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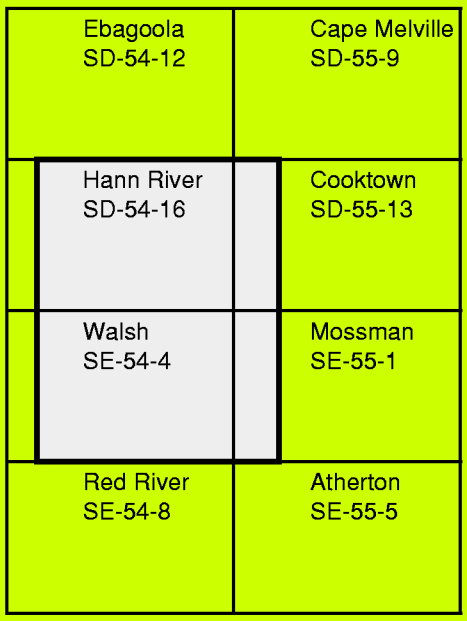
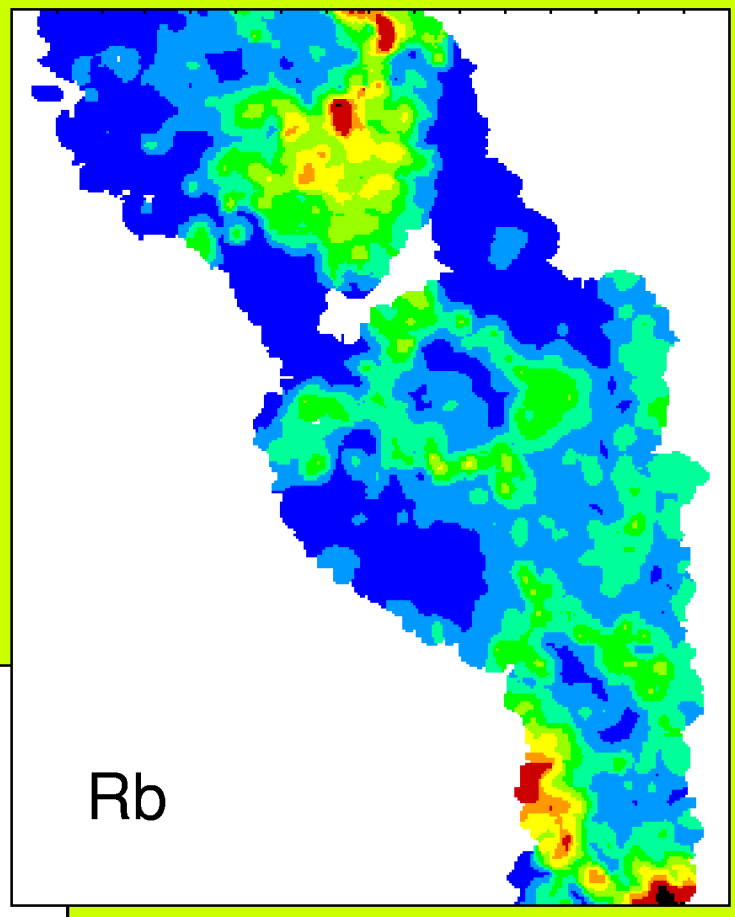
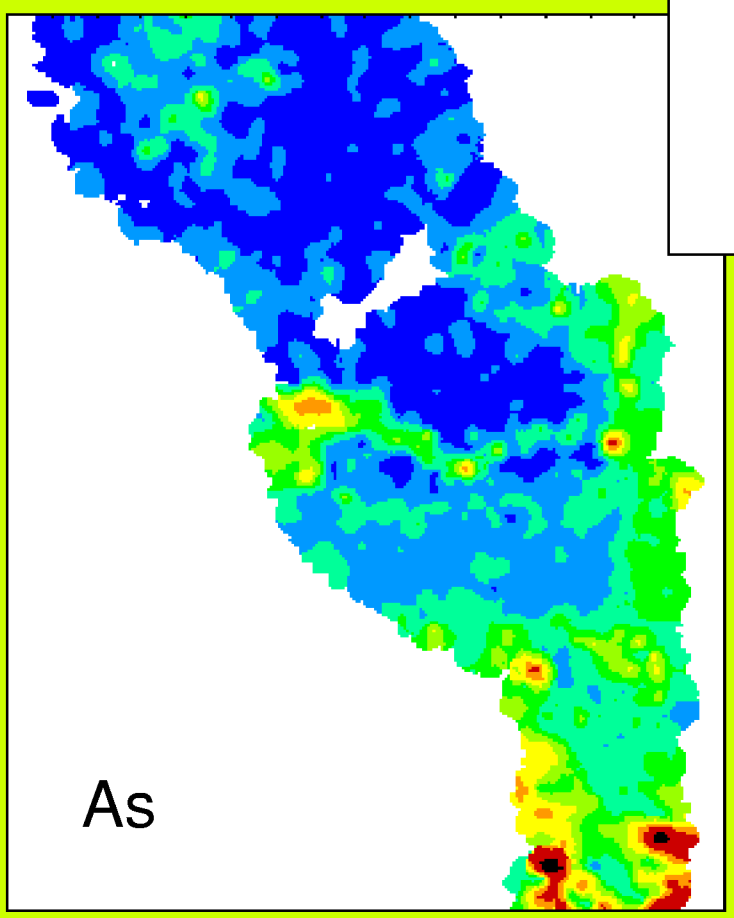
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

HANN RIVER Region

STREAM SEDIMENT GEOCHEMICAL ATLAS #3







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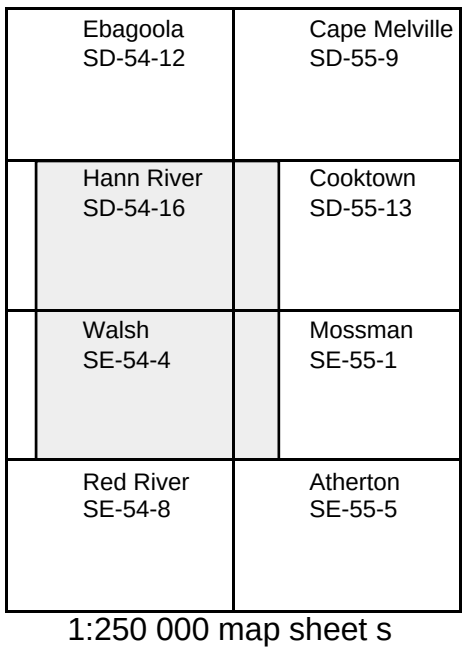
AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION

Stream Sediment Geochemical Atlas Series #3

HANN RIVER region, north Queensland



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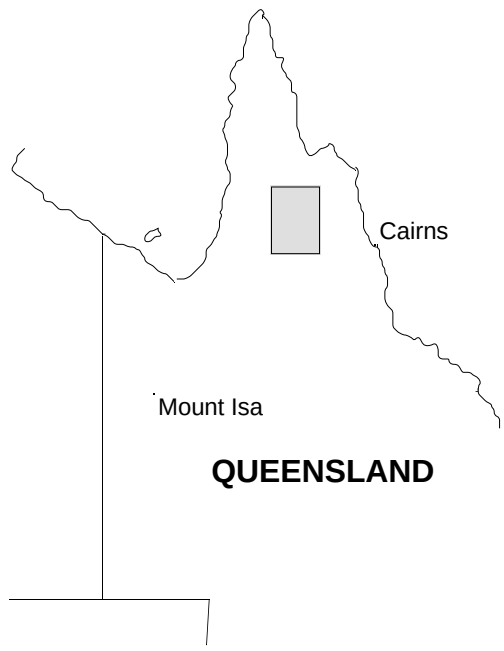

Regional Geology and Minerals Division

B I Cruikshank and P C Brugman

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DEPARTMENT OF PRIMARY INDUSTRIES AND ENERGY

Minister for Resources: Hon. David Beddall
Secretary: Greg Taylor

AUSTRALIAN GEOLOGICAL SURVEY ORGANISATION
(formerly BUREAU OF MINERAL RESOURCES, GEOLOGY AND GEOPHYSICS)

Executive Director: Neil Williams

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This atlas is a product of the National Geoscience Mapping Accord.

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ABSTRACT

This atlas constains colour images created from stream sediment geochemical data from the HANN RIVER region west of Cairns, north Queensland. The samples were collected by the North Queensland Project of the Regional Geology and Minerals Division, Australian Geological Survey Organisation.

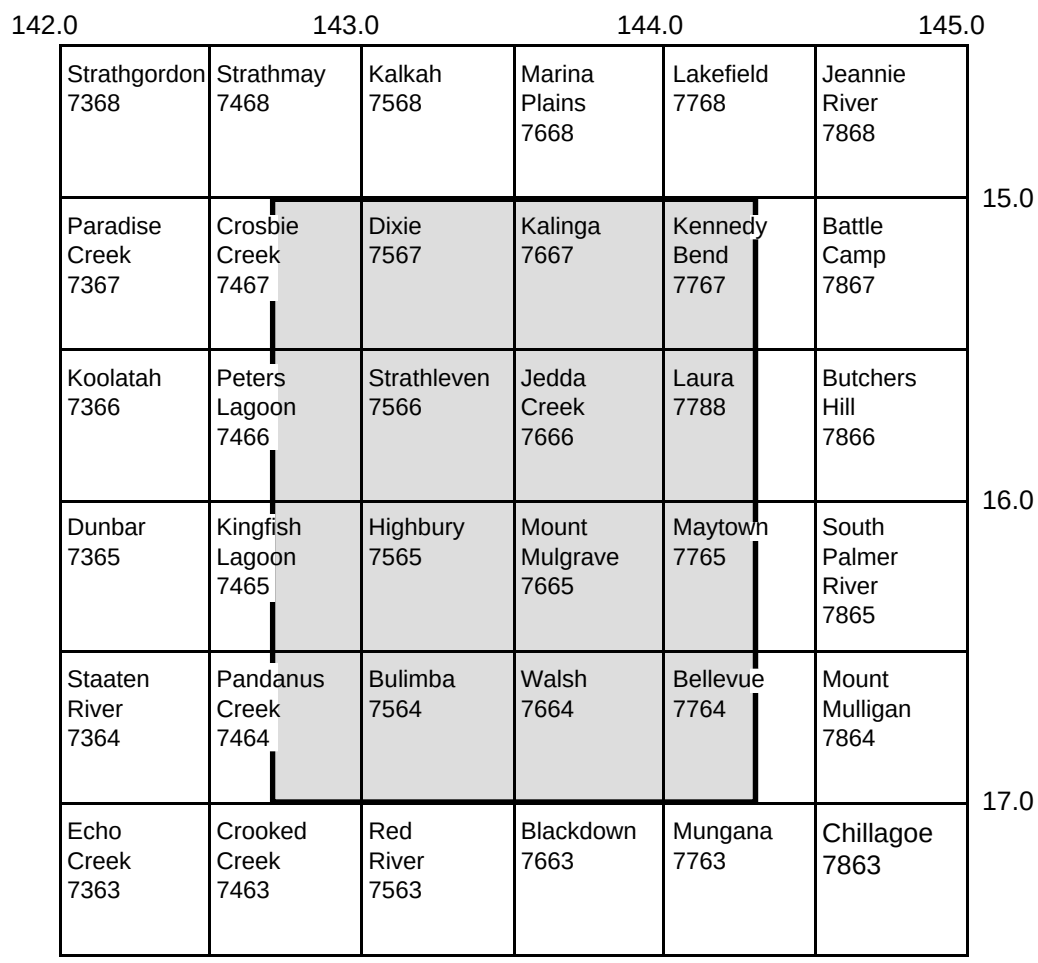
The images show the spatial distributions of some 39 elements over the sheet area, and a number of statistically derived parameters such as principal component factor scores, residuals of Cu, Pb, U and Zn (elements of economic interest with lithochemical overprinting), and additive indices for six types of potential mineralisation. Tables of basic univariate statistical parameters and factor loadings are included in appendices, and overlays of sample sites, simplified geology and mineral occurrences, are included.

INTRODUCTION

The HANN RIVER Region Stream Sediment Geochemical Atlas contains colour images of the distributions of element values (raw data) and statistically derived values (factor scores, element residual values and additive indices) from data resulting from field work in the HANN RIVER region, north Queensland. The samples were collected from parts of the Hann River (SD-54-16), Cooktown (SD-55-13), Walsh (SE-54-4) and Mossman (SE-55-1) 1:250 000 sheet areas by Regional Geology and Minerals Division's North Queensland Project. The surfical geochemical (stream sediment) sampling program was undertaken to provide a framework for the assessment of regional mineral potential, lithochemical correlation and environmental baseline studies.

The research forms part of the North Queensland NGMA Project undertaken jointly by the Australian Geological Survey Organisation and the Geological Survey of Queensland. The National Geoscience Mapping Accord, endorsed by the Australian (now Australian and New Zealand) Minerals and Energy Council in 1990 is a joint Commonwealth/State/Territory initiative to produce, using modern technology, a new generation of geoscientific maps, data sets, and other information of strategically important regions of Australia over the next 20 years.

The HANN RIVER region is bounded by latitudes 15°00'S and 17°00'S (15.0°S and 17.0°S), and by longitudes 142°42'E and 144°18'E (142.7°E and 144.3°E), and covers all, or part, of a number of 1:100 000 sheet areas in the area high-lighted below:



Analysis

Full details of sampling, chemical analytical and data processing techniques used are given in Cruikshank and Brugman (in prep.). The sampling density was one sample per 10-15 km^2 and two samples, 50-70 gm of -180 um fine sediment and 5-6 kg of -1 mm coarse sediment, were collected at each of the 1191 sample sites. The fine fraction was analysed in AGSO laboratoy in Canberra by X-ray fluorescence spectrometry (XRFS) for 31 elements (As, Ba, Bi, Ce, Cr, Cu, Fe, Ga, Ge, Hf, La, Mn, Mo, Nb, Nd, Ni, Pb, Rb, Sc, Se, Sn, Sr, Ta, Th, Ti, U, V, W, Y, Zn and Zr), and by Analabs in Perth by ICP-MS for 9 elements (Code GI222 - Ag, Be, Bi, Cd, Mo, P, Sb, Tl and W). A 2 kg split of the coarse fraction was analysed by Australian Laboratory Services in Brisbane by bulk cyanide leach/GFAAS for 3 elements (Method PM216 - Au, Pd and Pt). Analyses by Analabs are suffixed with an asterisk (*) and by Australian Laboratory Services with a crosshatch (#). Basic univariate statistics for the data are shown in Appendix 1. All concentrations are in parts per million (ppm) except for Au#, Pd# and Pt# which are in parts per billion (ppb). No parameters have been recorded for Bi, Mo, Se and Ta as the majority of values for each were below the limit of detection for the methods used.

Image production

The data were gridded to the following parameters:-

Longitude	minimum	- 142.7°
	maximum	- 144.3°
Latitude	minimum	- 15.0°
	maximum	- 17.0°
Grid spacing		- 0.0025°
Number of columns		- 641
Number of rows		- 801
Interpolation method		- Kriging
Search radius		- 0.050°
Nearest neighbours		- 10

A location approximating to the geometric centre of the drainage basin was used in preference to the sample site as this was believed to represent more accurately the spatial relationship between drainage basins. Grid files were converted to colour images by classifying grid point values into 9 percentage-based ranges as follows:-

	Percentage of values	Range	Approximate pseudo colour
1	100.0-99.9	0.1	Black
2	99.9-99.0	0.9	Red
3	99.0-98.0	1.0	Orange
4	98.0-95.0	3.0	Yellow
5	95.0-90.0	5.0	Yellow-green
6	90.0-80.0	10.0	Green
7	80.0-60.0	20.0	Blue-green
8	60.0-30.0	30.0	Light blue
9	30.0-0.0	30.0	Dark blue
	Not Sampled		White

For some images a reduced number of colours and different percentage ranges were used, usually where the data contained a significant number of low or 'Not Detected' values. The images were scaled to approximate the aspect ratio of a 1:750 000 map but have not been rectified to a standard map projection (i.e., they are rectangular). Image maps were annotated and printed on a colour laser copier fitted with a PostScript interpreter.

Maps 1 to 39 show raw element distributions. Maps for Bi, Mo, Se and Ta have been excluded because of the large proportions of 'Not detected' values in their data. Tungsten is shown as W (XRFS by AGSO Laboratory) and W* (ICP-MS by Analabs).

Factor analysis

Principal component factor analysis of log-transformed data, using a Varimax orthogonal transformation solution, resulted in the extraction of 6 Factors, with factor loadings shown in Appendix 2. Principal, or major, loadings are the highest absolute factor loading for the element, and minor loadings are any other absolute factor loadings greater than 0.30. The 6 factors extracted are:-

Factor 1 (accounts for 31.4% of variation in dataset) comprises U, Ce, Th, Y, Nd, La, Nb, P*, W, Zr and Hf, with minor contributions from Pb and Ti, and a negative contribution from Sb*. This factor is considered to represent resistant heavy minerals in the sediment, primarily the phosphate minerals monazite ([Ce,La,Nd,Th]PO_4) and xenotime ([Y,HREE]PO_4 - HREE are heavy Rare Earth Elements), and zircon ([Zr,Hf]SiO_4). These minerals often contain U in appreciable amounts.

Factor 2 (17.0%) comprises Fe, V, Cu, Ni, Sc, Zn, Cr, Ti, Mn, As and Cd*, with minor contributions from Ga, Nb, Pd#, Mo*, Be*, and Au#, and a negative contribution from Tl*. This factor is considered to be related to Fe geochemistry both in the entry of elements into Fe-rich mafic minerals such as pyroxenes, amphiboles and biotite, and in the co-precipitation with, or adsorption onto, hydrated Fe-oxides (and Mn-oxides) in the secondary environment.

Factor 3 (13.4%) comprises Rb, Ba, Sr, Be*, Ga, Pb and Tl*, with minor contributions from Mn, P* and Zn, and negative contributions from Sn, Zr and Hf. This factor is highly intercorrelated with

Image production

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Longitude	minimum	- 142.7°
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	Percentage of values	Range	Approximate pseudo colour
1	100.0-99.9	0.1	Black
2	99.9-99.0	0.9	Red
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Factor analysis

Principal component factor analysis of log-transformed data, using a Varimax orthogonal transformation solution, resulted in the extraction of 6 Factors, with factor loadings shown in Appendix 2. Principal, or major, loadings are the highest absolute factor loading for the element, and minor loadings are any other absolute factor loadings greater than 0.30. The 6 factors extracted are:-

Factor 1 (accounts for 31.4% of variation in dataset) comprises U, Ce, Th, Y, Nd, La, Nb, P*, W, Zr and Hf, with minor contributions from Pb and Ti, and a negative contribution from Sb*. This factor is considered to represent resistant heavy minerals in the sediment, primarily the phosphate minerals monazite ([Ce,La,Nd,Th]PO_4) and xenotime ([Y,HREE]PO_4 - HREE are heavy Rare Earth Elements), and zircon ([Zr,Hf]SiO_4). These minerals often contain U in appreciable amounts.

