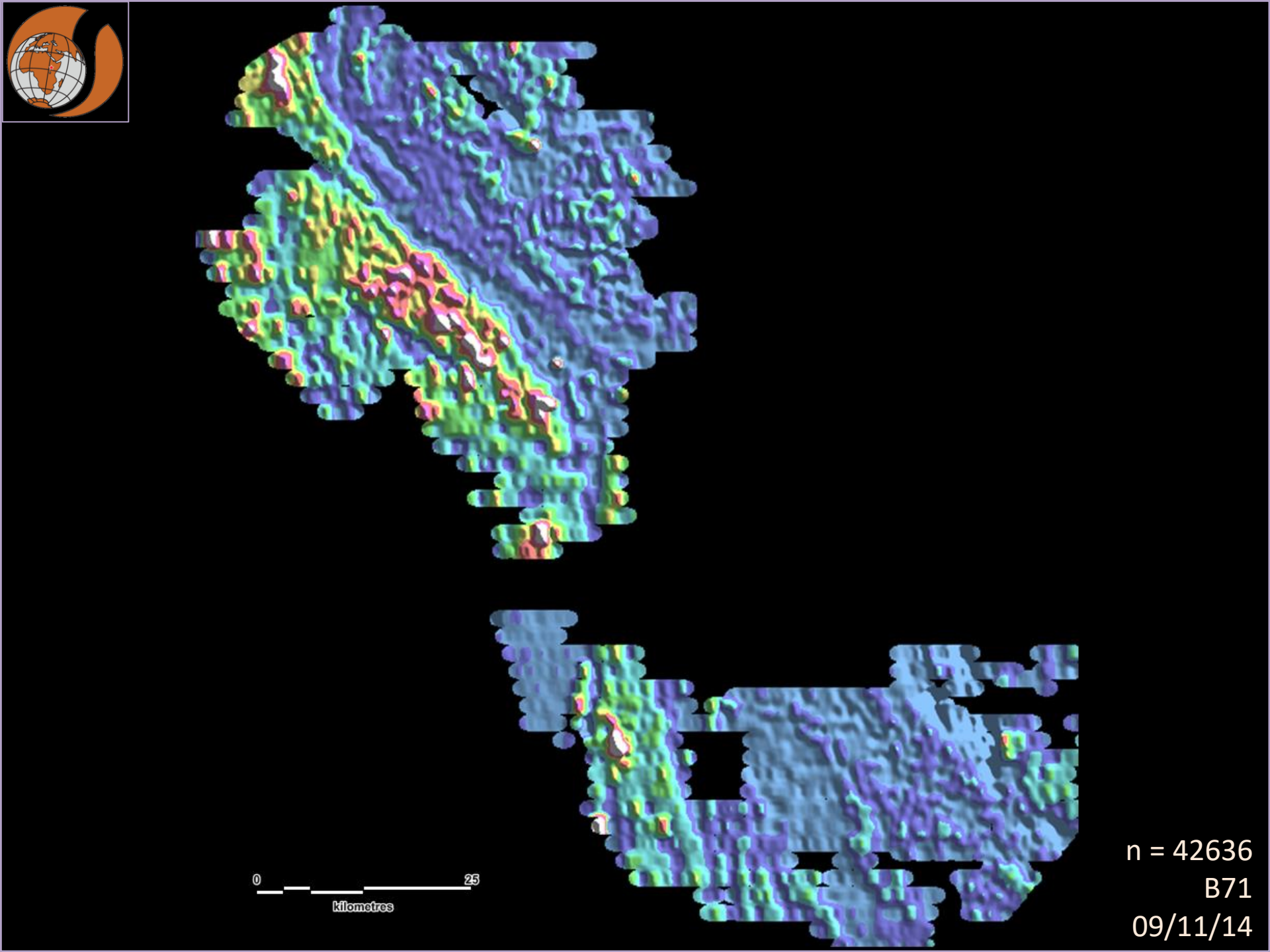
B70
02/11/14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25
kilometres
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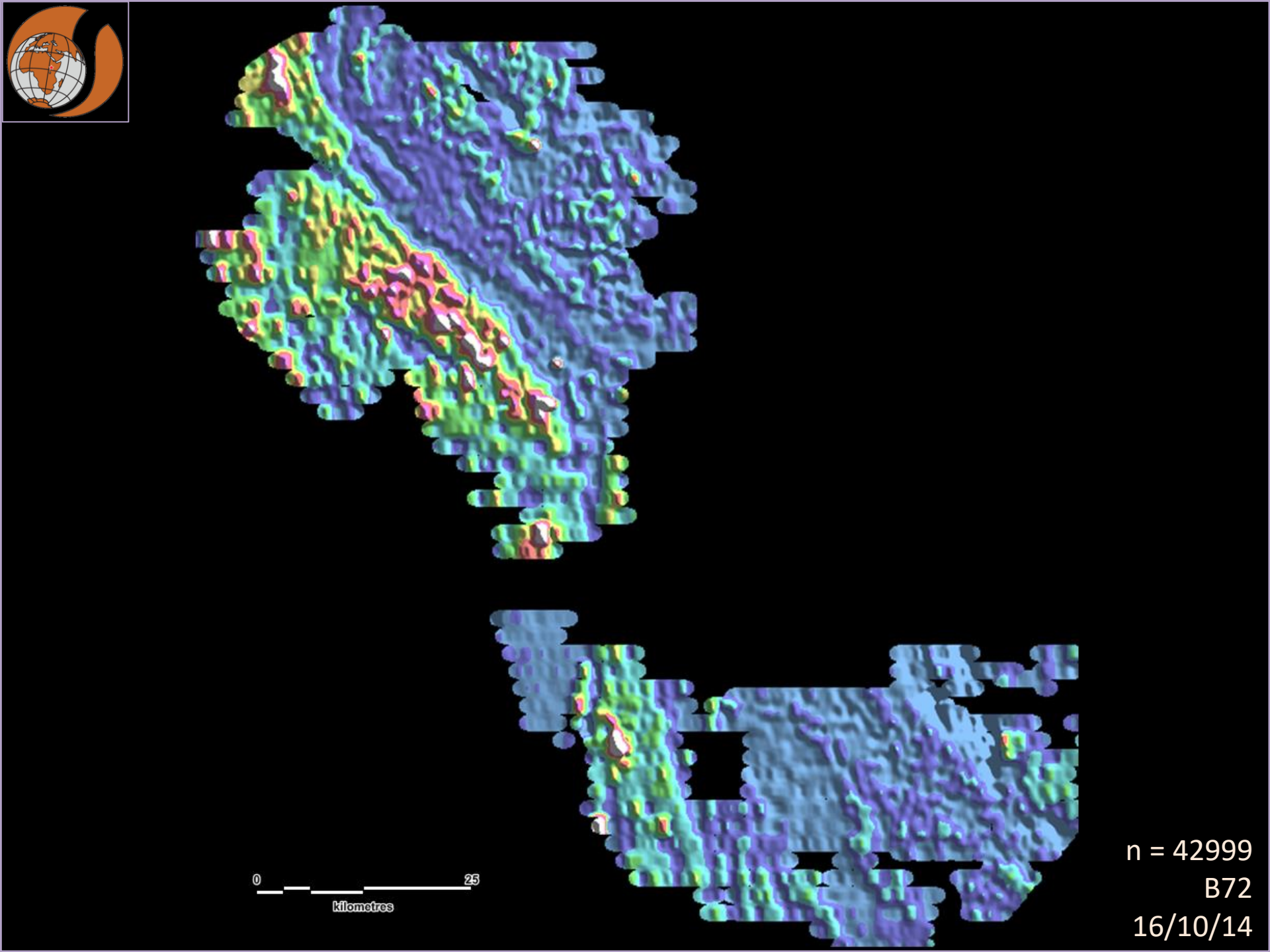
B71
09/11/14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25
kilometres
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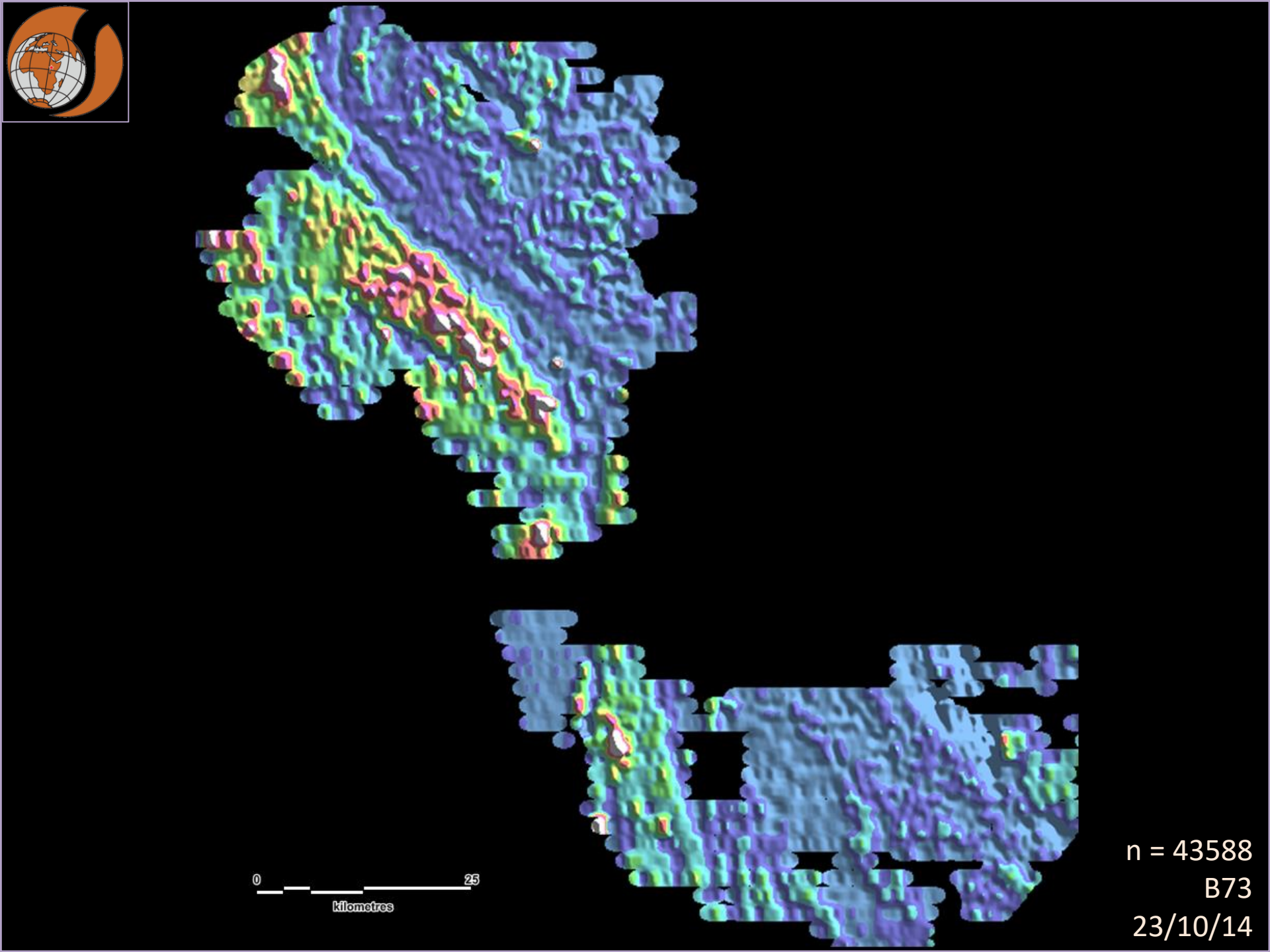
B72
16/10/14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25
kilometres
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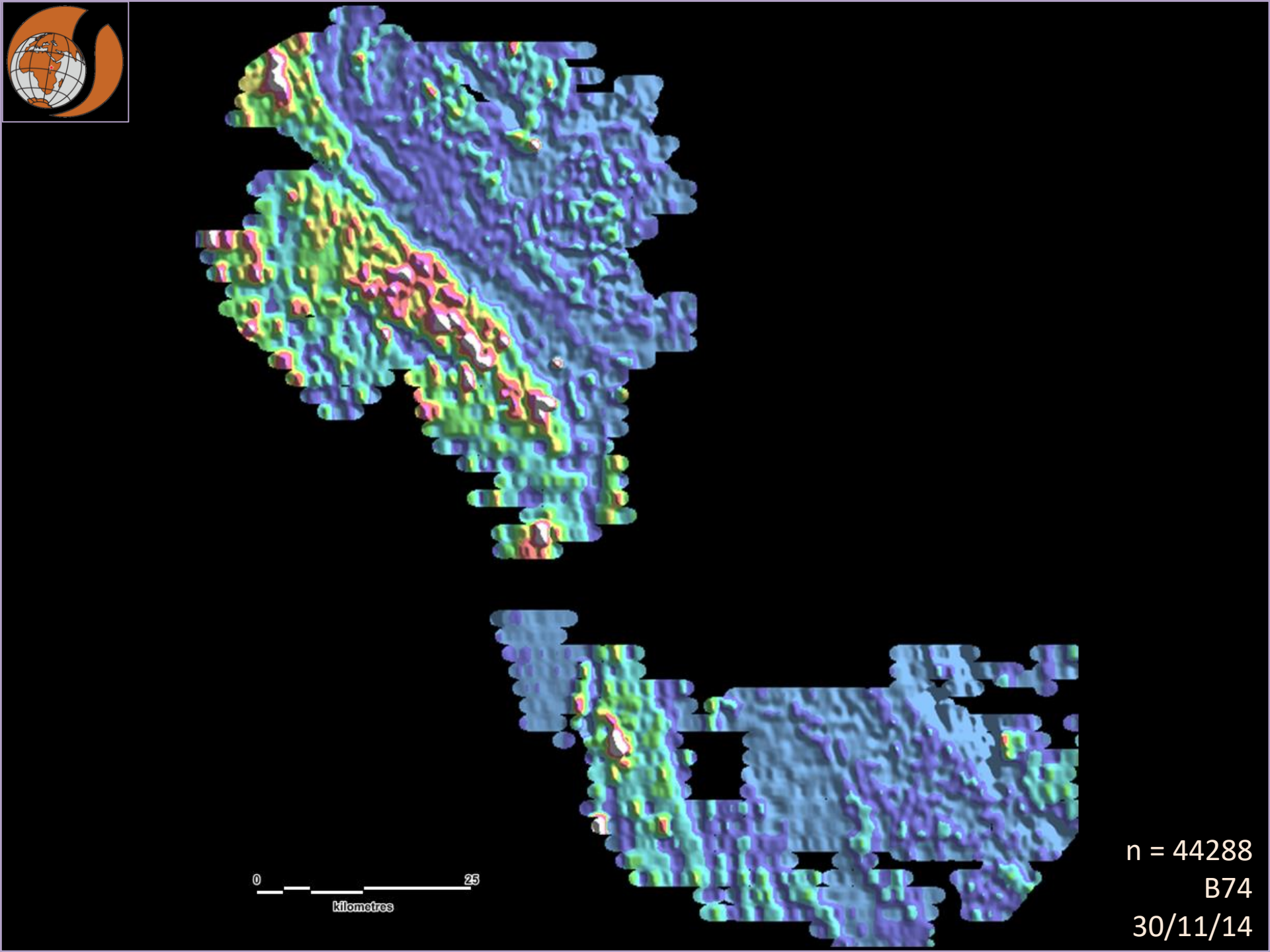
B73
23/10/14