Factor 2 (17.0%) comprises Fe, V, Cu, Ni, Sc, Zn, Cr, Ti, Mn, As and Cd*, with minor contributions from Ga, Nb, Pd#, Mo*, Be*, and Au#, and a negative contribution from Tl*. This factor is considered to be related to Fe geochemistry both in the entry of elements into Fe-rich mafic minerals such as pyroxenes, amphiboles and biotite, and in the co-precipitation with, or adsorption onto, hydrated Fe-oxides (and Mn-oxides) in the secondary environment.

Factor 3 (13.4%) comprises Rb, Ba, Sr, Be*, Ga, Pb and Tl*, with minor contributions from Mn, P* and Zn, and negative contributions from Sn, Zr and Hf. This factor is highly intercorrelated with

Factor 1 (see Appendix 2) and is considered to be related to the weathering of granites, probably containing K-rich minerals.

Factor 4 (5.9%) comprises Sb*, W*, Sn, Mo* and Ag*, and minor contributions from As and Tl*.

Factor 5 (4.1%) comprises Bi*.

Factor 6 (3.3%) comprises Pt#, Pd# and Au#, with a negative contribution from Ge.

The distributions of factor scores are shown in images 40 to 45.

Element residuals

Residual values for Cu, Pb, U and Zn were estimated by stepwise regression against all the factor scores, allowing the process to eliminate insignificant factors, and subtraction of the 'fitted' value obtained from the observed or analysed value. For example, the observed concentration of U has been corrected for the concentration of U held in the resistant minerals Monazite, Xenotime and Zircon as estimated by regression of U (log-transformed) against factor scores. Similarly, Cu, Pb and Zn have been corrected for lithological and secondary effects represented in the factors as appropriate. The 'fitted' value (X_p) was estimated from a stepwise regression equation derived from a dataset from which 'outliers' (samples with large residuals) were deleted to more accurately define the parameters of the background population. The equations used are:-

$$\log(Cu_p) = 0.486*F2 + 0.048*F5 + 0.069*F6 + 0.643$$

$$\log(Pb_p) = 0.151*F1 - 0.027*F2 + 0.169*F3 + 0.012*F4 + 0.058*F5 + 1.183$$

$$\log(U_p) = 0.400*F1 - 0.031*F2 + 0.071*F3 + 0.017*F4 - 0.012*F6 + 0.631$$

$$\log(Zn_p) = 0.086*F1 + 0.320*F2 + 0.144*F3 - 0.020*F4 + 0.076*F5 + 0.021*F6 + 1.207$$

where F1 is the Factor 1 scores, F2 the Factor 2 scores. etc. The distributions of residual Cu, Pb, U and Zn are shown in images 46 to 49, respectively.

Additive indices

Additive Indices are summations of standardised values for economic and pathfinder elements characteristic of particular types of mineralisation. The standardised values are dimensionless and are calculated by subtracting the element mean for the dataset from the individual element value and dividing by the element standard deviation. Six Additive Indices were calculated, these being:-

Gold Index (AuI)	- Ag* + As + Au# + Sb*
Base Metal Index (BMI)	- Ba + Cu(res) + Pb(res) + Zn(res)
Heavy Mineral Index (HMI)	- Ce + La + Nd + P* + Th + Y
Porphyry Copper Index (PCI)	- Cu(res) + Mo* + Rb
Platinum Index (PtI)	- Cr + Ni + Pd# + Pt# + V
Uranium Index (UI)	- As + Bi* + Mo* + U(res)

where (res) indicates an element residual value has been used.

Distribution of the values are shown in images 50 to 55.

Overlays showing:-

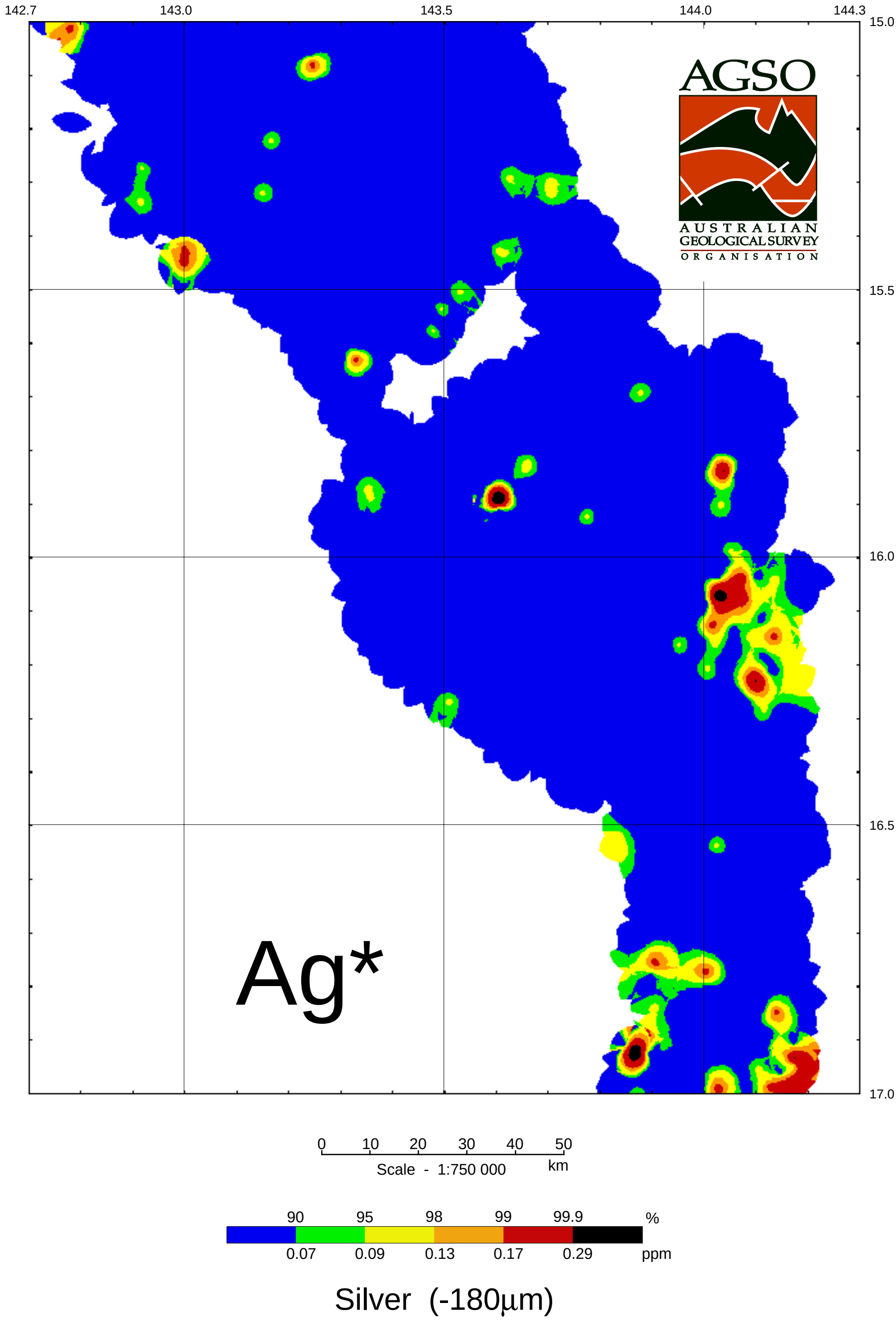
1) sample sites,
2) simplified geology
and 3) mineral occurrences

are included in a pocket in the inside back cover of this atlas.

References

Cruikshank, B.I., & Brugman, P.C., in prep. Stream sediment geochemistry of the HANN RIVER Region, north Queensland. Australian Geological Survey Organisation, Record (unpublished).

Hann River Region



Silver (-180µm)

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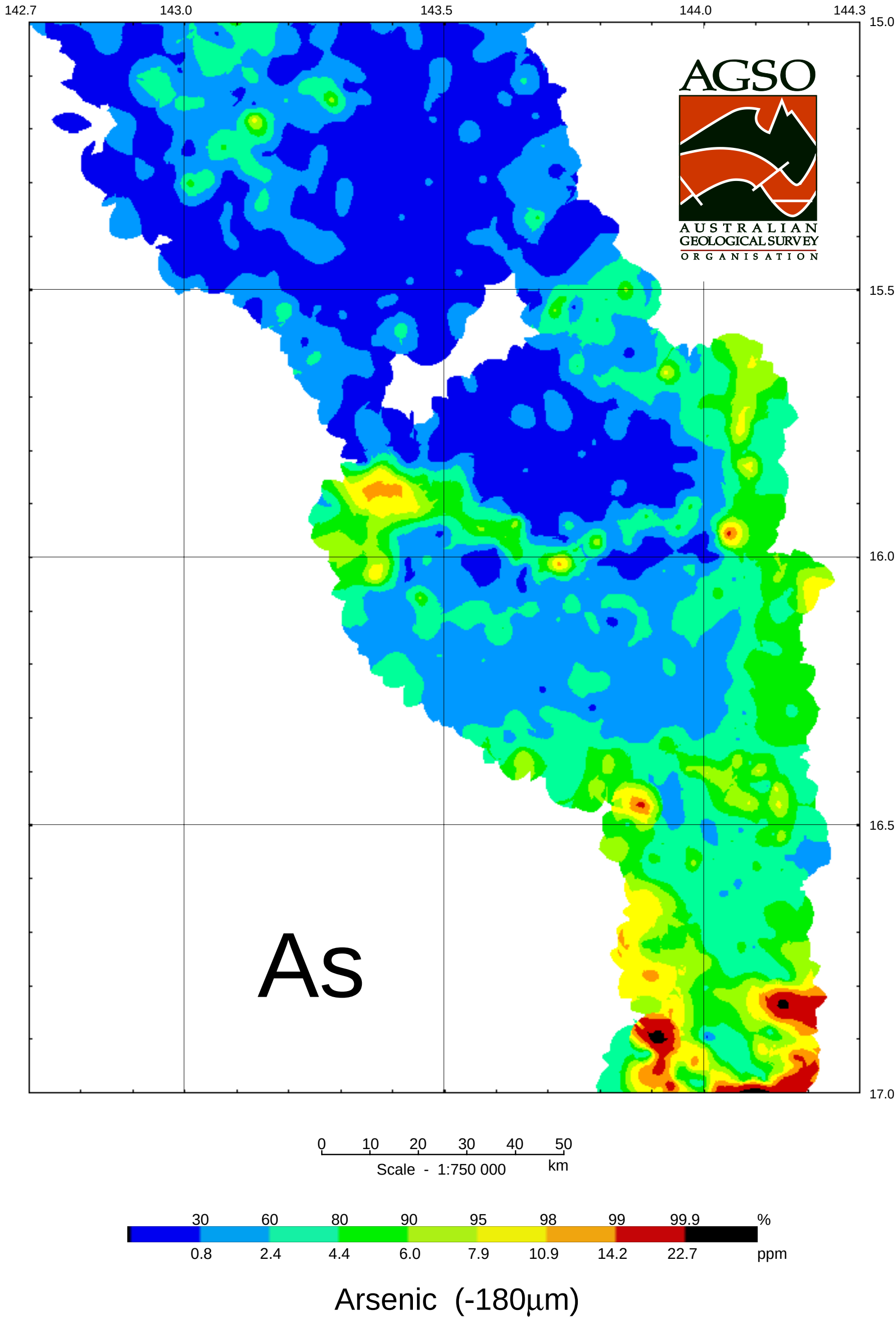

Arsenic (-180µm)

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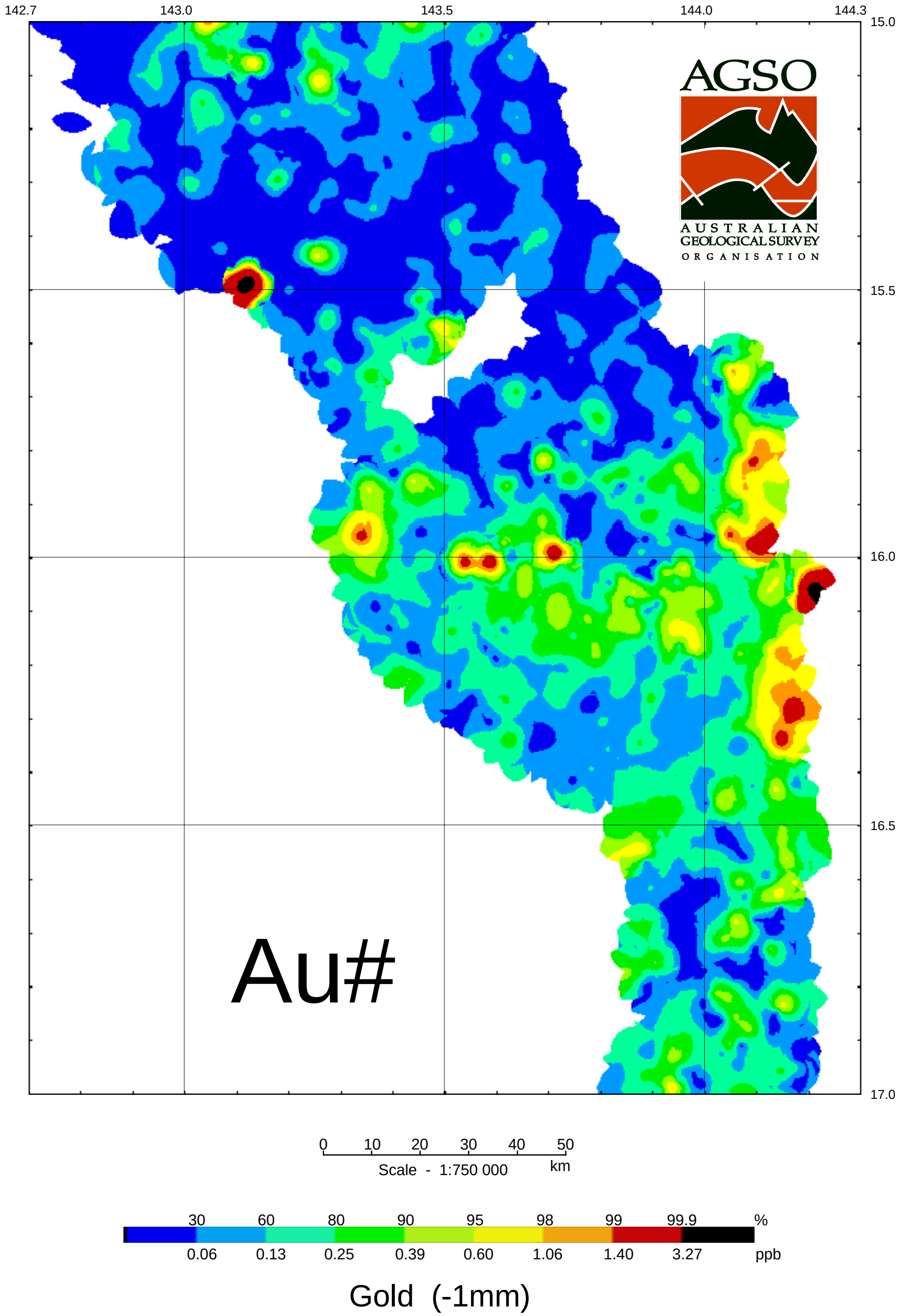

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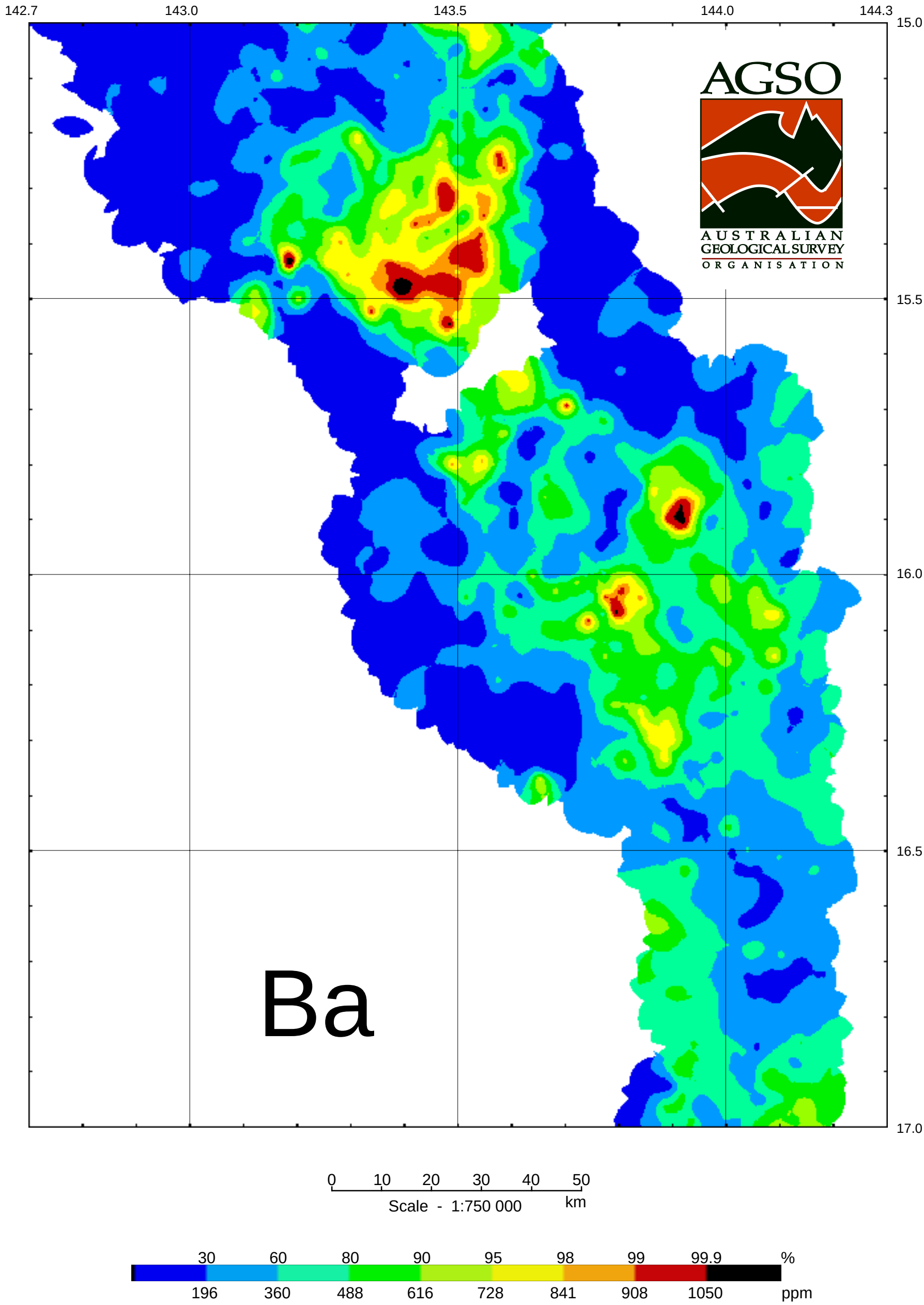

Barium (-180µm)

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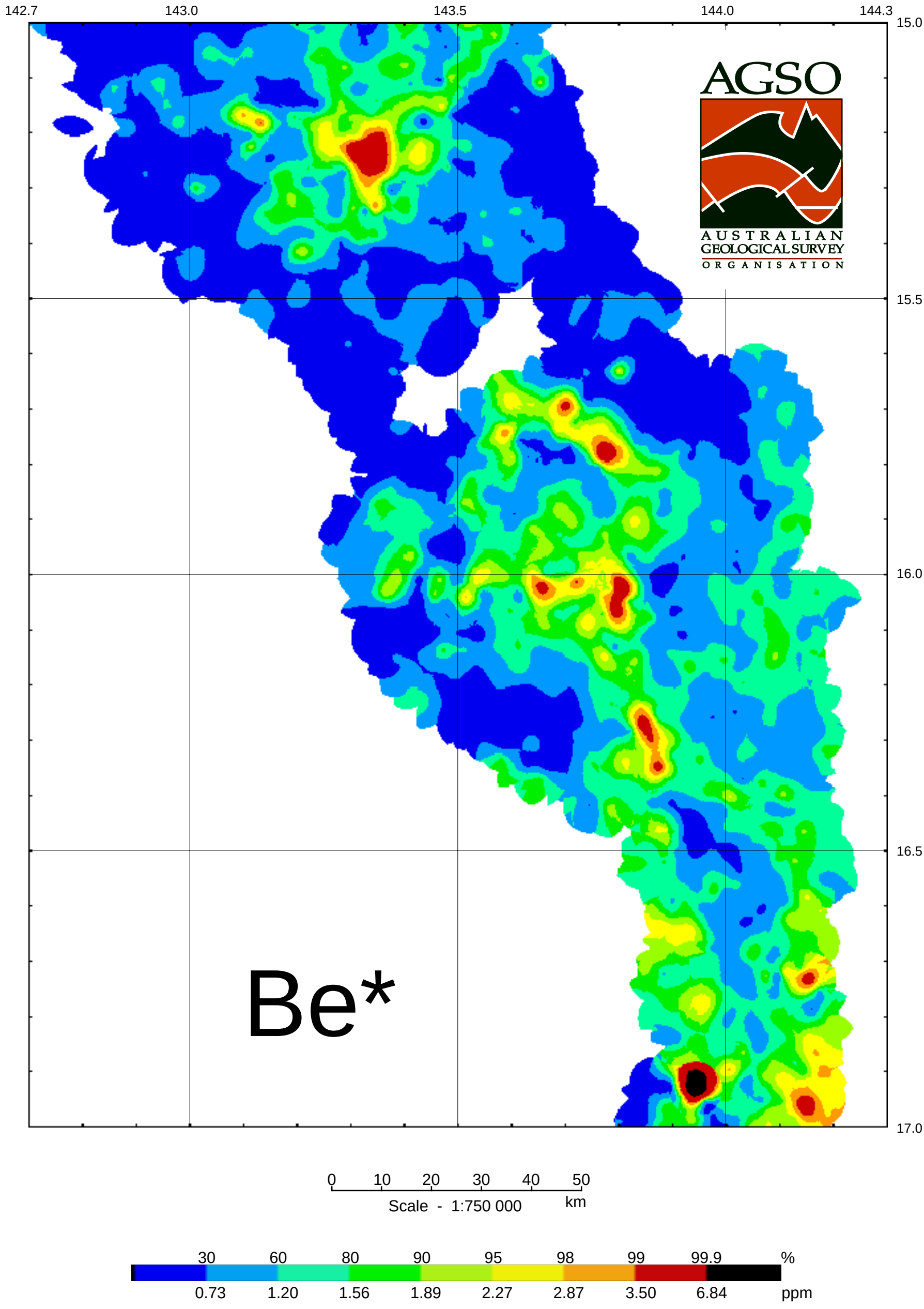
Hann River Region



Beryllium (-180µm)

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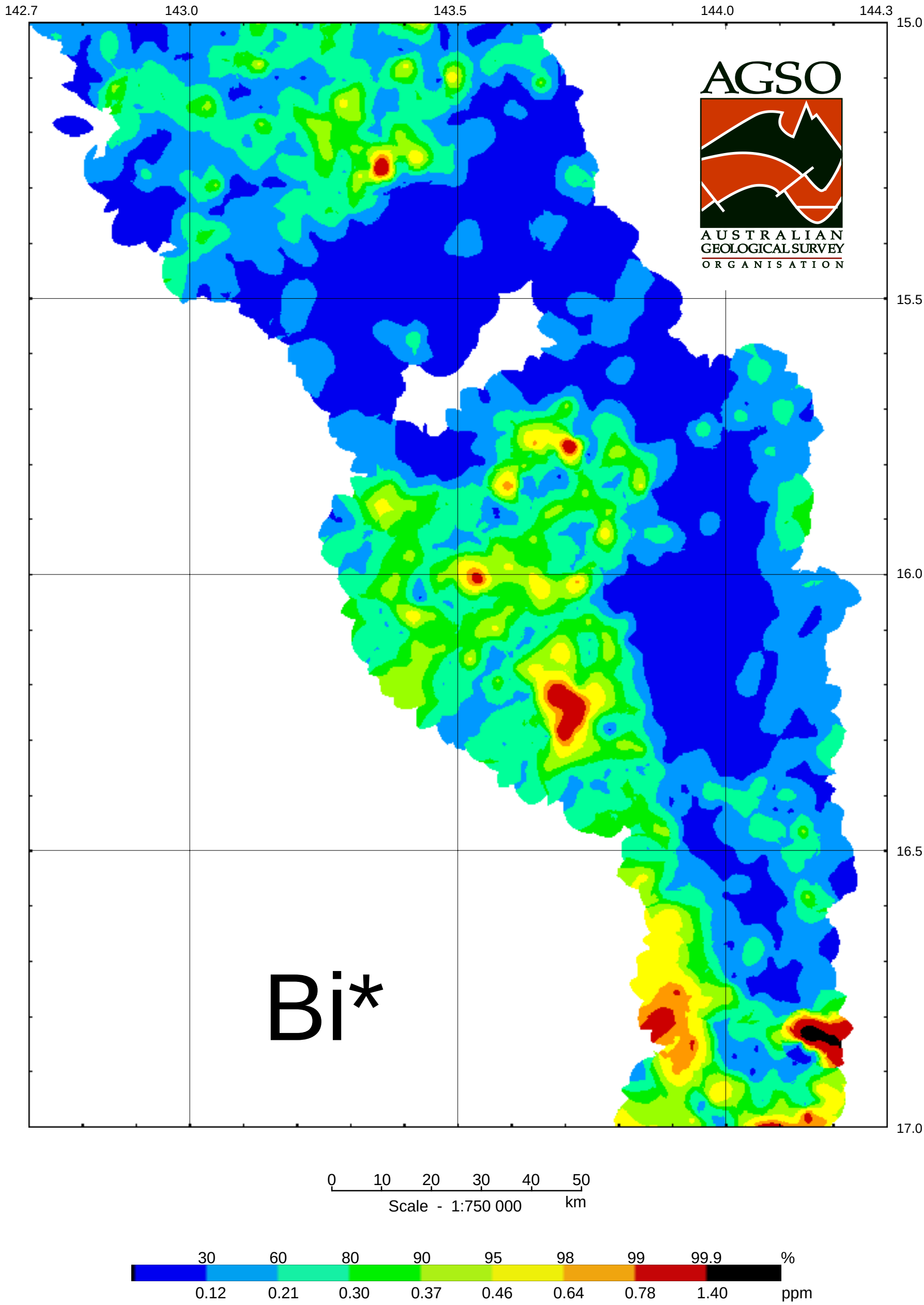

Bismuth (-180µm)

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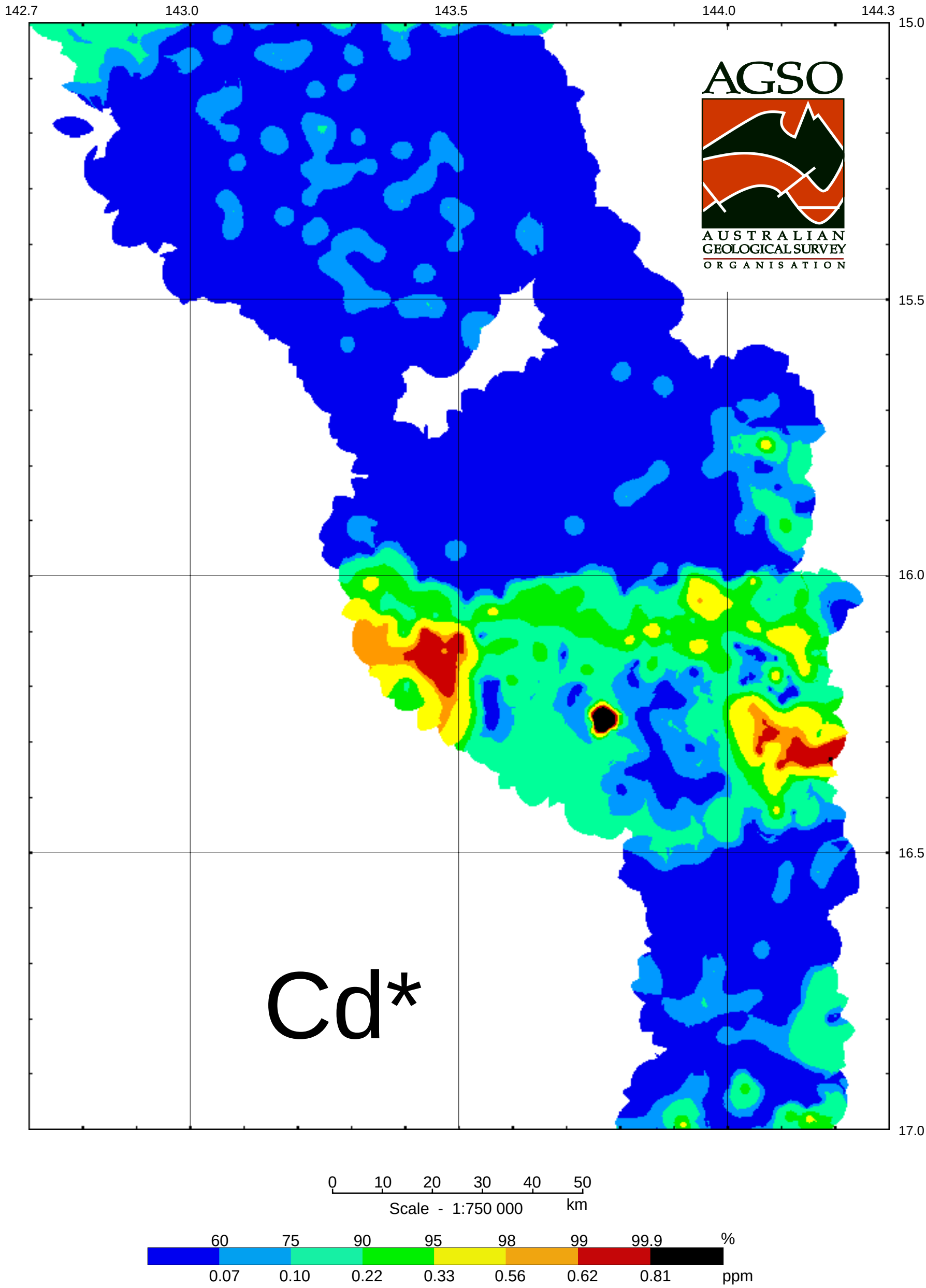

Cadmium (-180µm)

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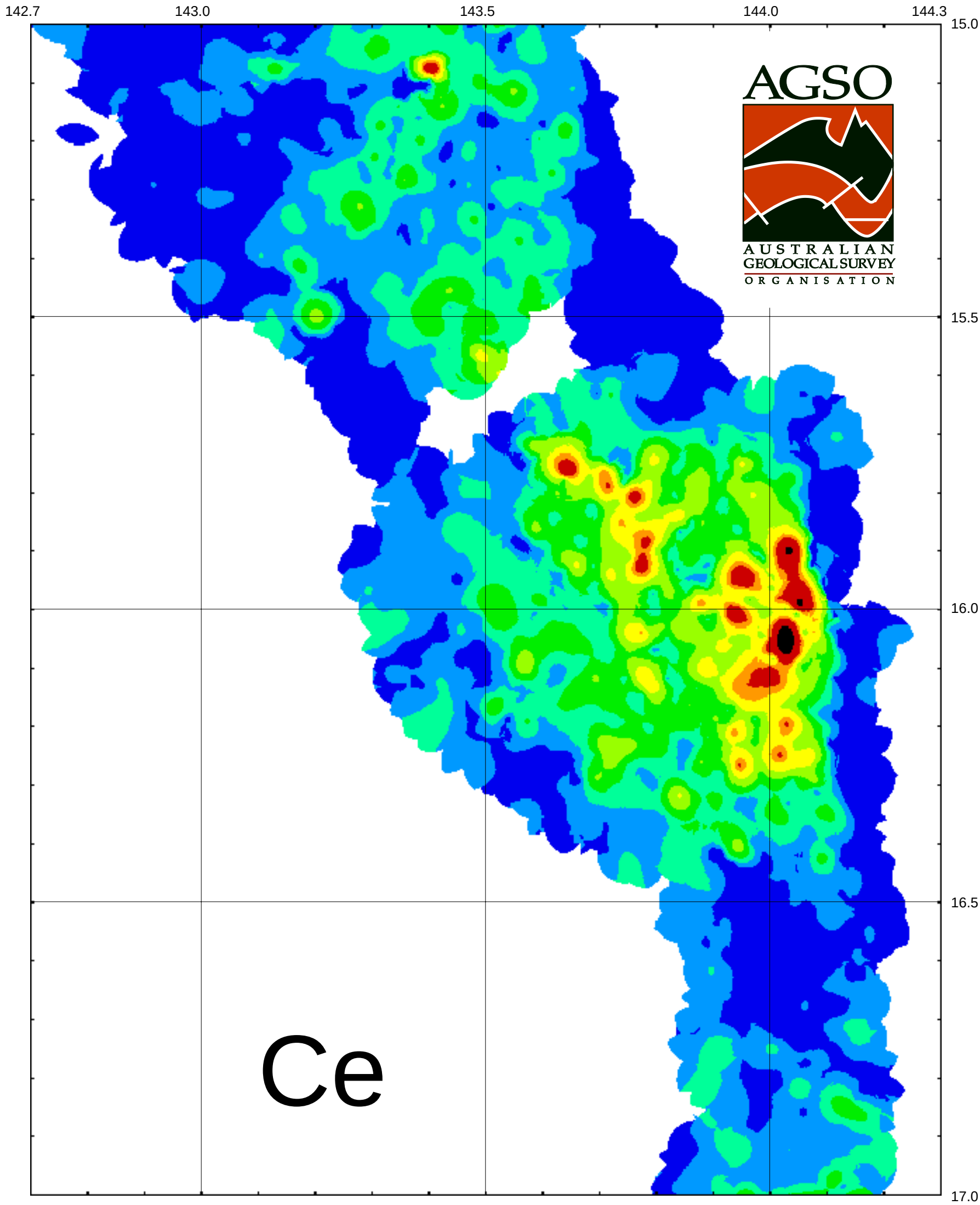

0 10 20 30 40 50 km

Scale - 1:750 000

30	60	80	90	95	98	99	99.9	%
48	101	207	409	754	1287	1688	3304	ppm

Cerium (-180µm)

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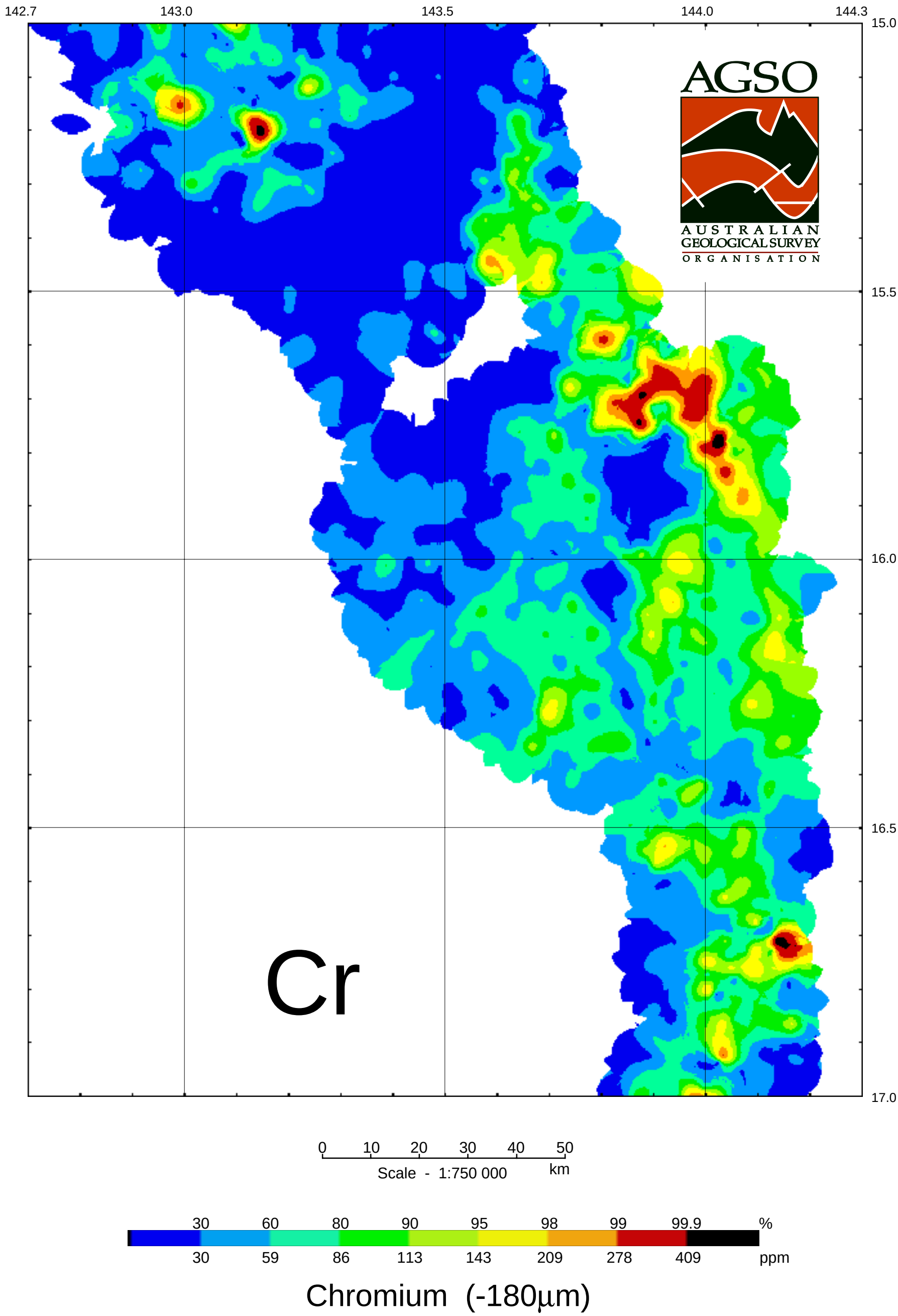