0
25
kilometres
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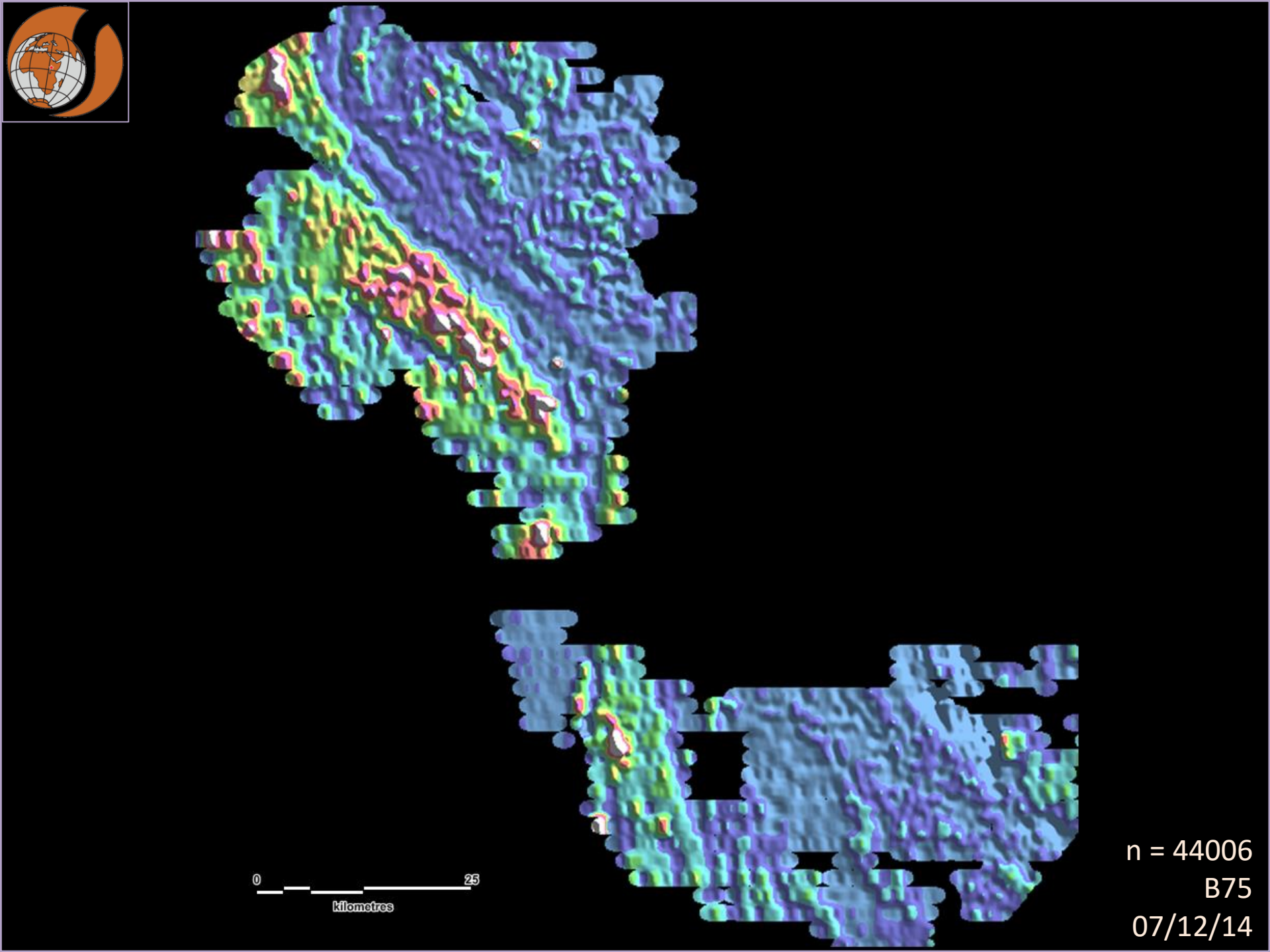
B74
30/11/14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25
kilometres
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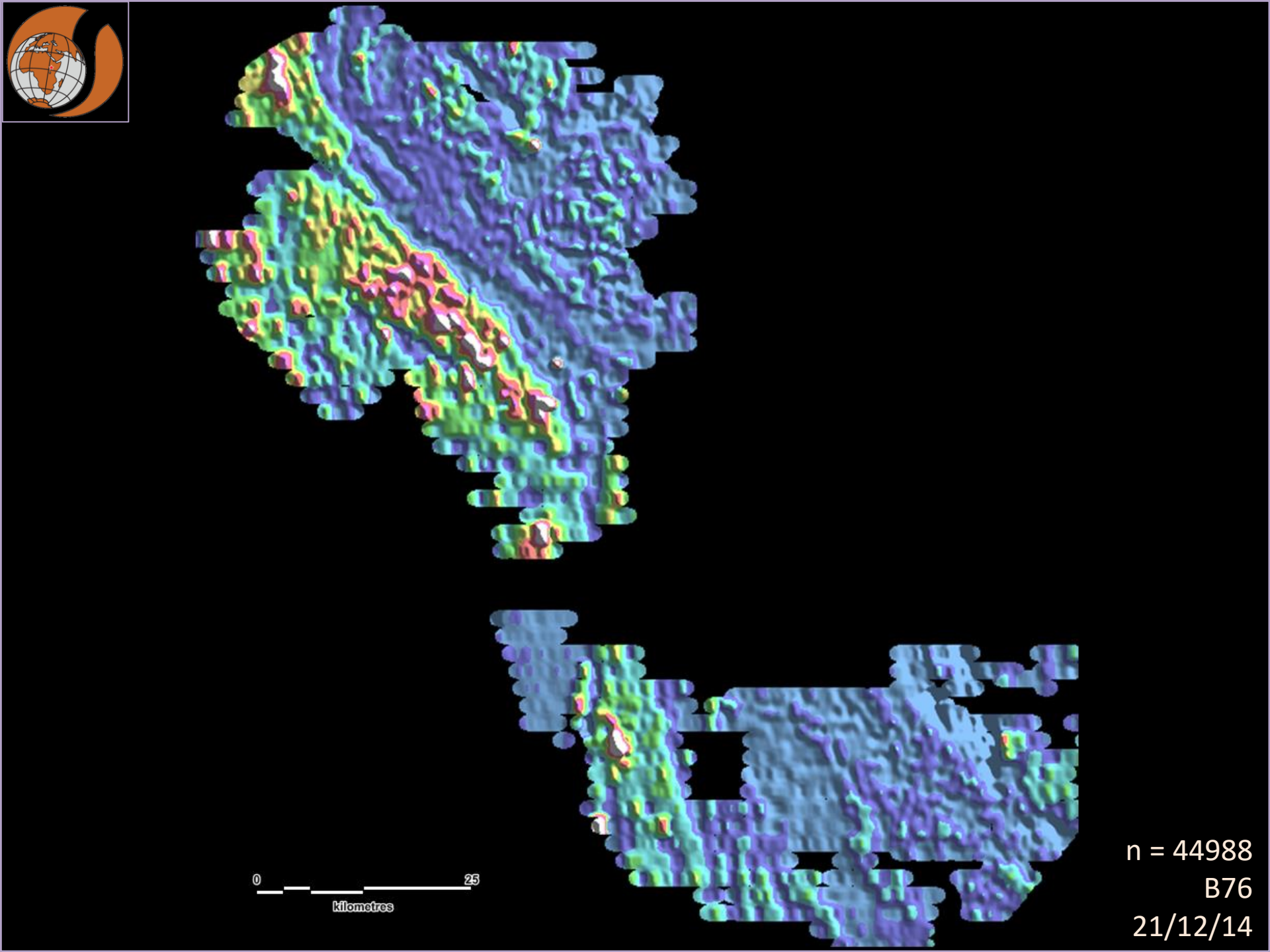
B75
07/12/14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25
kilometres
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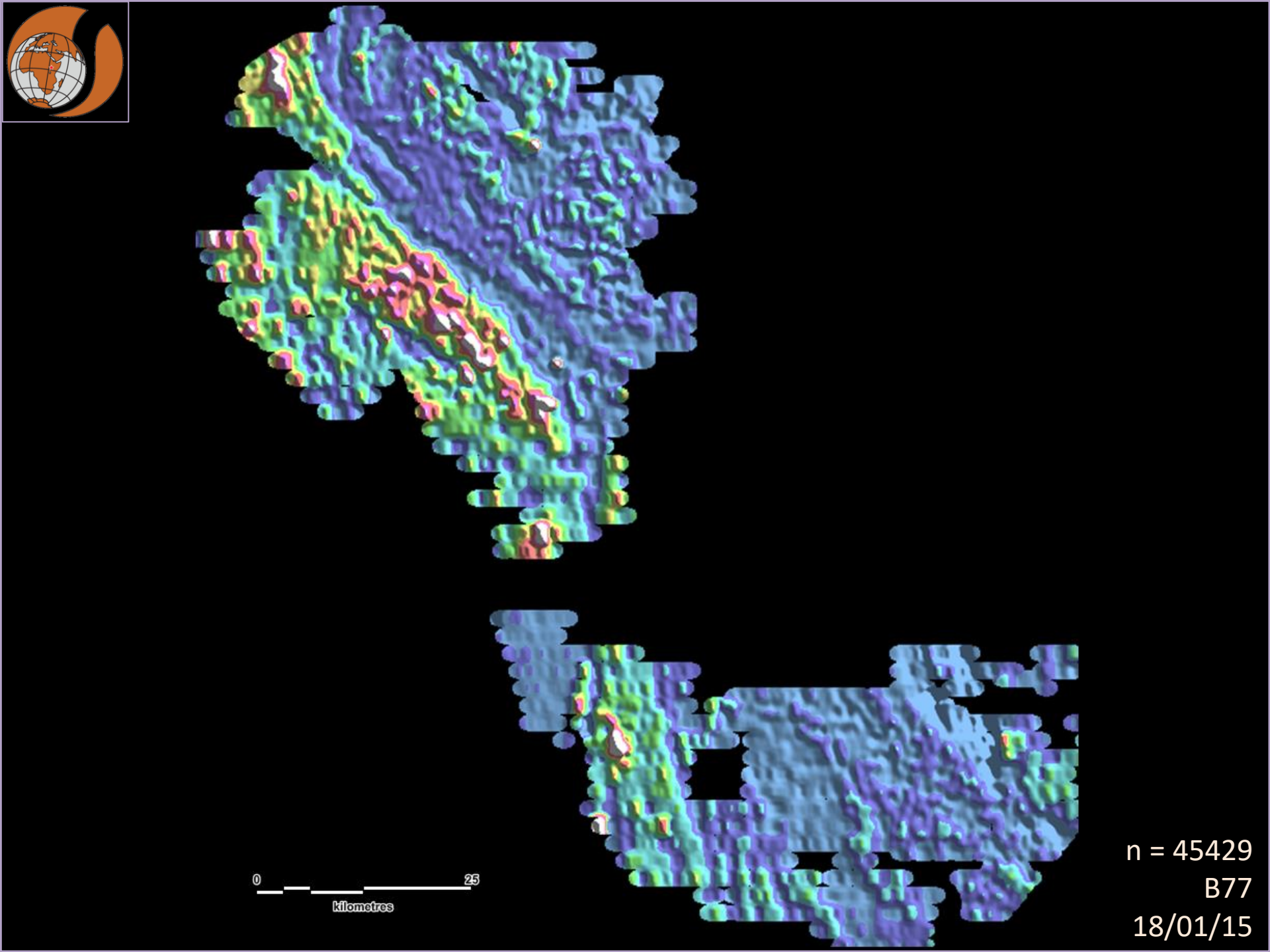
B76
21/12/14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25
kilometres
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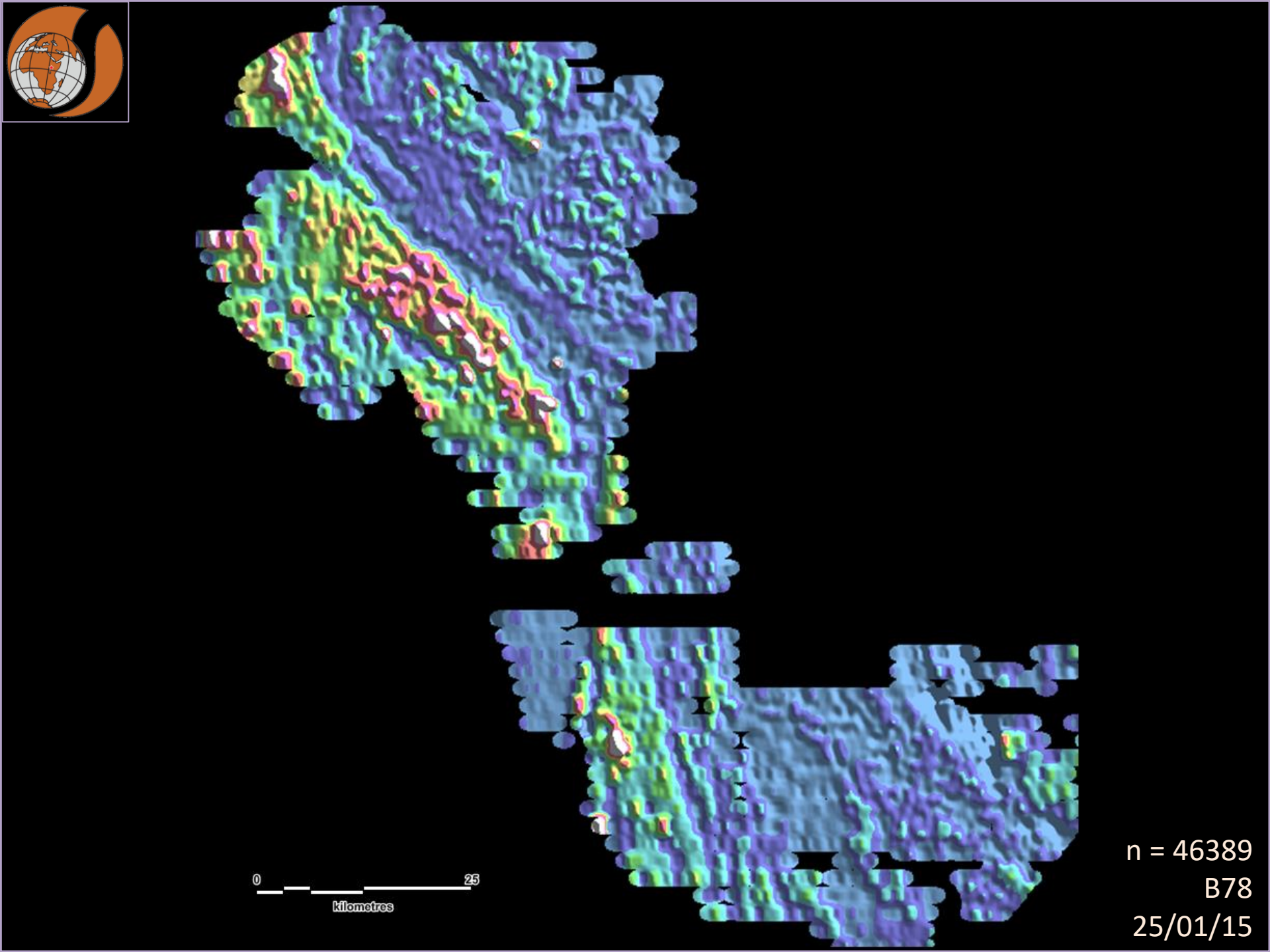
B77
18/01/15