Chromium (-180µm)

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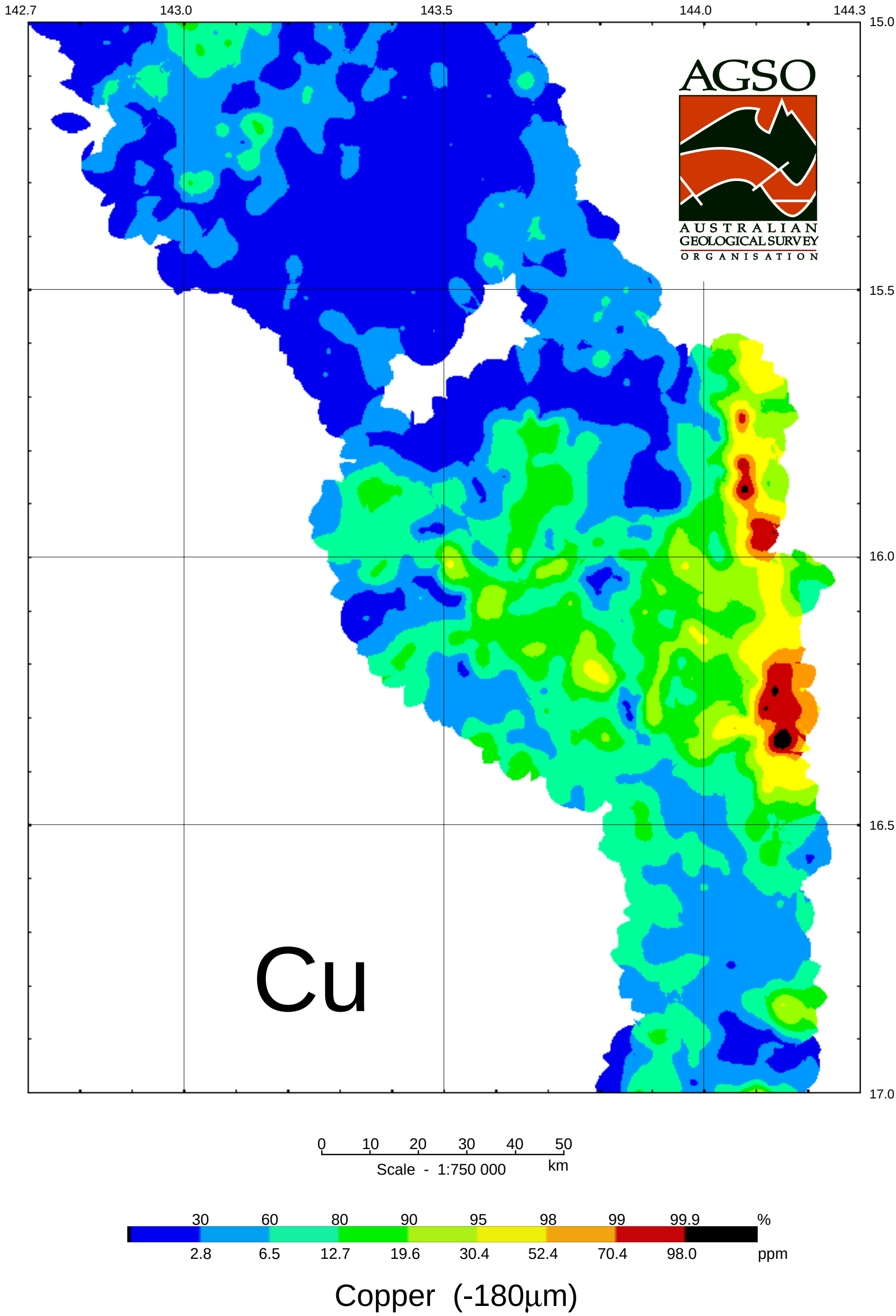

Copper (-180µm)

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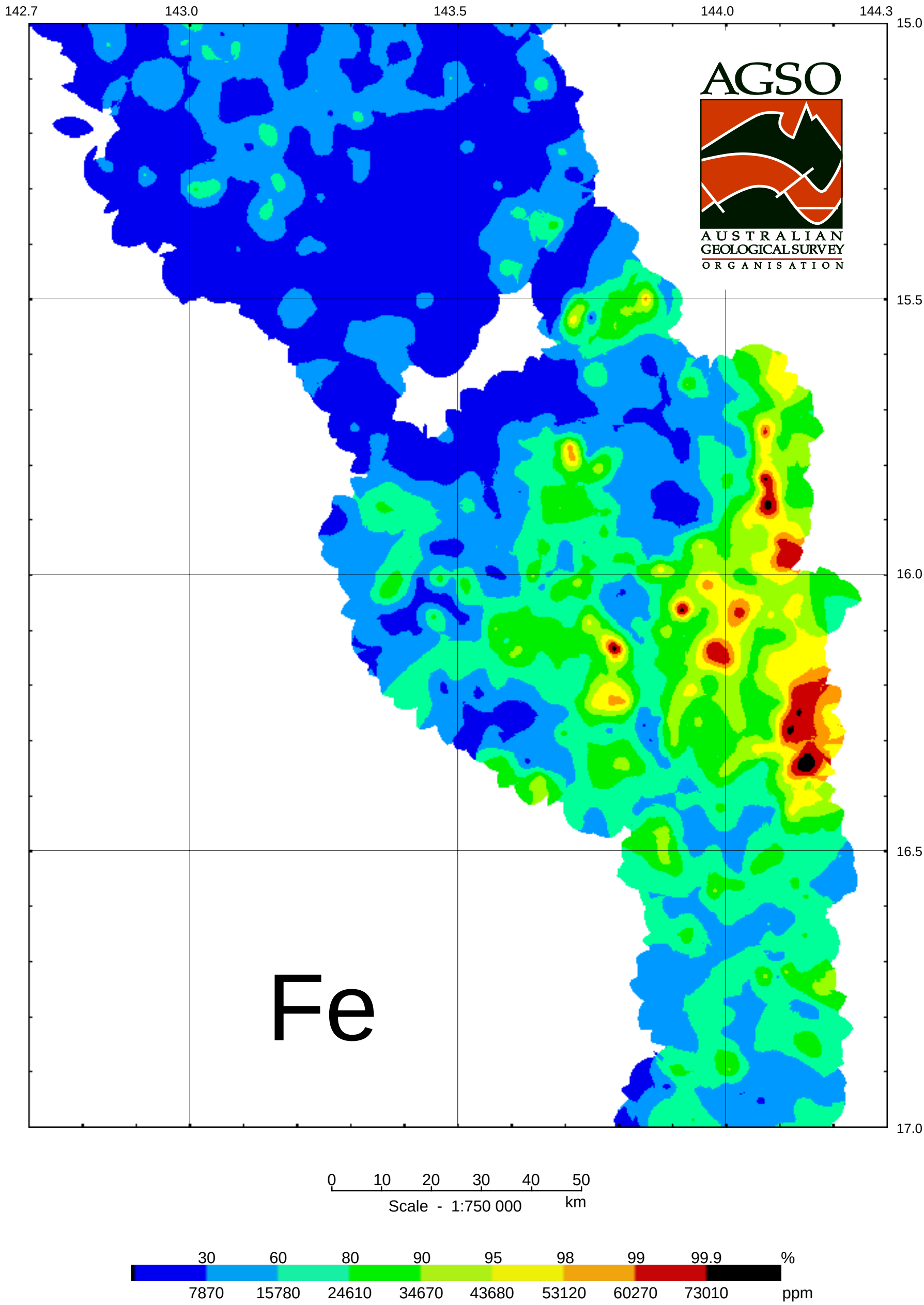

Iron (-180µm)

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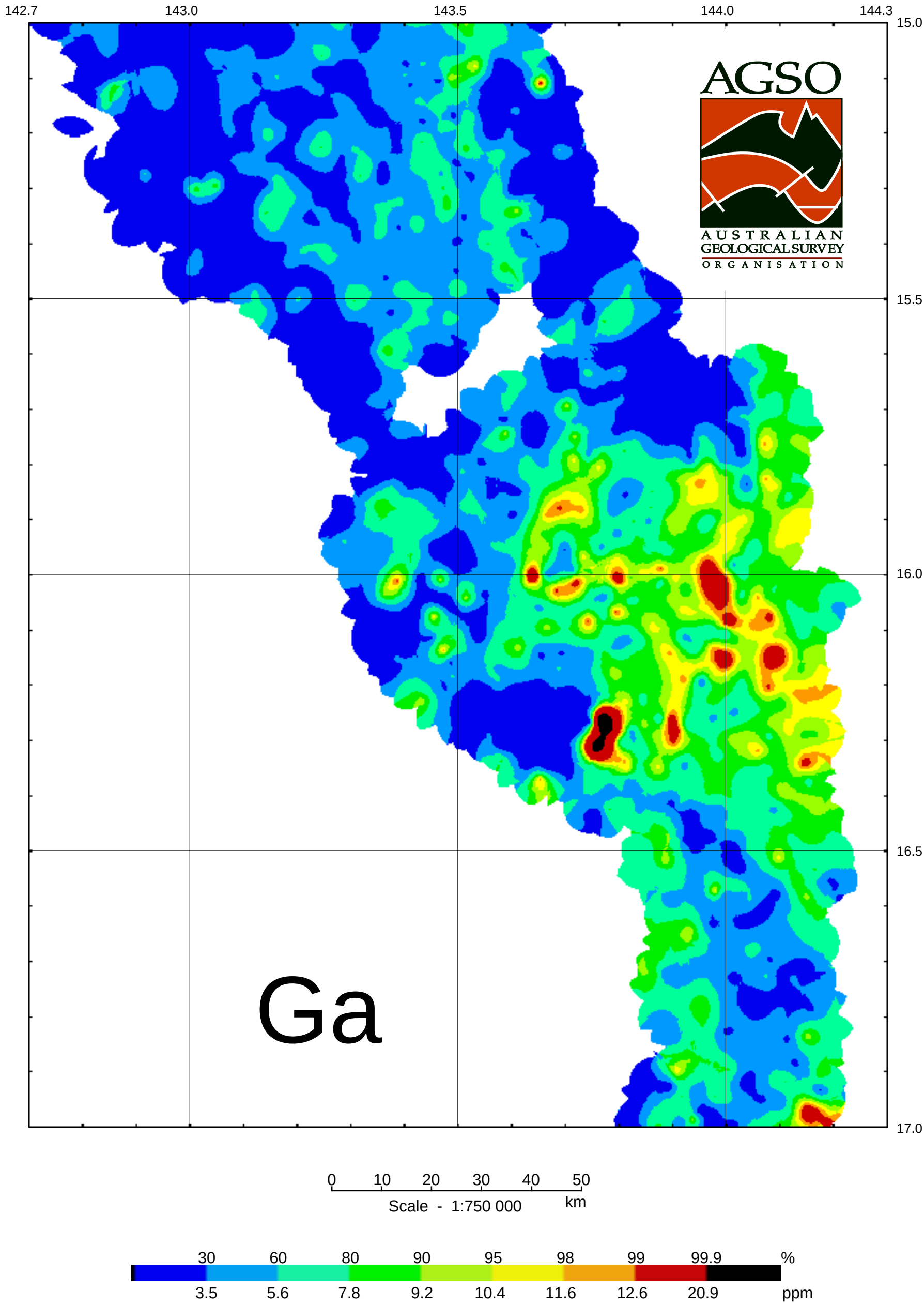

Gallium (-180µm)

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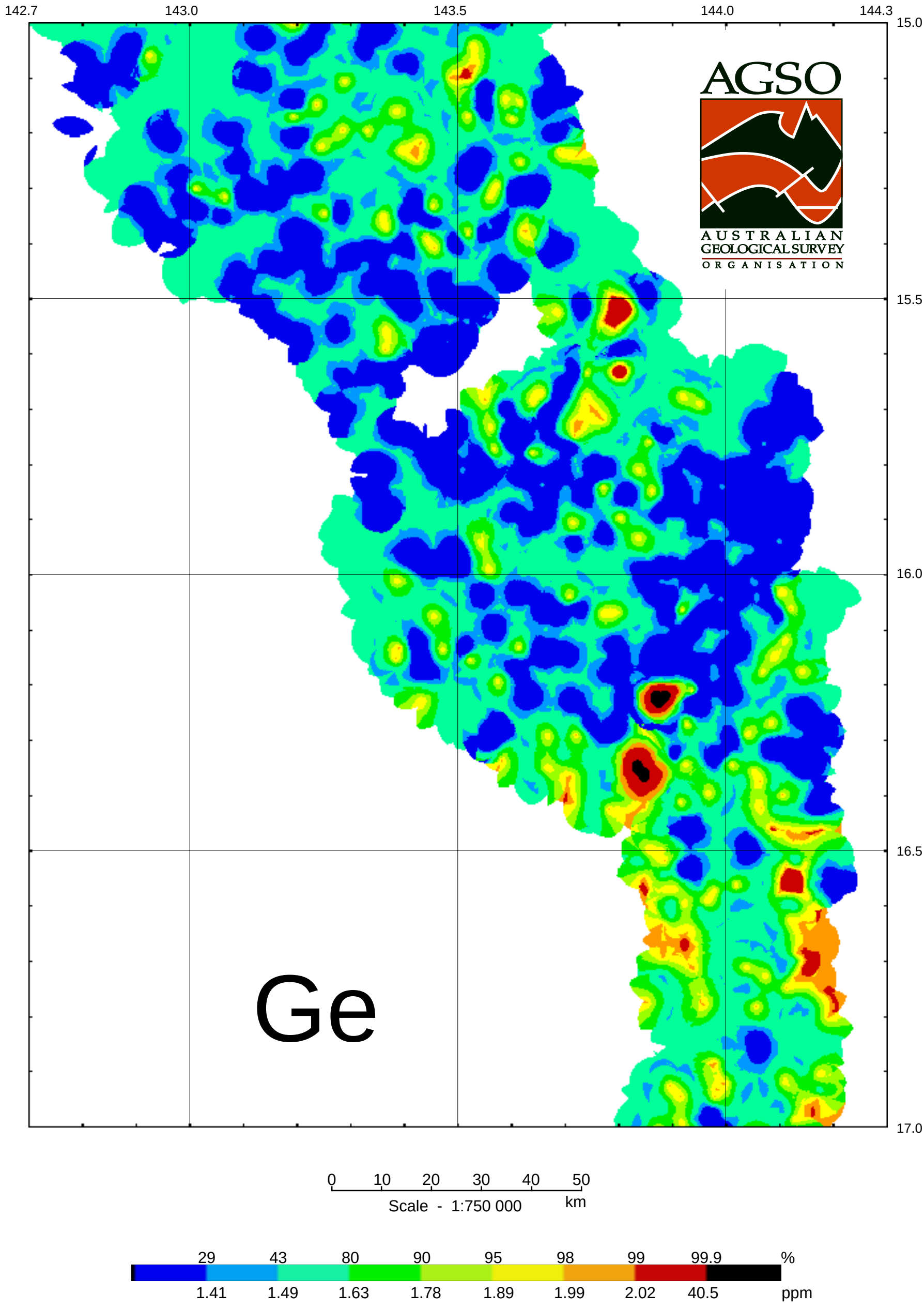

Germanium (-180µm)

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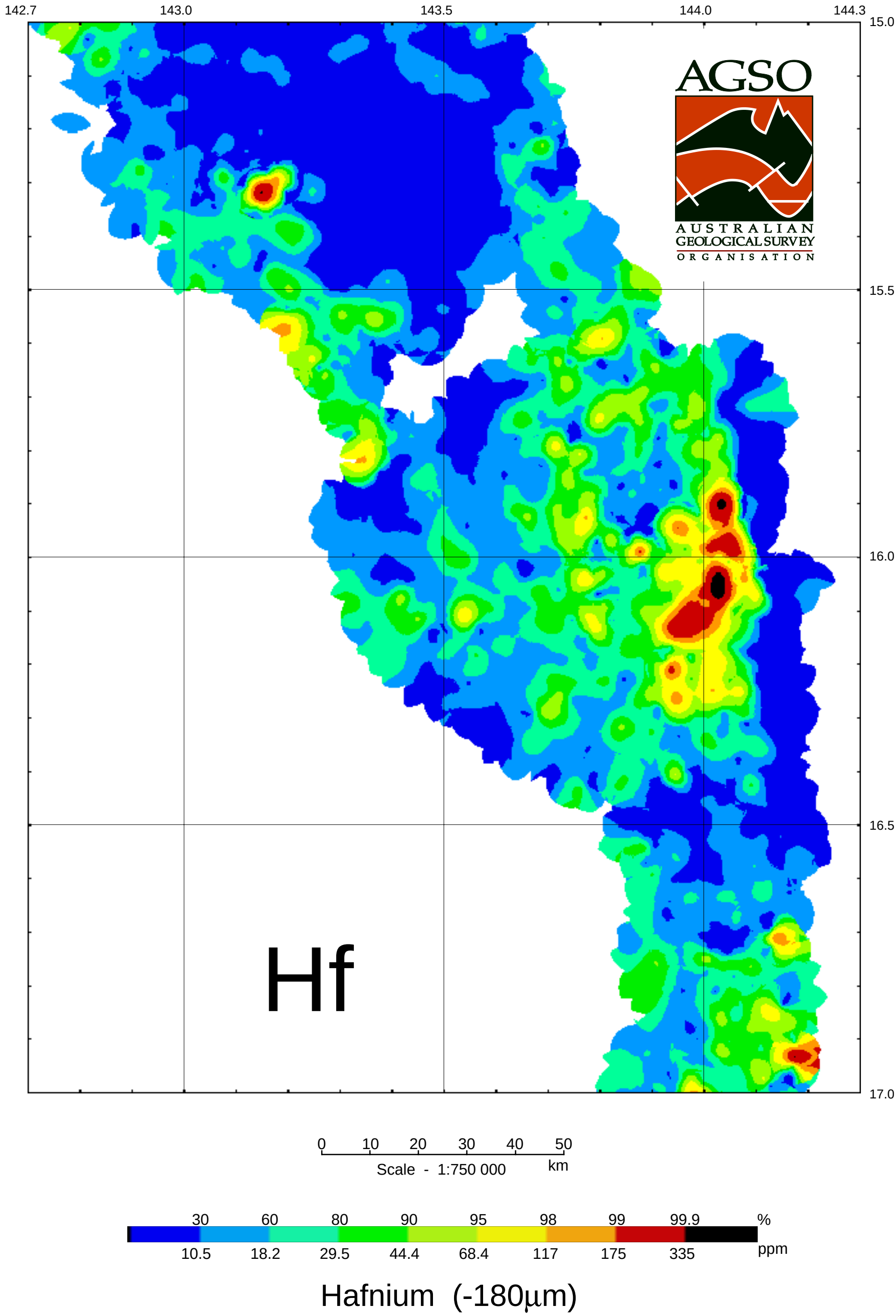

Hafnium (-180µm)

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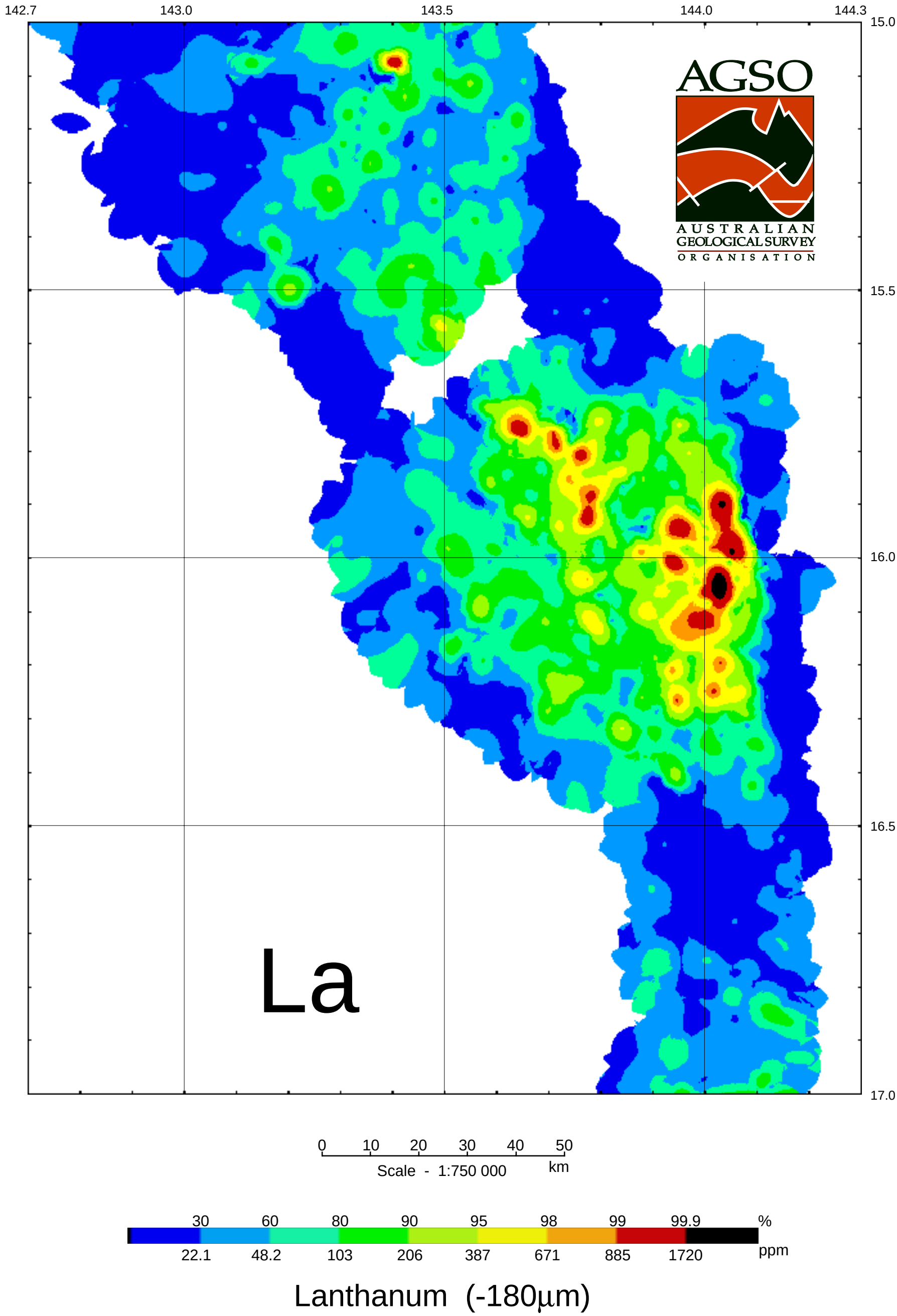

Lanthanum (-180µm)

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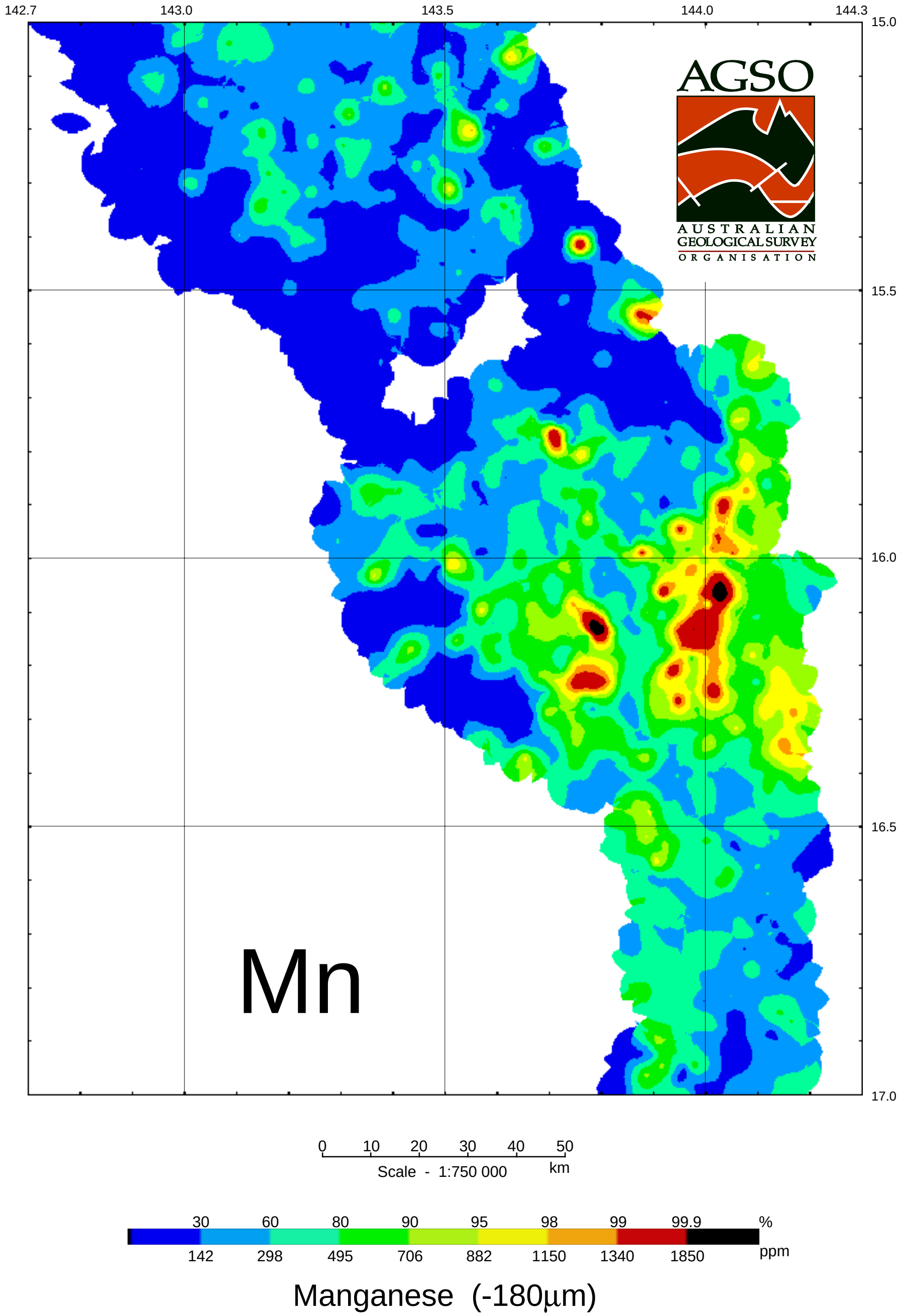

Manganese (-180µm)

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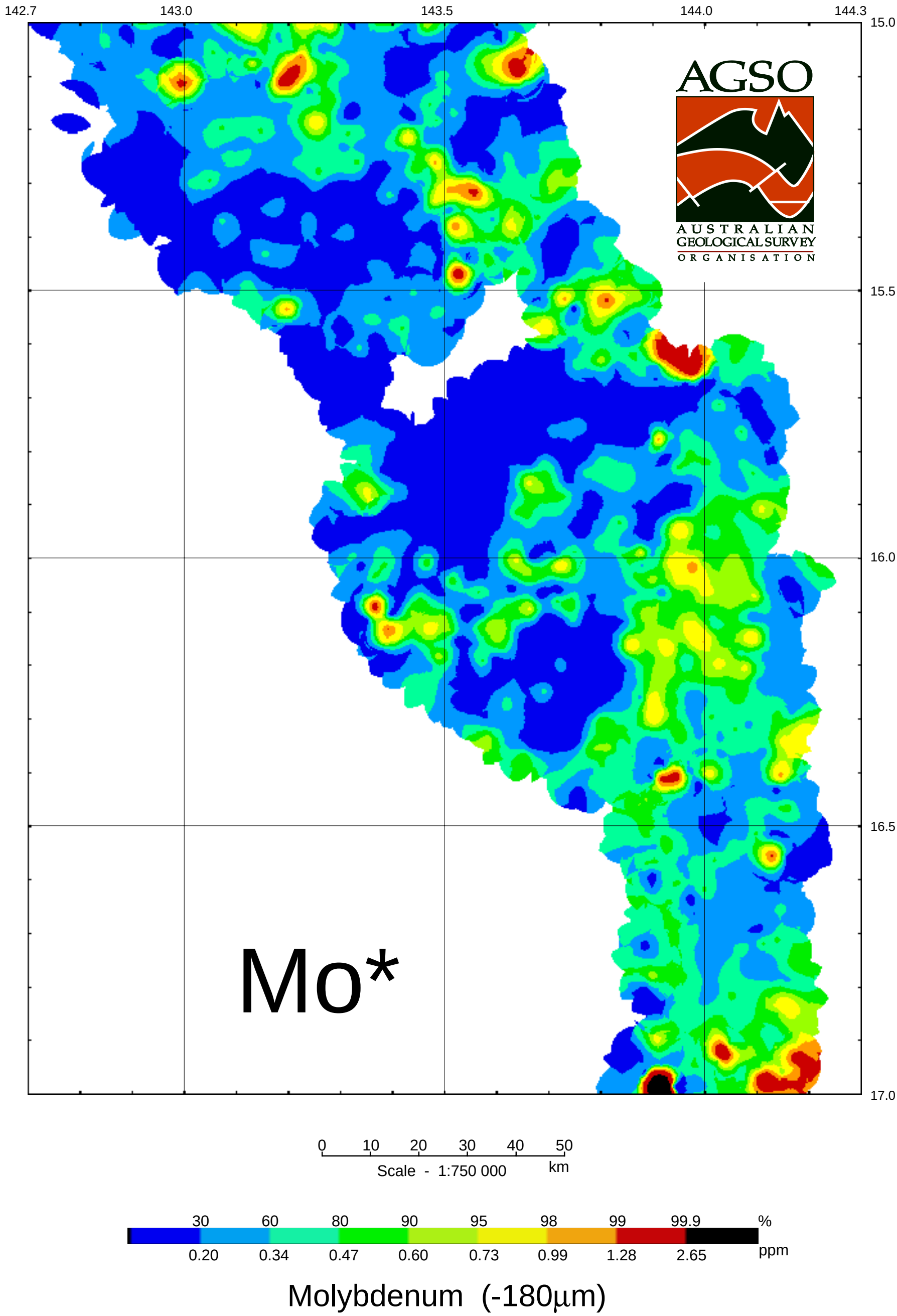

Molybdenum (-180µm)

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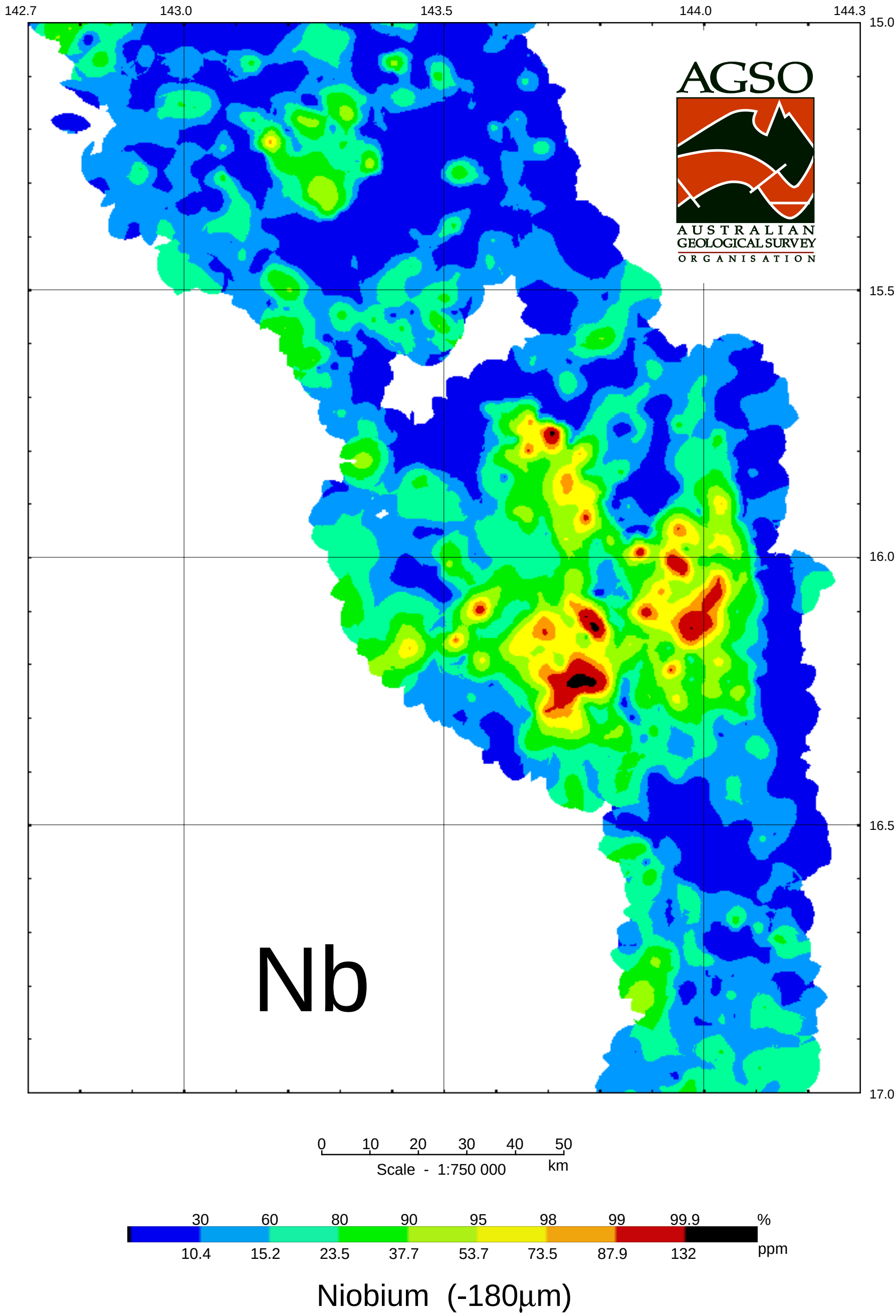
Hann River Region



Niobium (-180µm)

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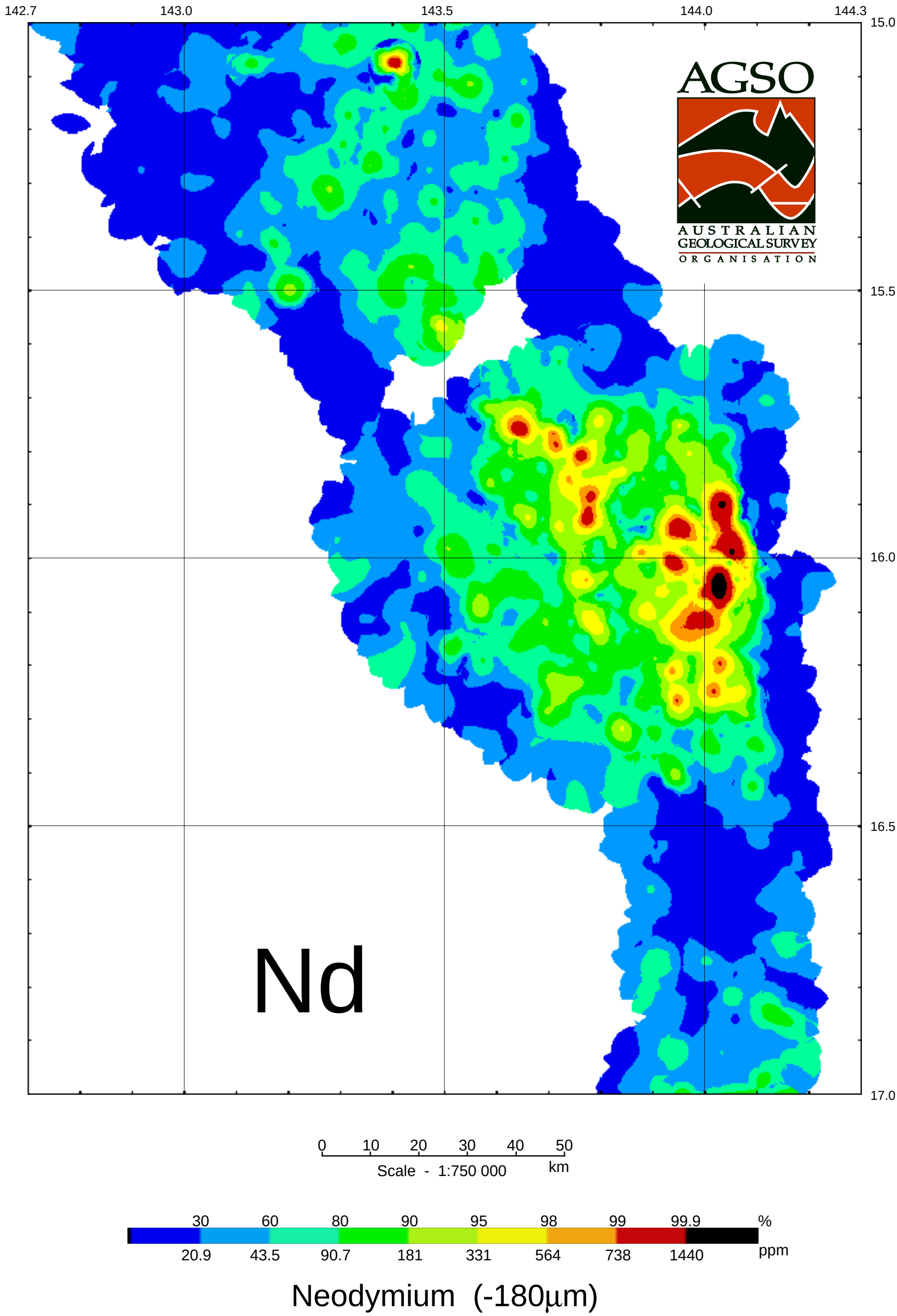
Hann River Region



Neodymium (-180µm)