0
25
kilometres
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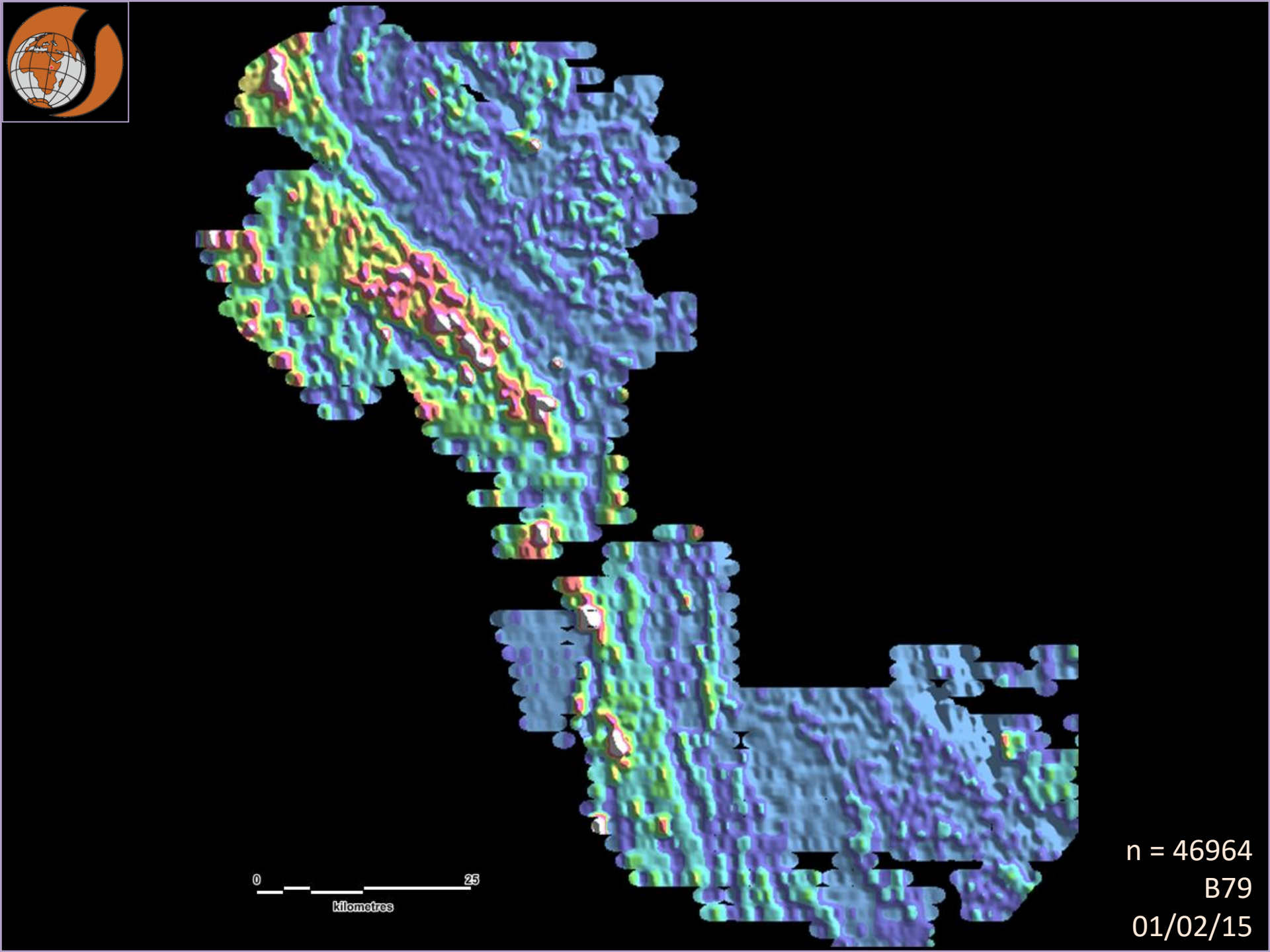
B78
25/01/15