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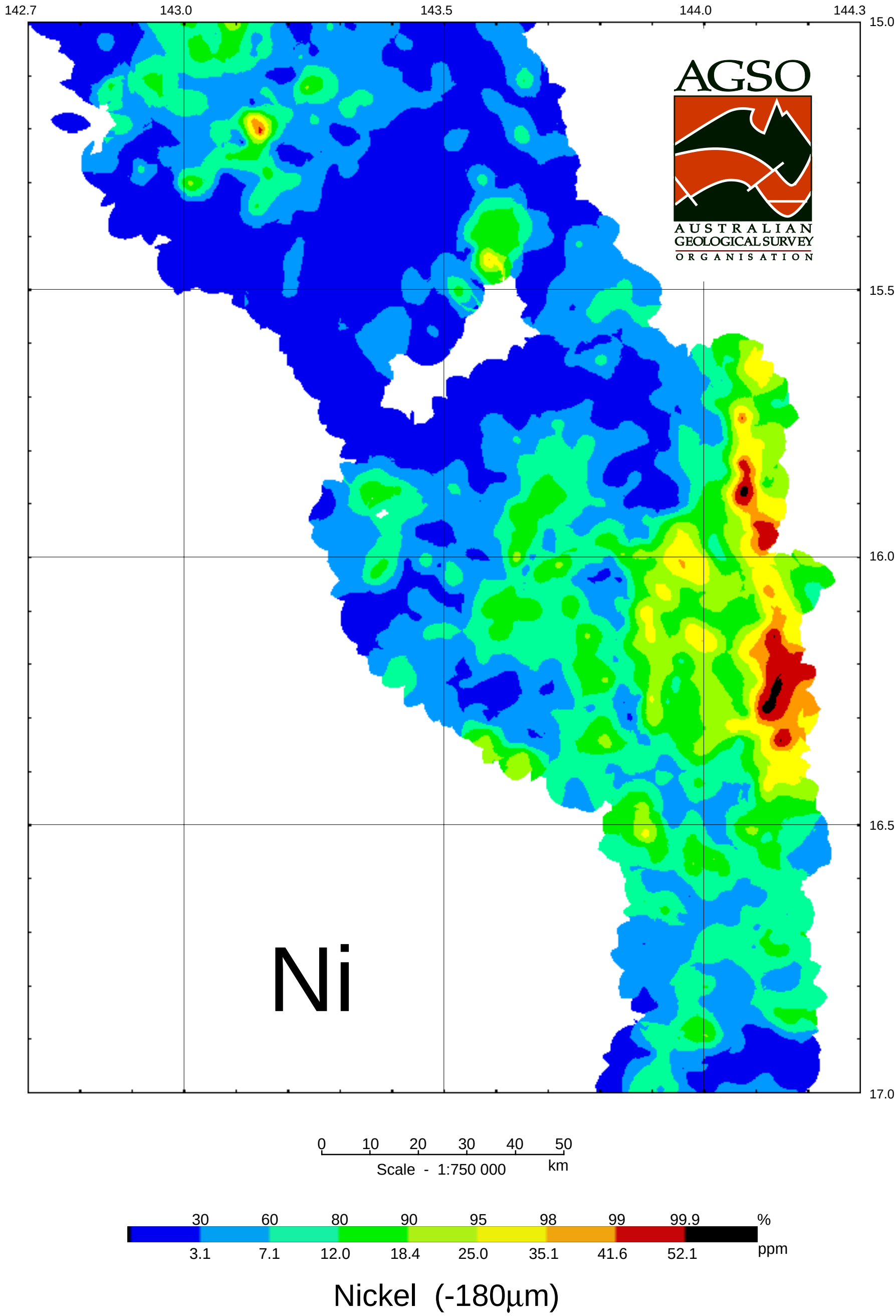
Hann River Region



Nickel (-180µm)

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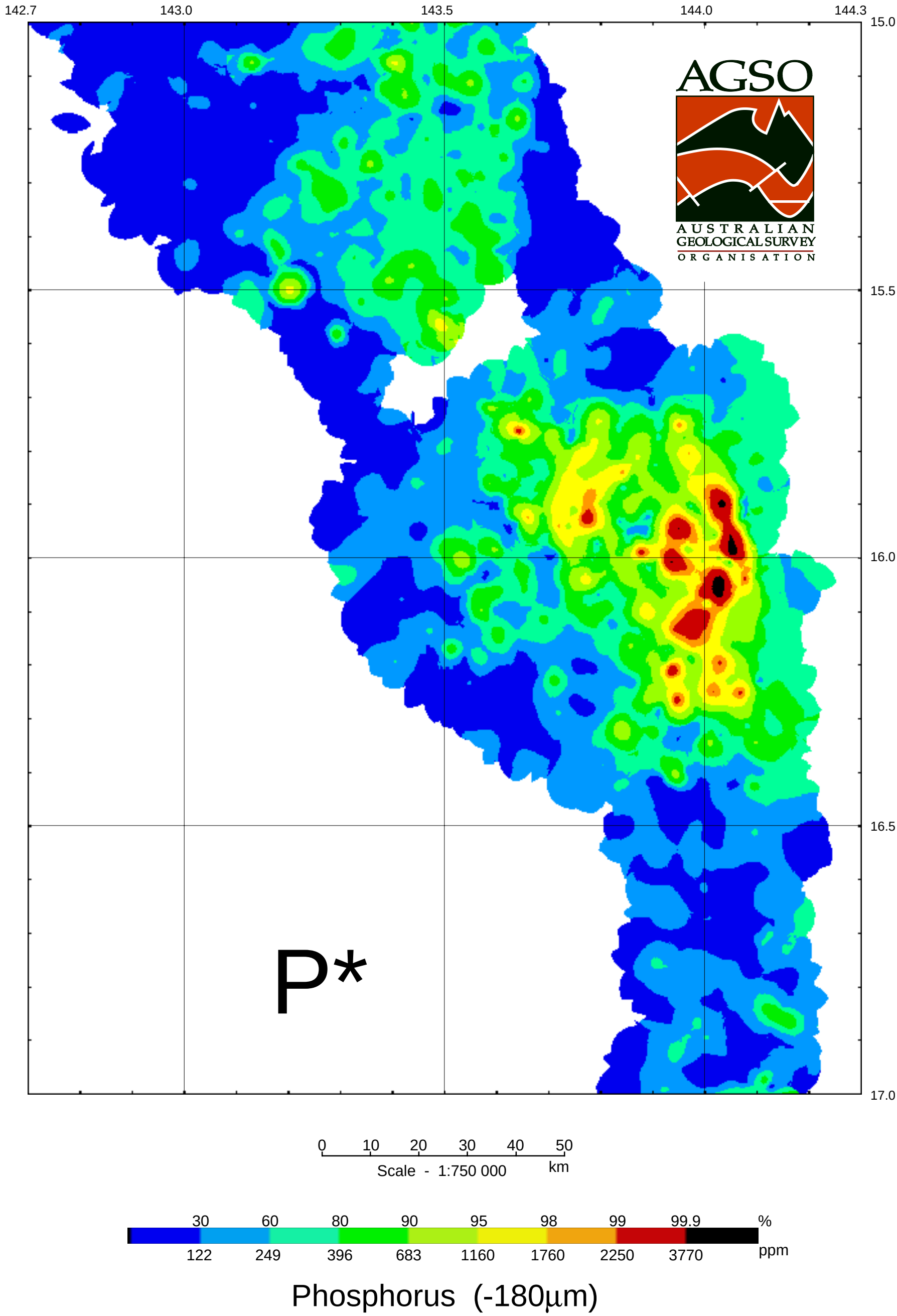

Phosphorus (-180µm)

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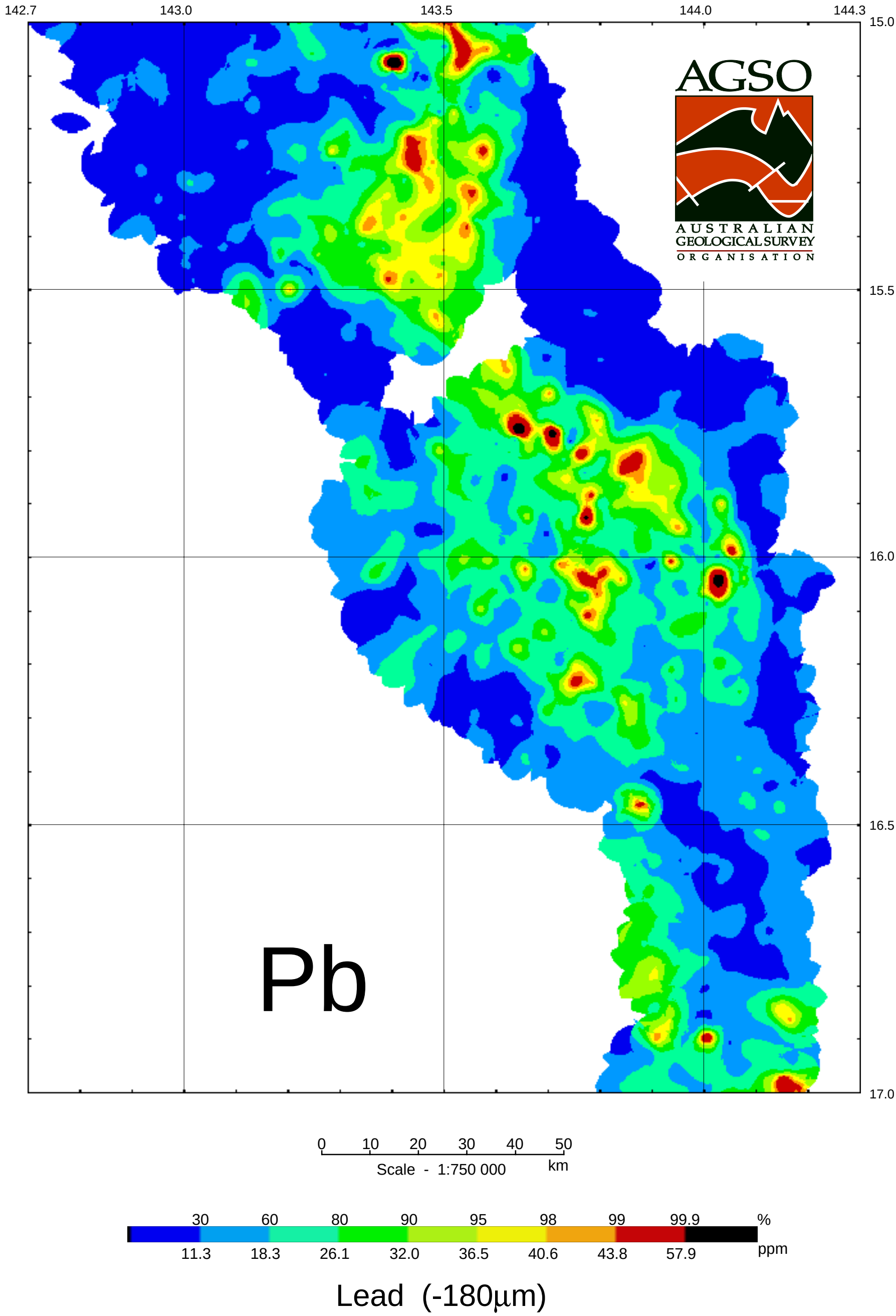

Lead (-180µm)

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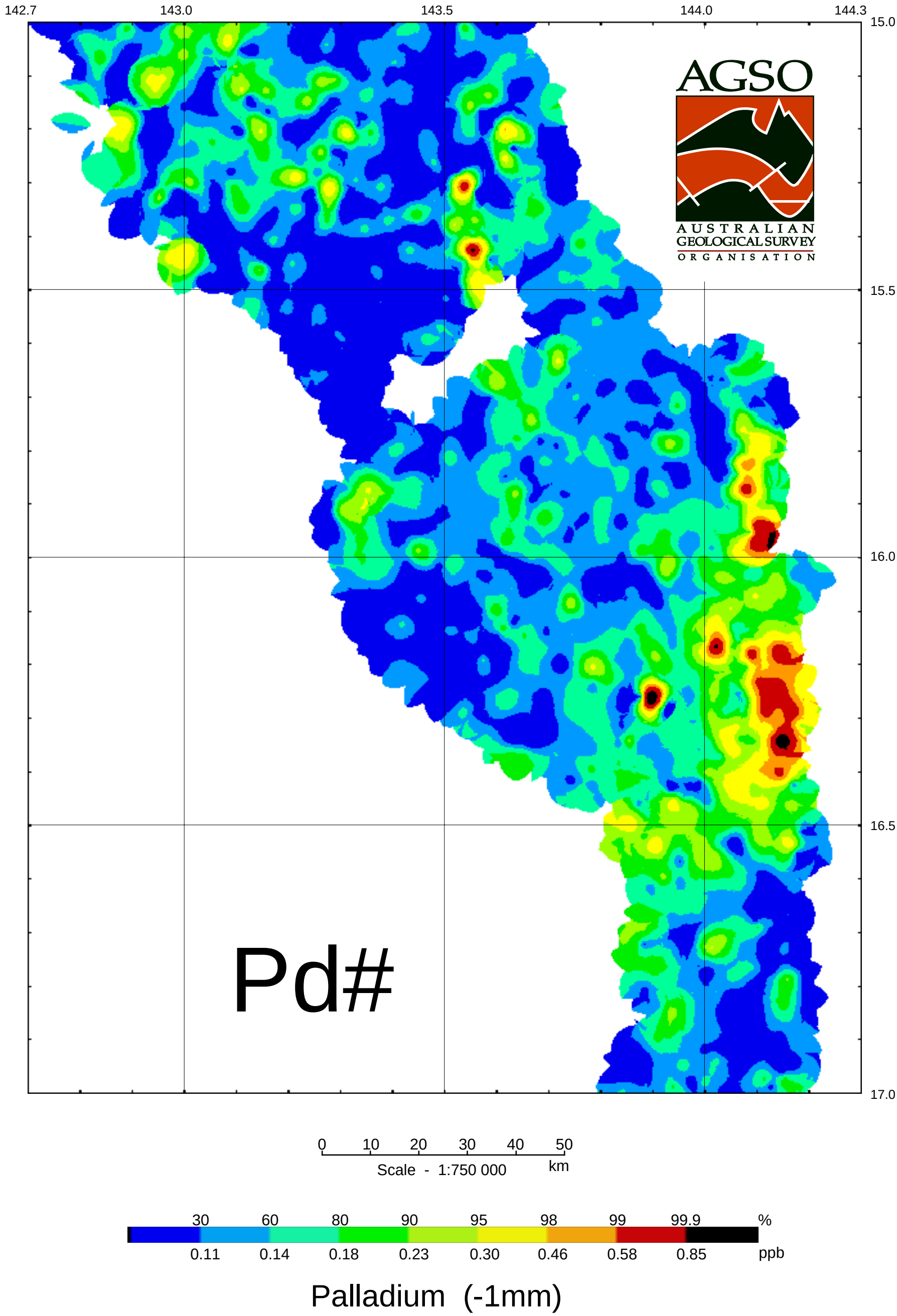

Palladium (-1mm)

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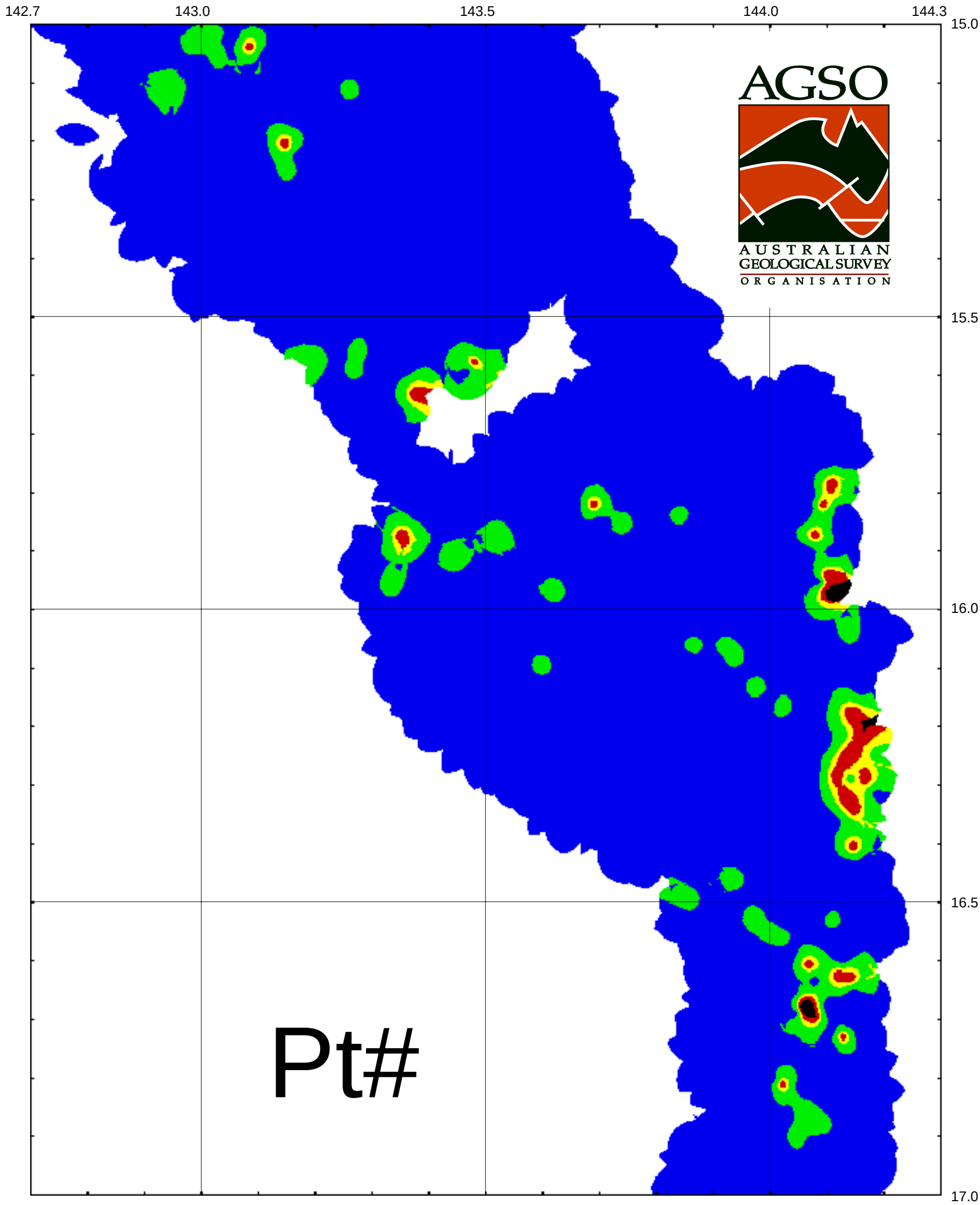

0 10 20 30 40 50 km

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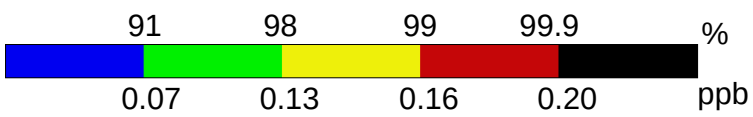

Platinum (-1mm)

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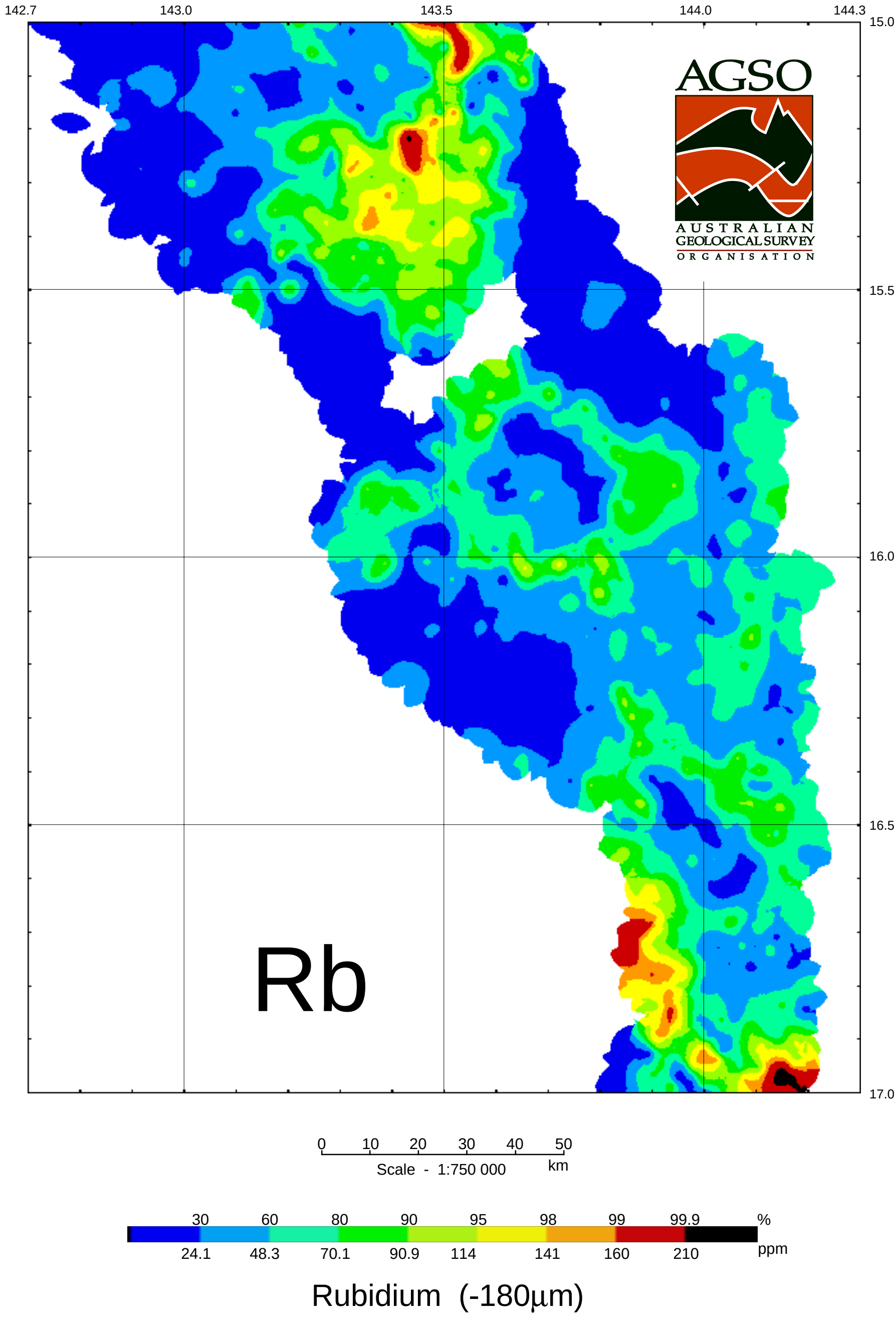

Rubidium (-180µm)

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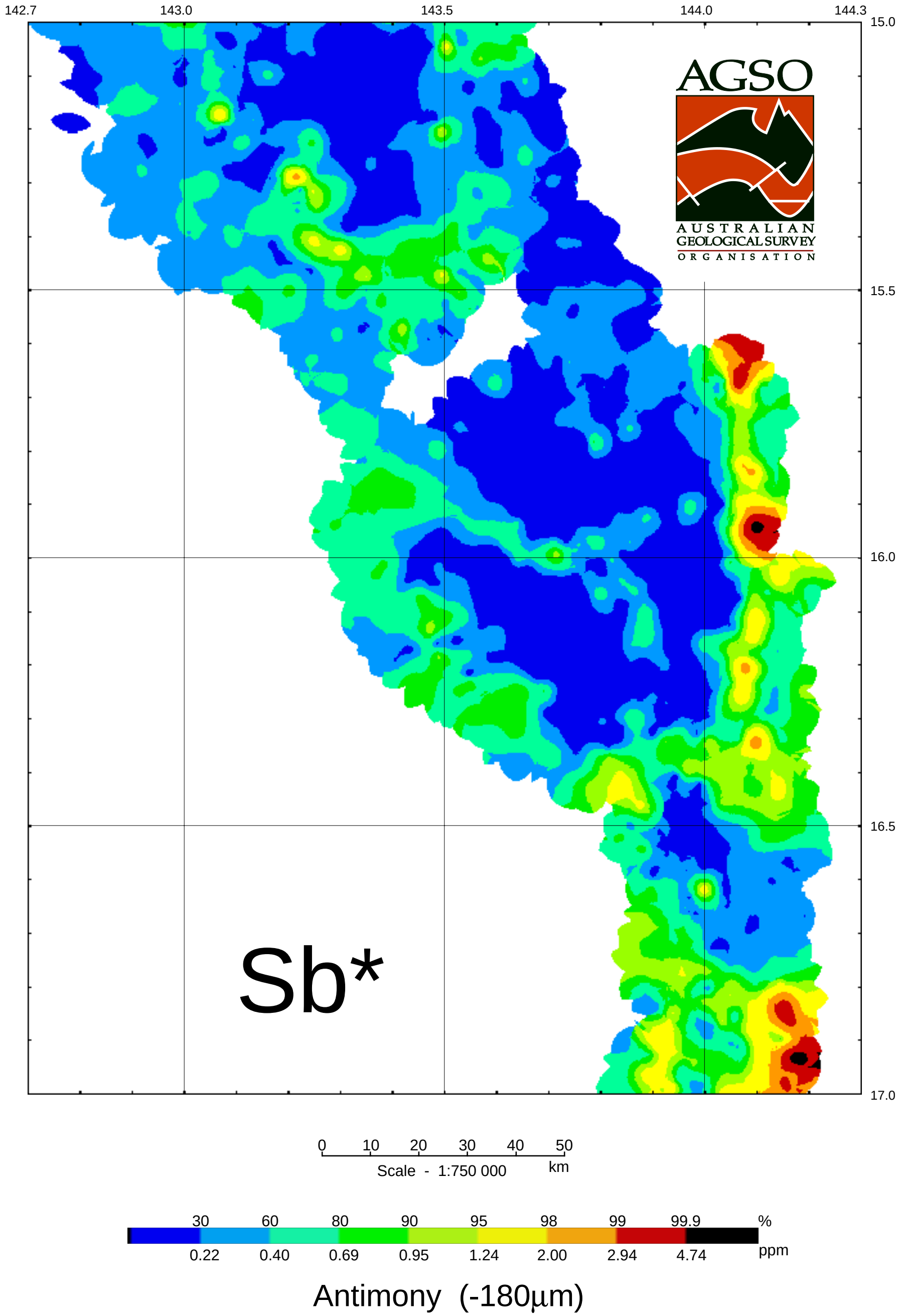

Antimony (-180µm)

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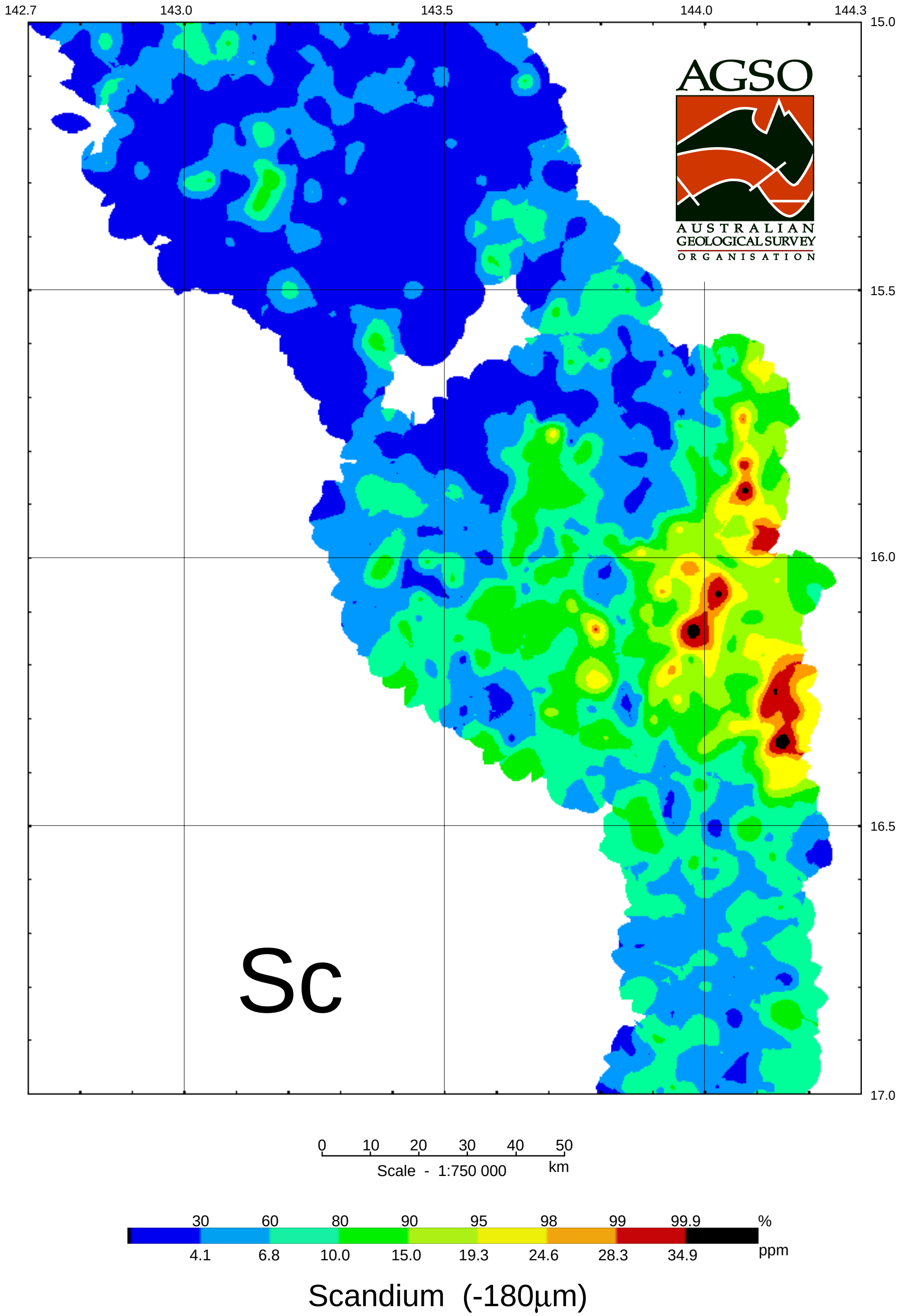

Scandium (-180µm)

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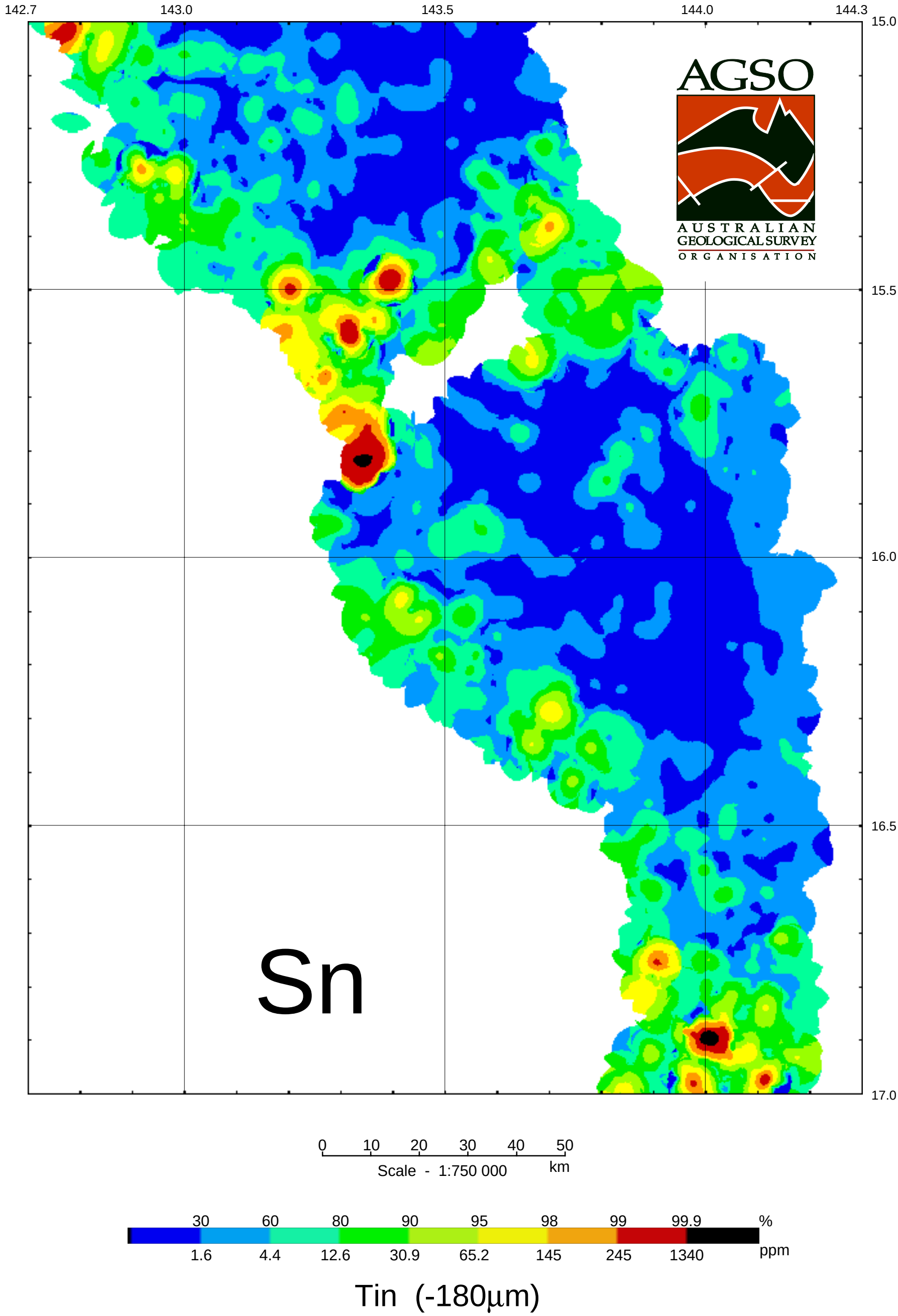

Tin (-180µm)

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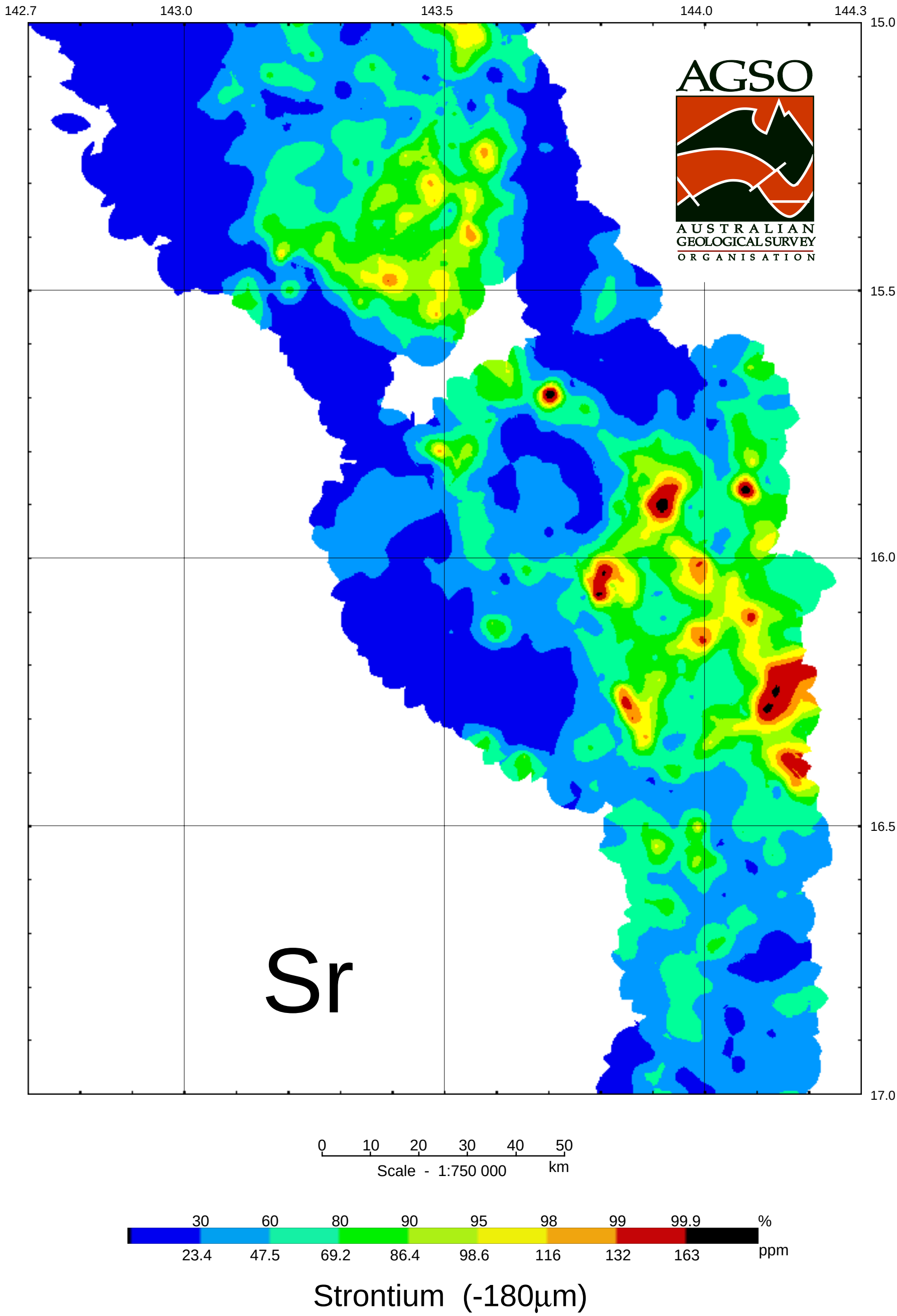

Strontium (-180µm)