0
25
kilometres
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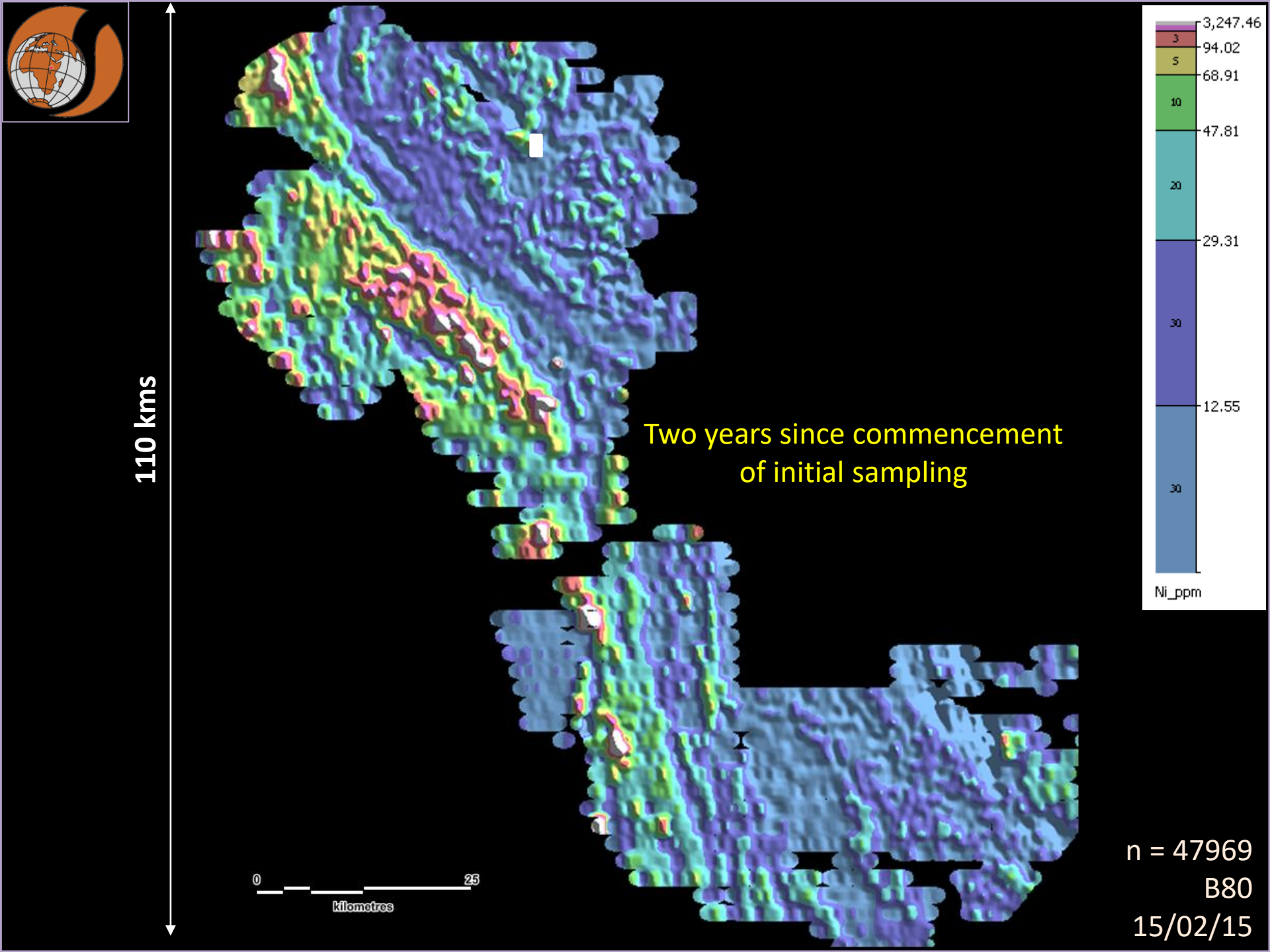
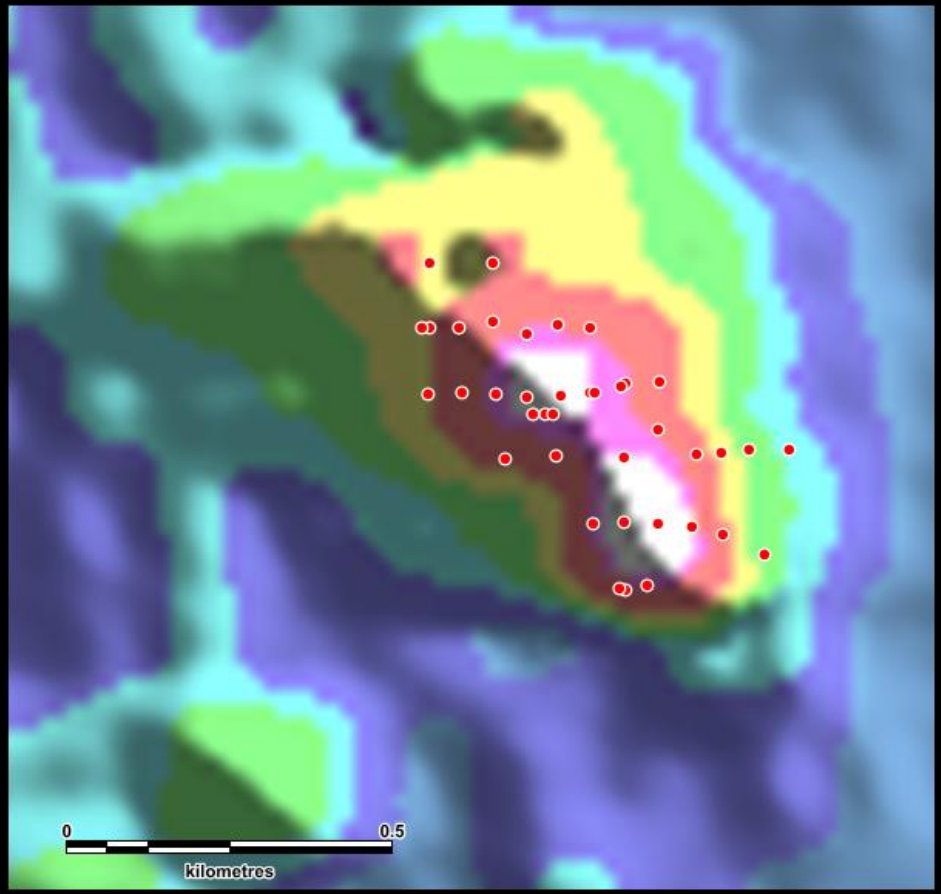
B79
01/02/15

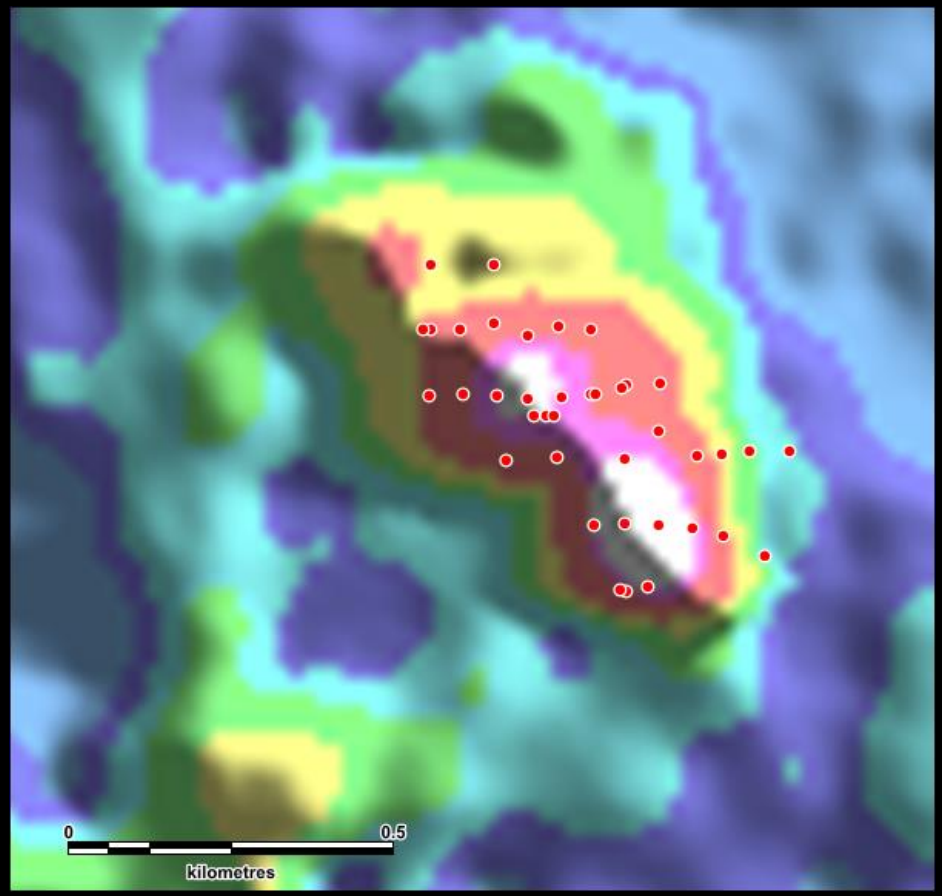

110 kms
Two years since commencement
of initial sampling
3,247.46
3
94.02
5
68.91
10
47.81
20
29.31
30
12.55
30
Ni_ppm
0
25
kilometres
n = 47969
B80
15/02/15

Akelikongo: Drilling

Ni images with Drill holes

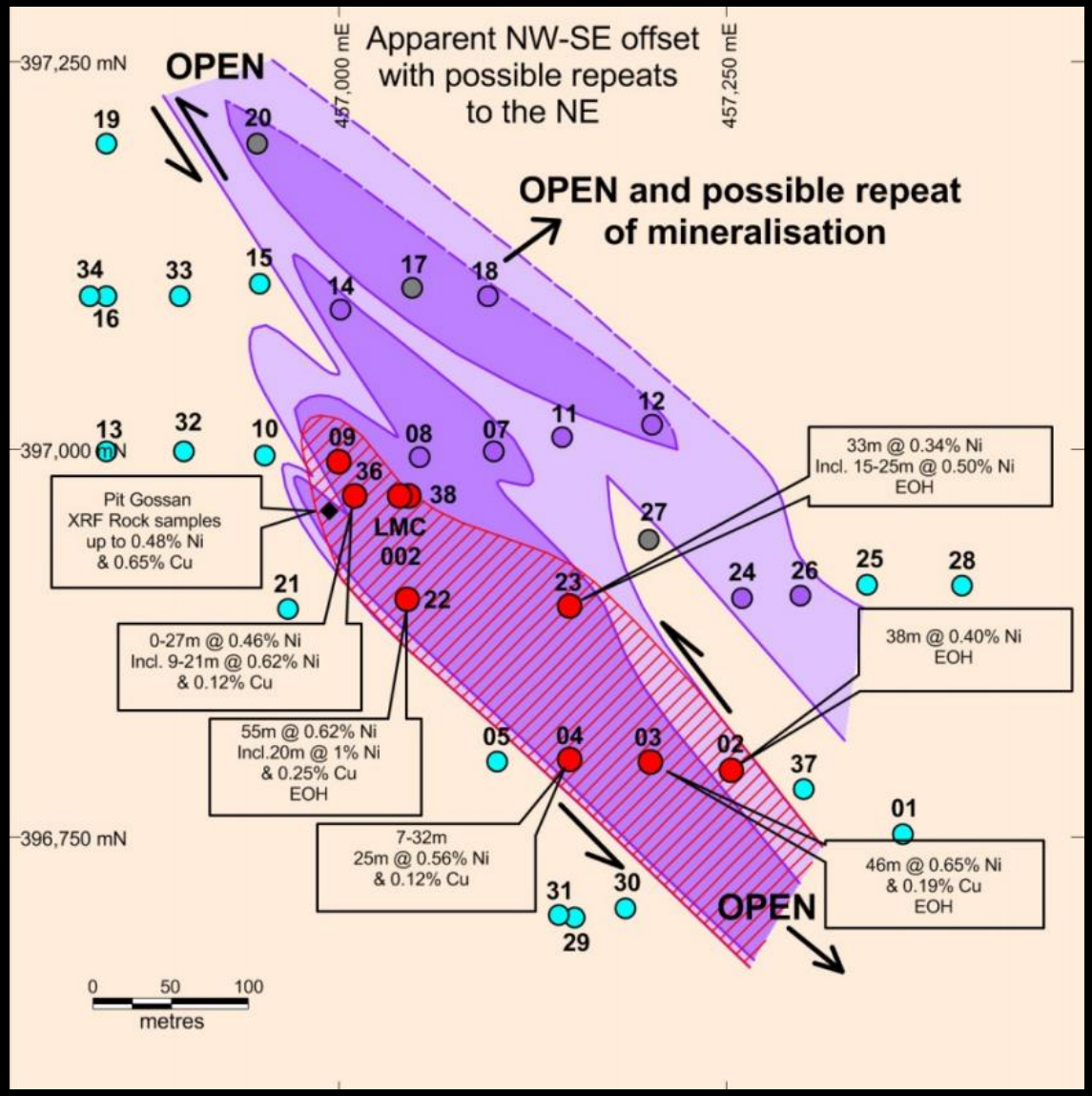


Cu images with Drill holes



Akelikongo

ASX: 15/07/2014 Progress Report
Kitgum-Pader



>0 .4% Ni

Ultramafic high Ni background

Mixed ultramafic and country rock

Country rock

22 Drillhole No, prefix LMR0

EOH Mineralised at end of hole

Mineralized zone >0.4% Ni & >900 ppm Cu

Ultramafic complex (high MgO)

Ultramafic complex (low MgO)

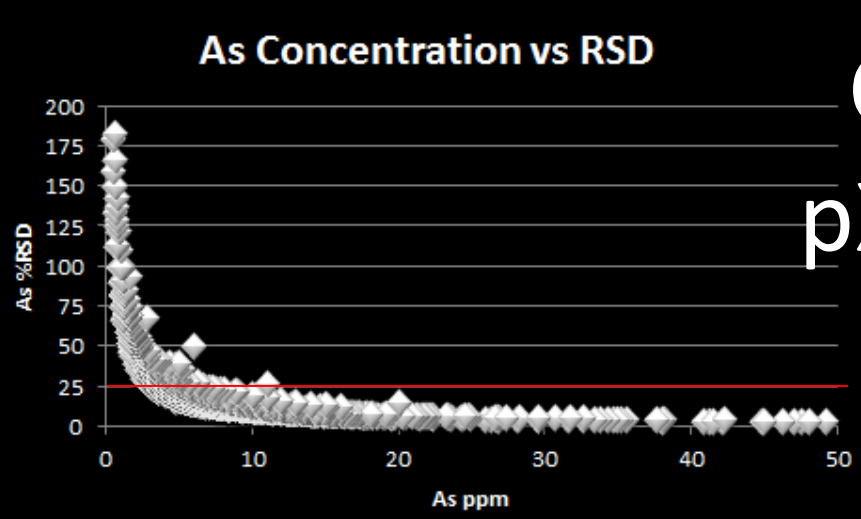
Country rock

AKD002


Akelikongo Section AKD002
123.8m-124.3m
1.8% Ni 0.13% Cu
127.3m-127.64m
3.4% Cu 0.23% Ni

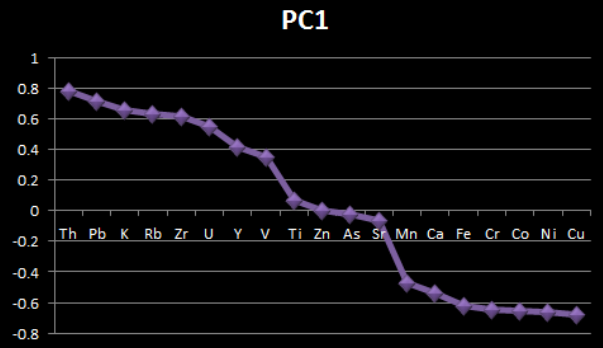
Confidence in pXRF Elements

Element	25% RSD	Confidence
Ag	>20?	0.0
As	**4.2**	**75.3**
Au	>10?	0.0
Bi	>20?	0.0
Ca	**175**	**99.7**
Cd	>20?	0.0
Cl	>500?	0.0
Co	**7.5**	**92.0**
Cr	**25**	**99.6**
Cu	**8**	**99.5**
Fe	**<200**	**100.0**
Hg	5.5	0.4
K	**<200**	**100.0**
Mn	**<50**	**100.0**
Mo	6	1.9
Ni	**30**	**50.0**
P	>20000?	0.0
Pb	**6**	**89.4**
Rb	**5**	**100.0**
S	350	0.5
Sb	>40?	0.0
Se	>2?	0.0
Sn	>40?	0.0
Sr	**<10**	**100.0**
Th	**8.5**	**87.6**
Ti	**<750**	**100.0**
U	7	0.9
V	**30**	**100.0**
W	12	0.7
Y	**4**	**100.0**
Zn	**<5**	**100.0**
Zr	**<20**	**100.0**



- Detected element suites will vary according to the geology and matrix of the material analyzed.
- The matrix effect on detection limits of the pXRF data can be very significant;
- Based on the 25% RSD benchmark the 18 pXRF elements have a high level of confidence:
  - **As, Ca, Co, Cr, Cu, Fe, K, Mn, Ni, Pb, Rb, Sr, Th, Ti, V, Y, Zn & Zr**
- ...and 14 elements have a low level of confidence:

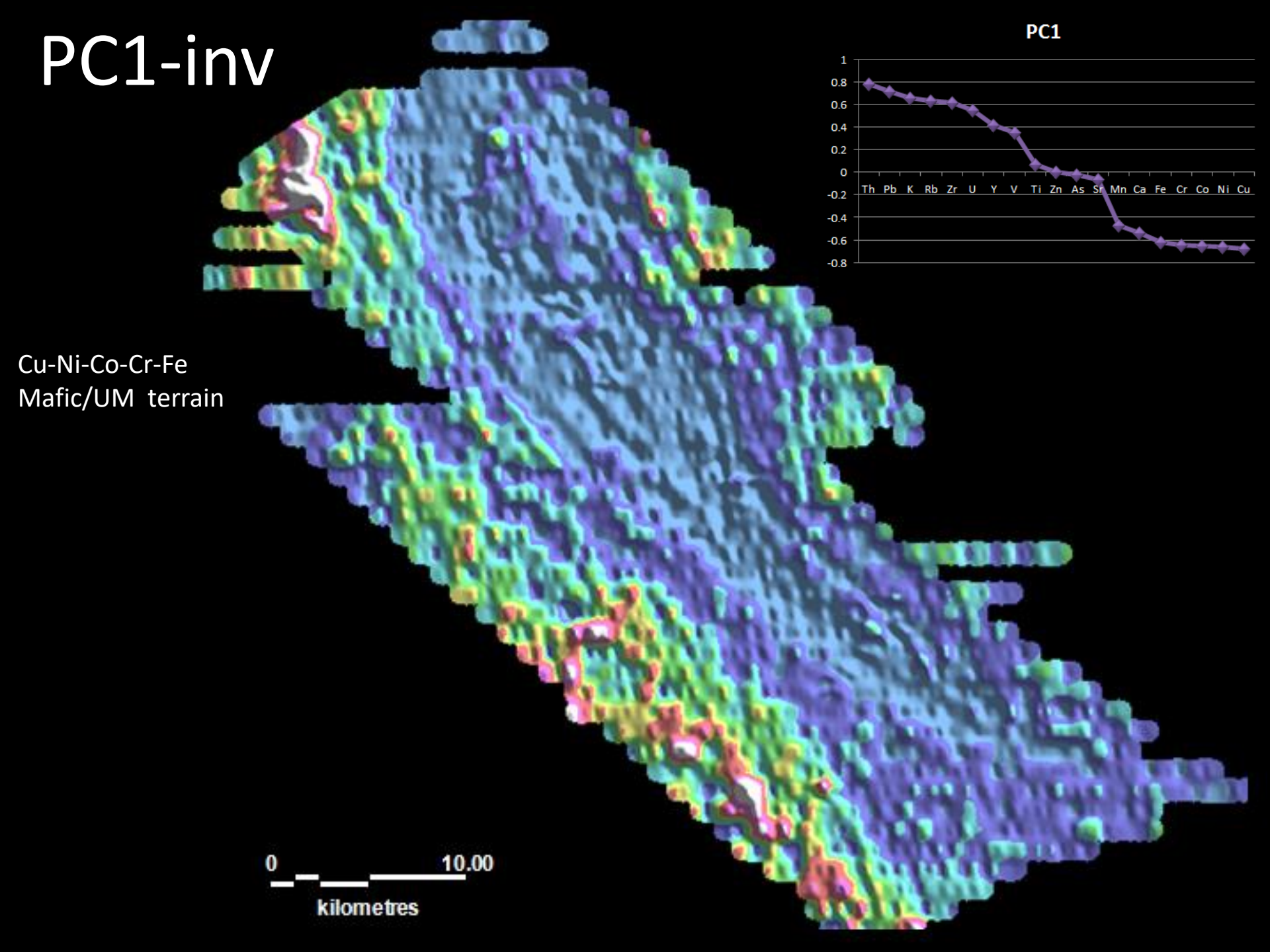
PC1



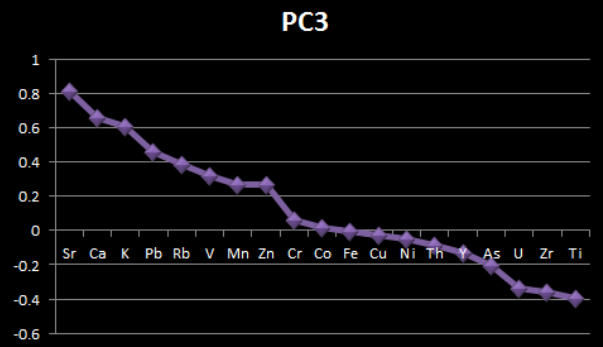
Th-Pb-K-Rb-Zr-U
Granitic terrain

0 10.00
kilometres

PC1-inv


PC1
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
Th Pb K Rb Zr U Y V Ti Zn As Sr Mn Ca Fe Cr Co Ni Cu
Cu-Ni-Co-Cr-Fe
Mafic/UM terrain
0
10.00
kilometres

PC3

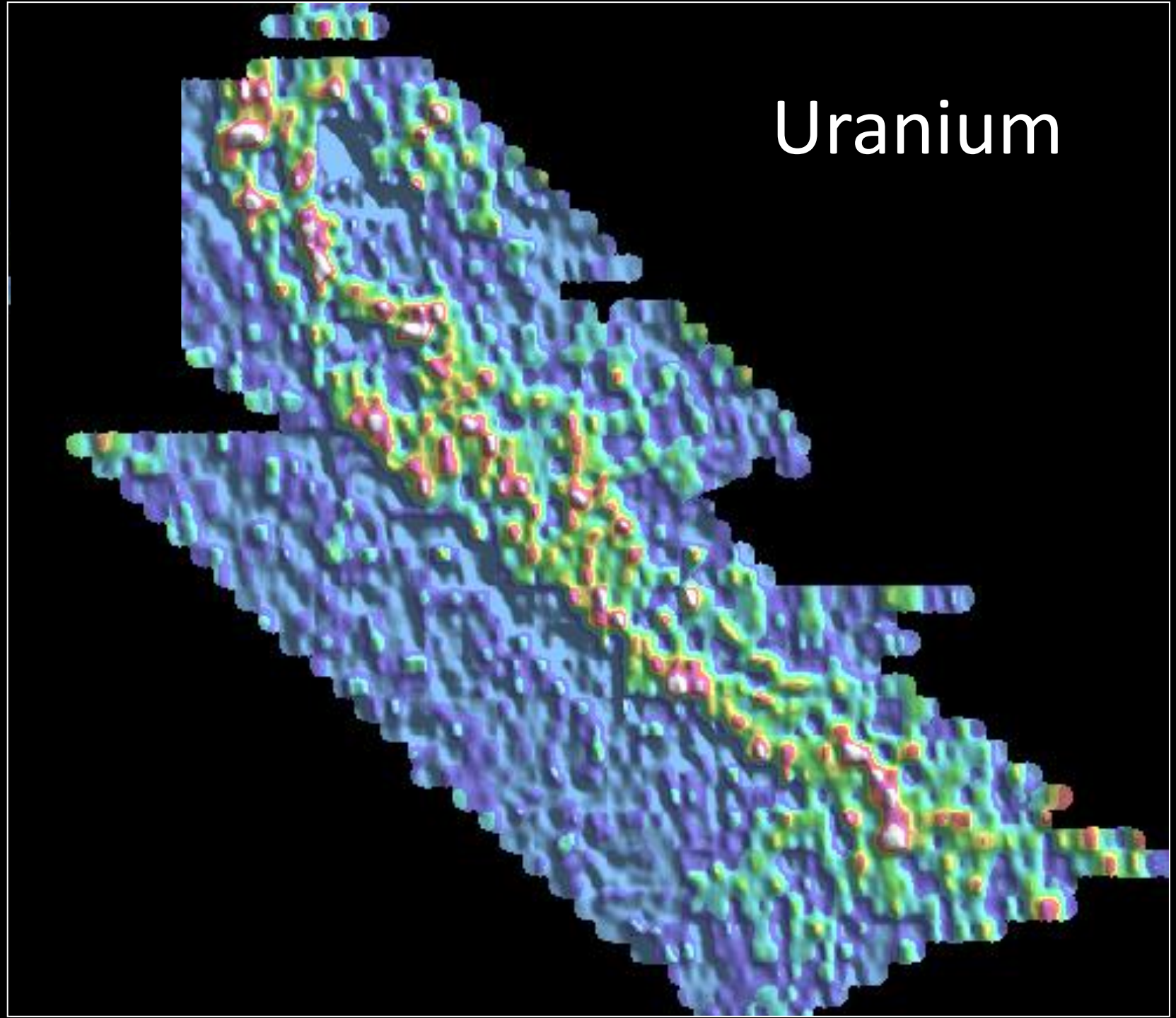


Sr-Ca-K-Pb
Feldspar rich terrain

0 10.00
kilometres

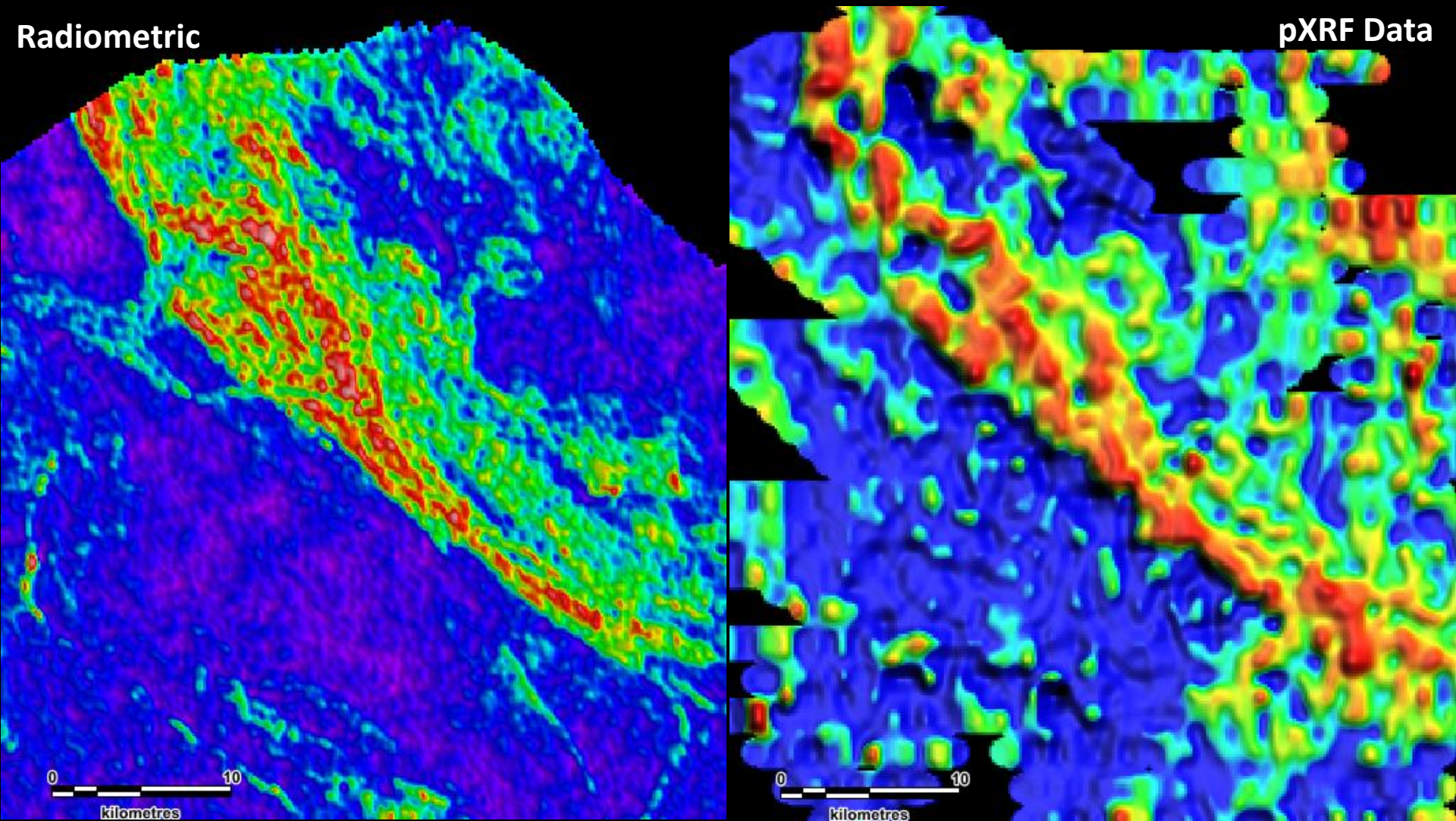
Instrument determined Limits of Detection

Recommend download RAW data

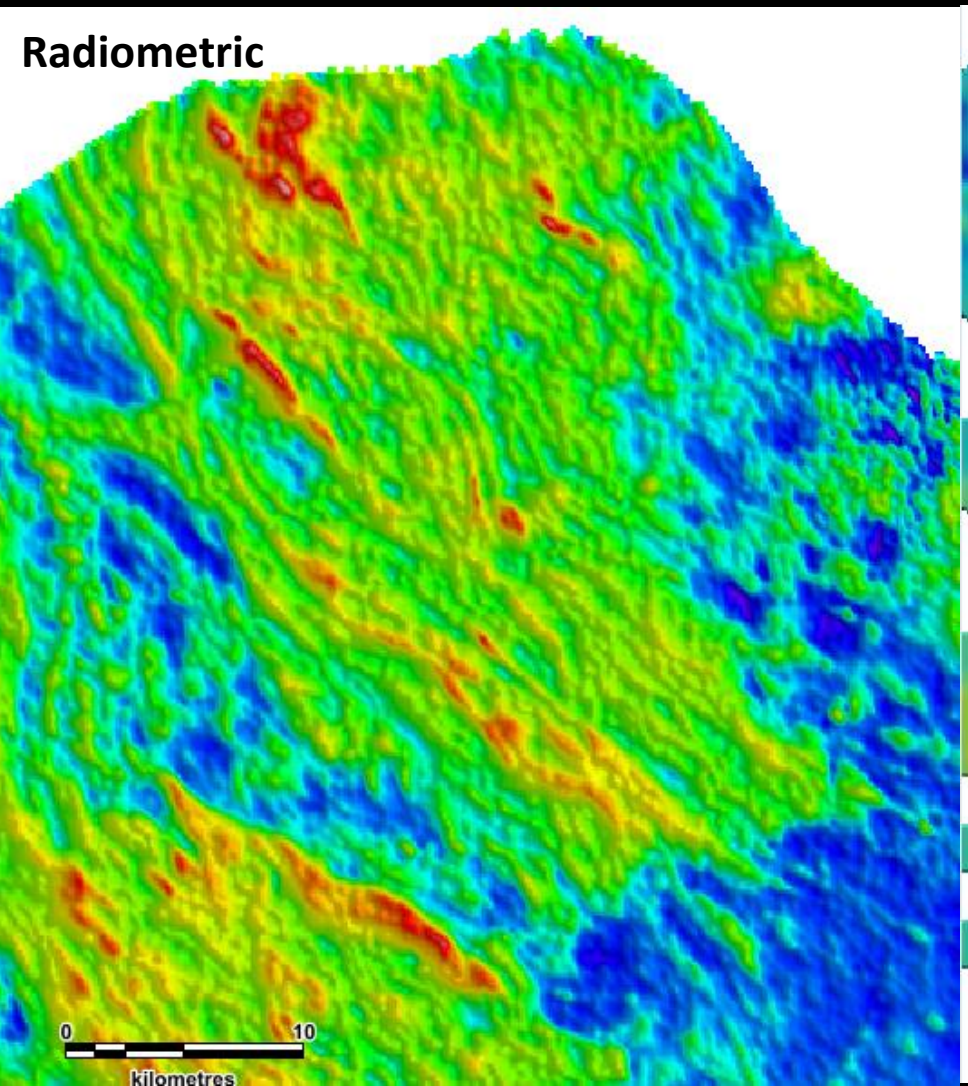

Uranium

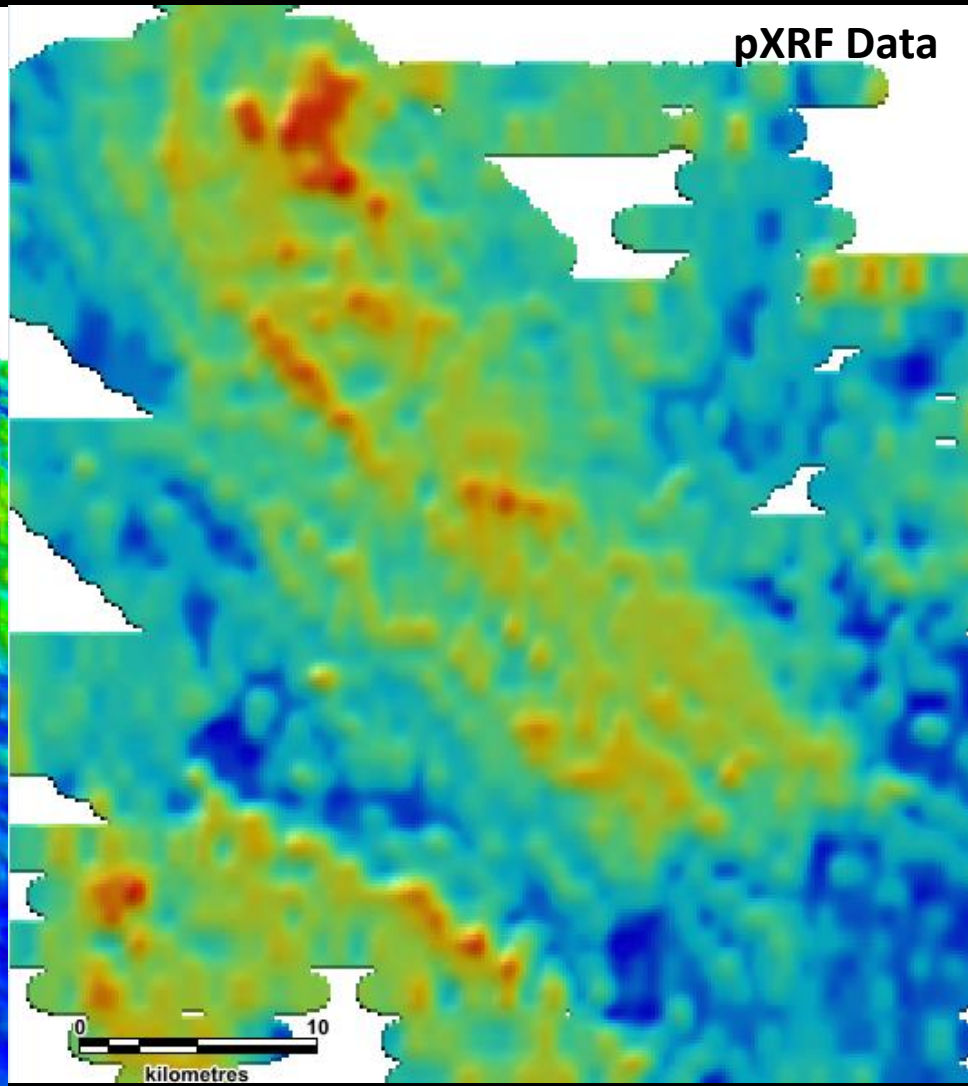
Are these uranium values realistic?

Comparison between Radiometric and pXRF data: **Uranium**



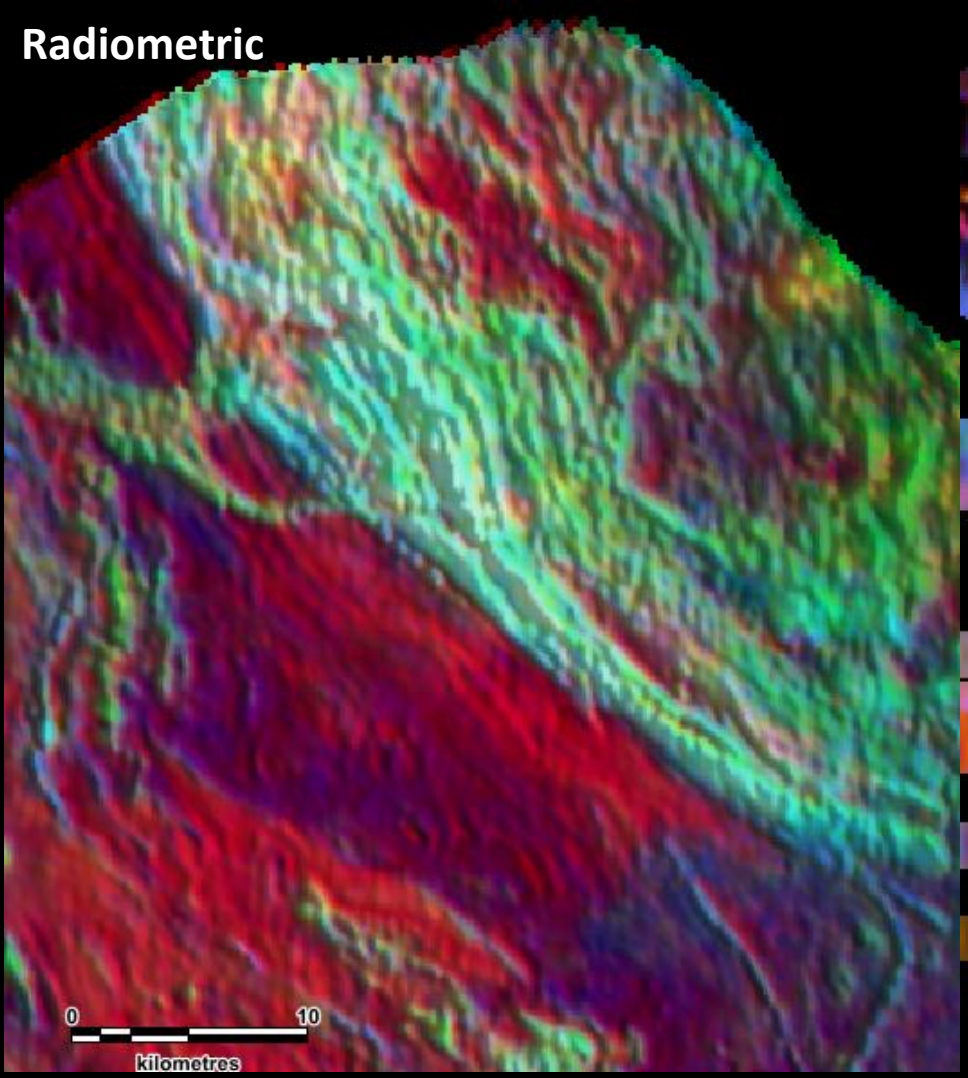
Comparison between Radiometric and pXRF data: **Potassium**



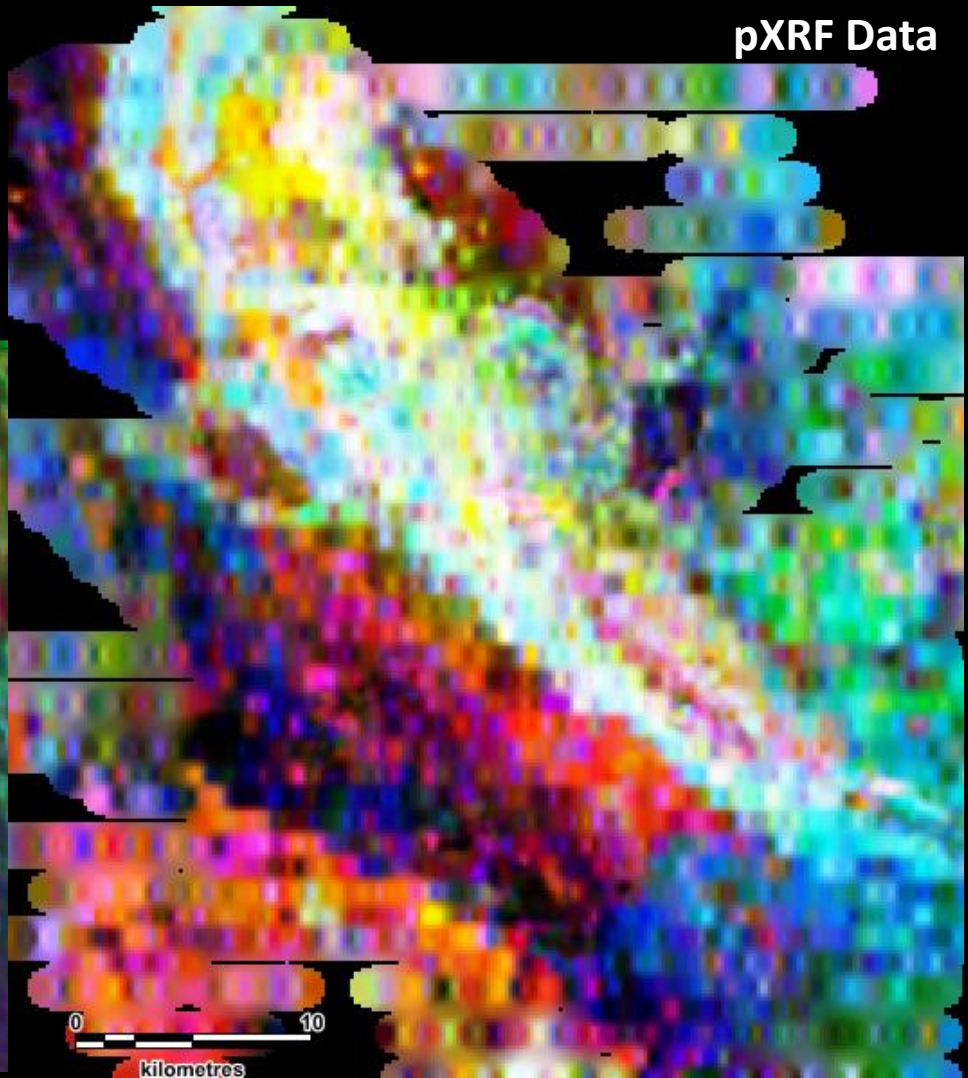


Comparison between Radiometric and pXRF data: **K-Th-U (RGB)**

Radiometric



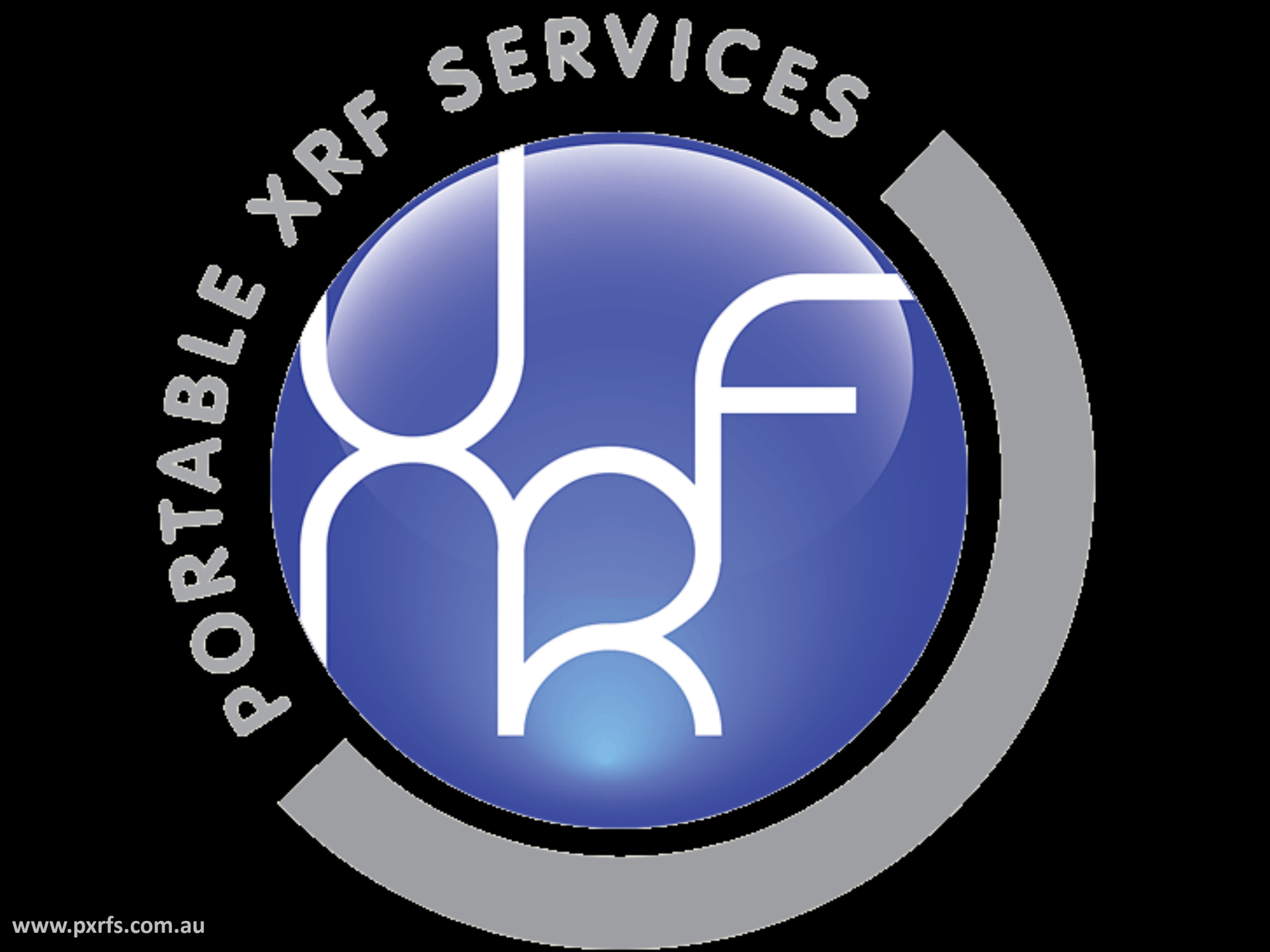
pXRF Data



Summary & Conclusions

- "**Off the shelf**" pXRF are
  - individual and unique instruments.
  - precise yet inaccurate.
- Separate **batteries** will effect element response
- Over time pXRF **performance will degrade**
  - Most noticeably in light elements (Si. Al, Mg)
- pXRF instruments provides "**fit for purpose**" data for geochemical mapping and mineral exploration in remote and challenging environments, globally.
- **Use Raw** (uncensored) pXRF data

Presentation available from pXRFS.com.au



www.pxrfs.com.au