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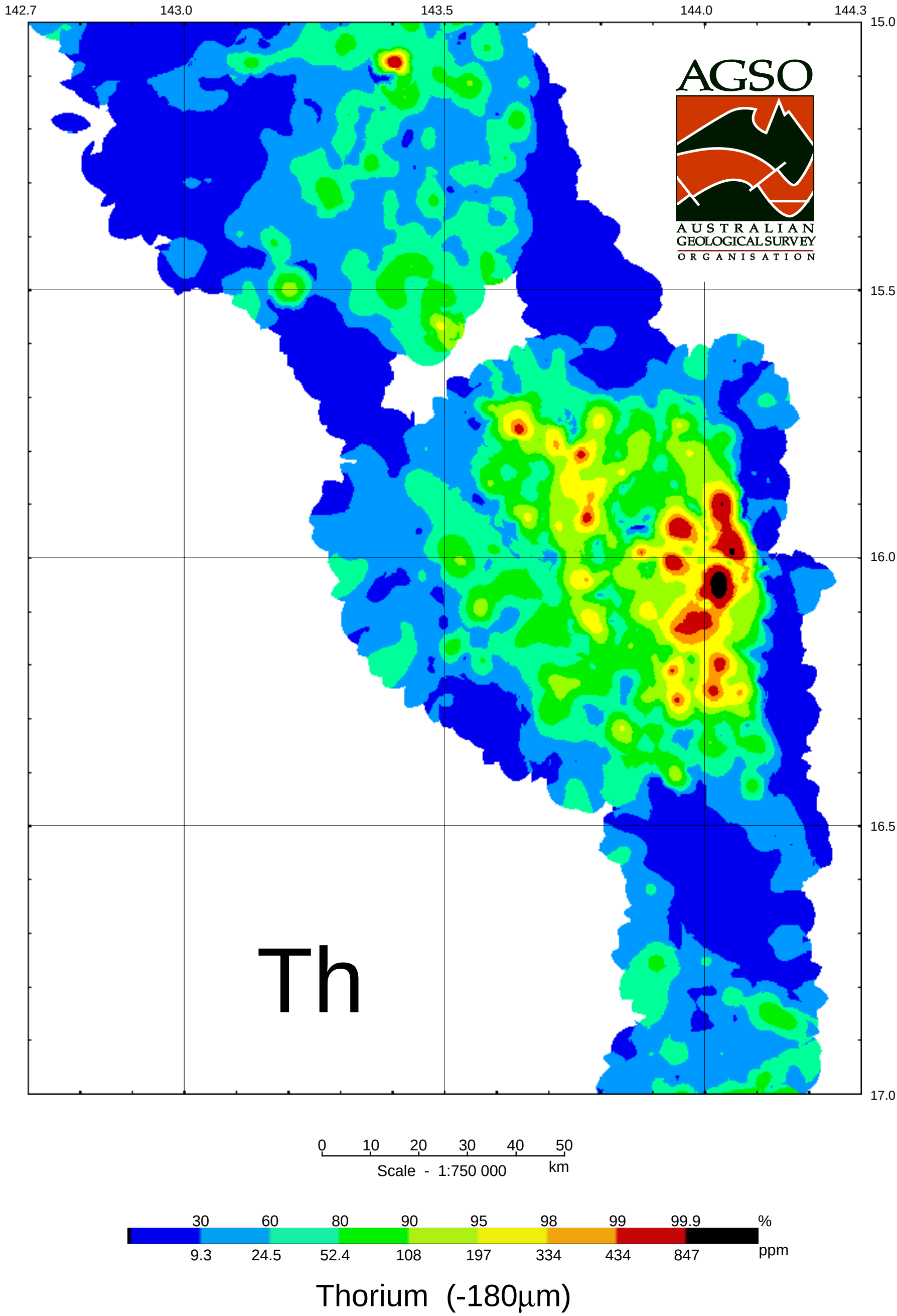

Thorium (-180µm)

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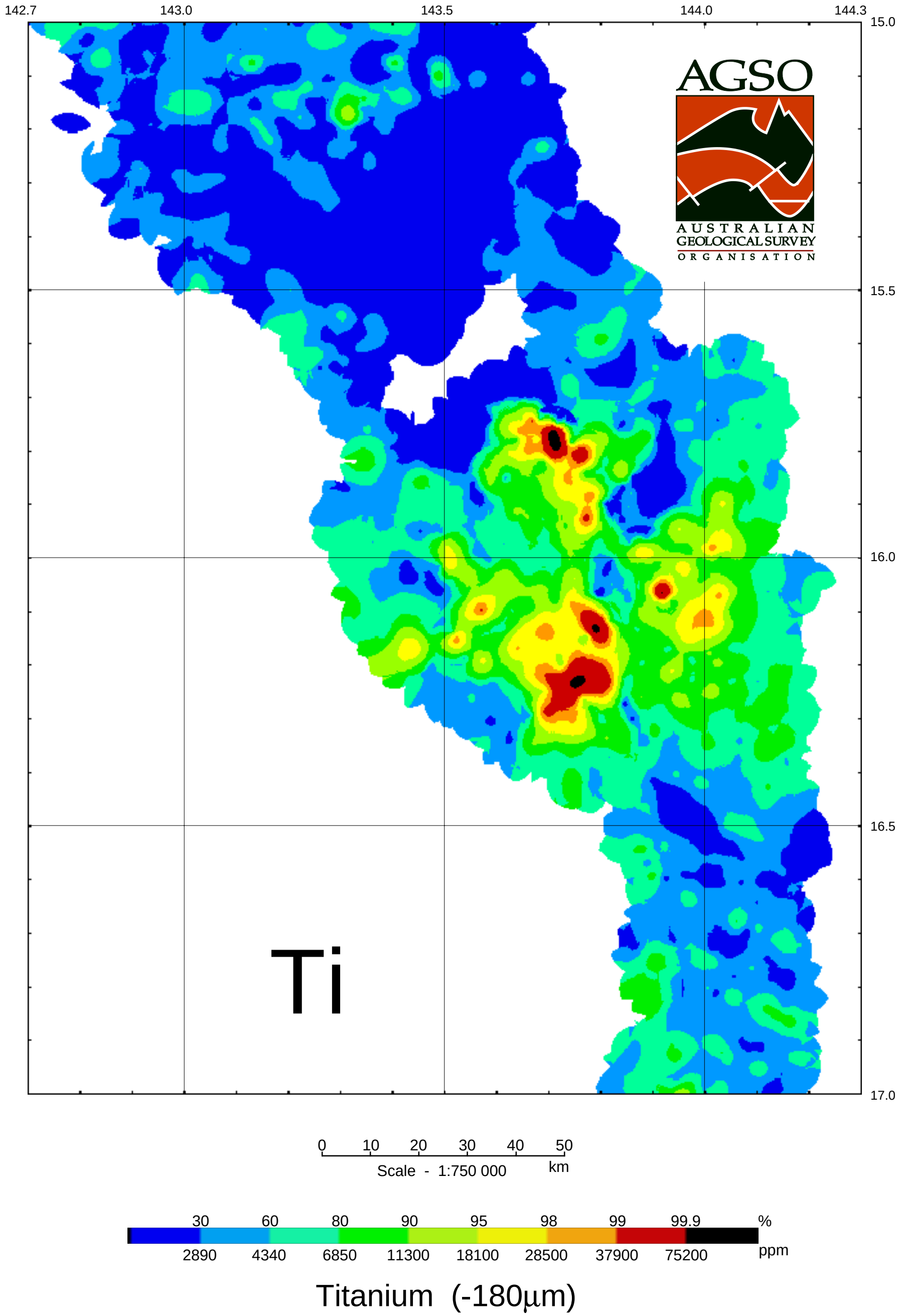

Titanium (-180µm)

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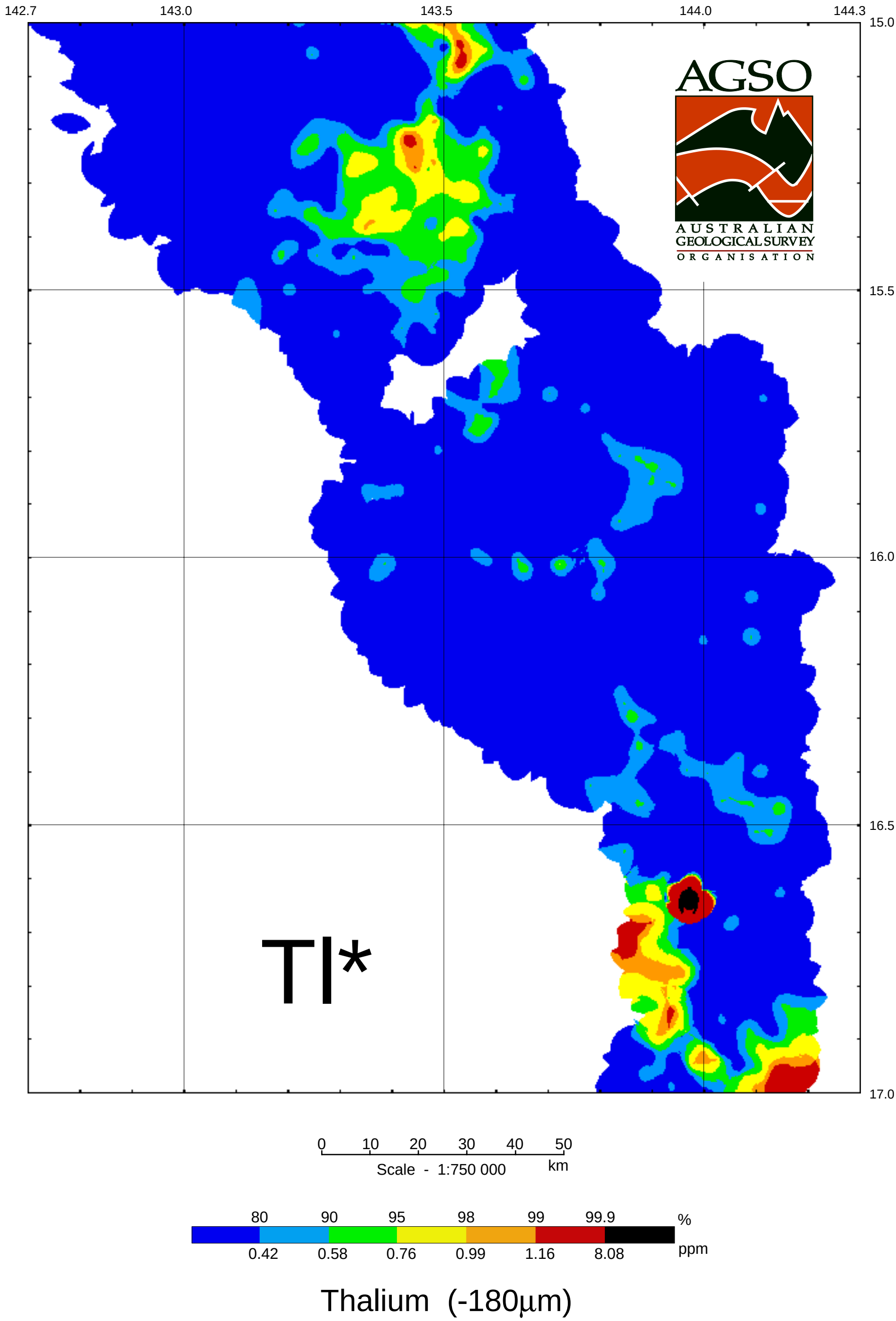

Thalium (-180µm)

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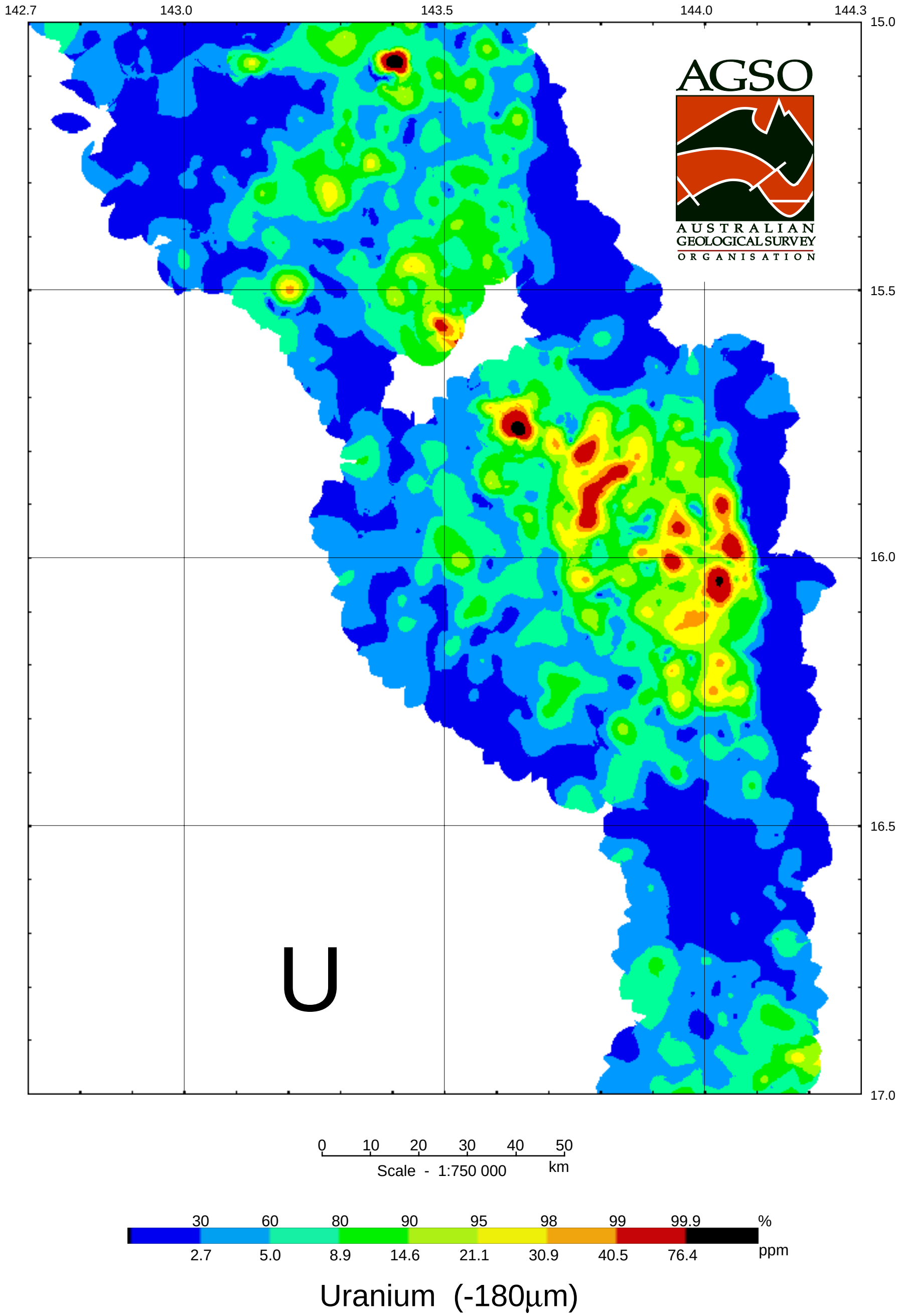

Uranium (-180µm)

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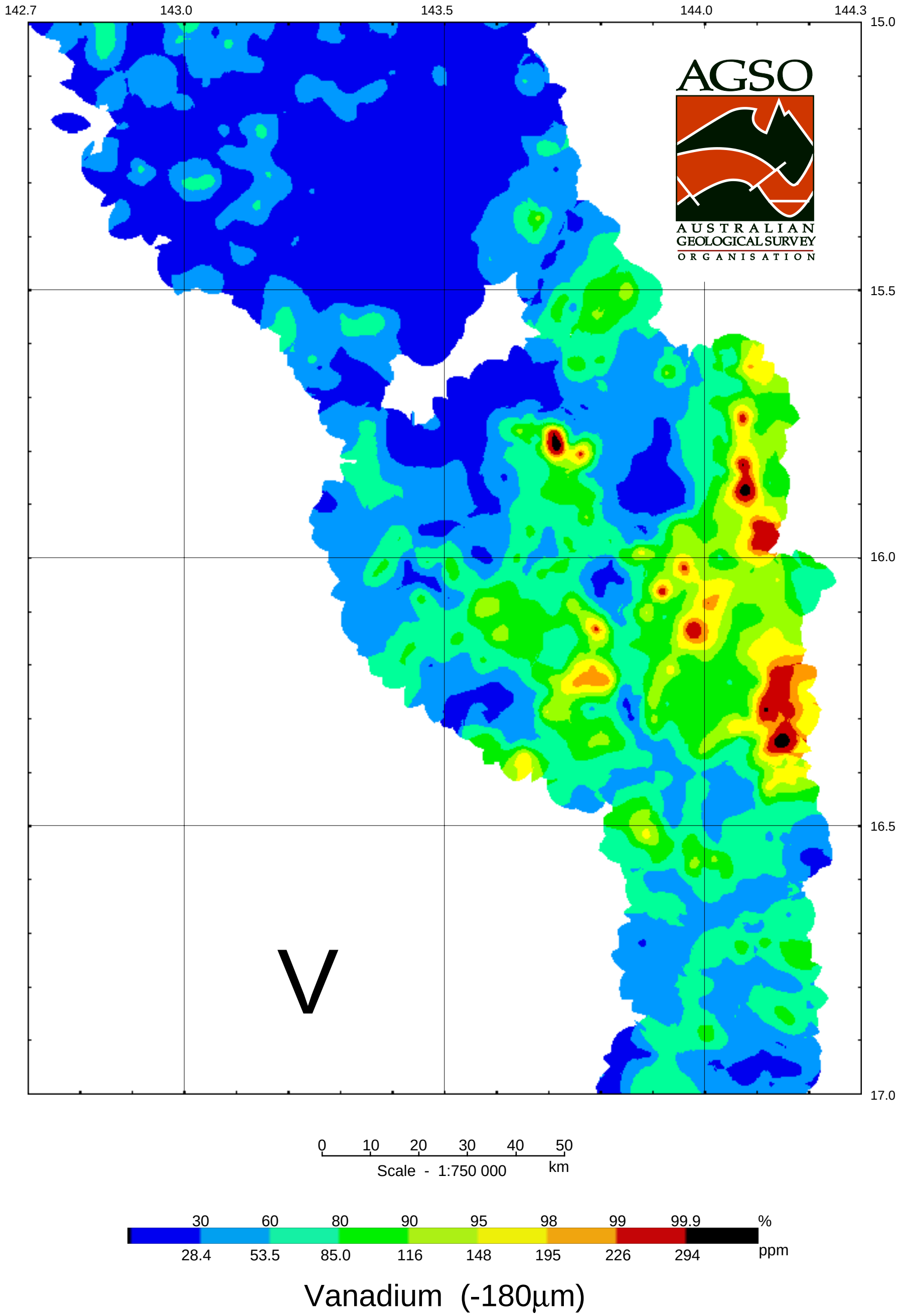

Vanadium (-180µm)

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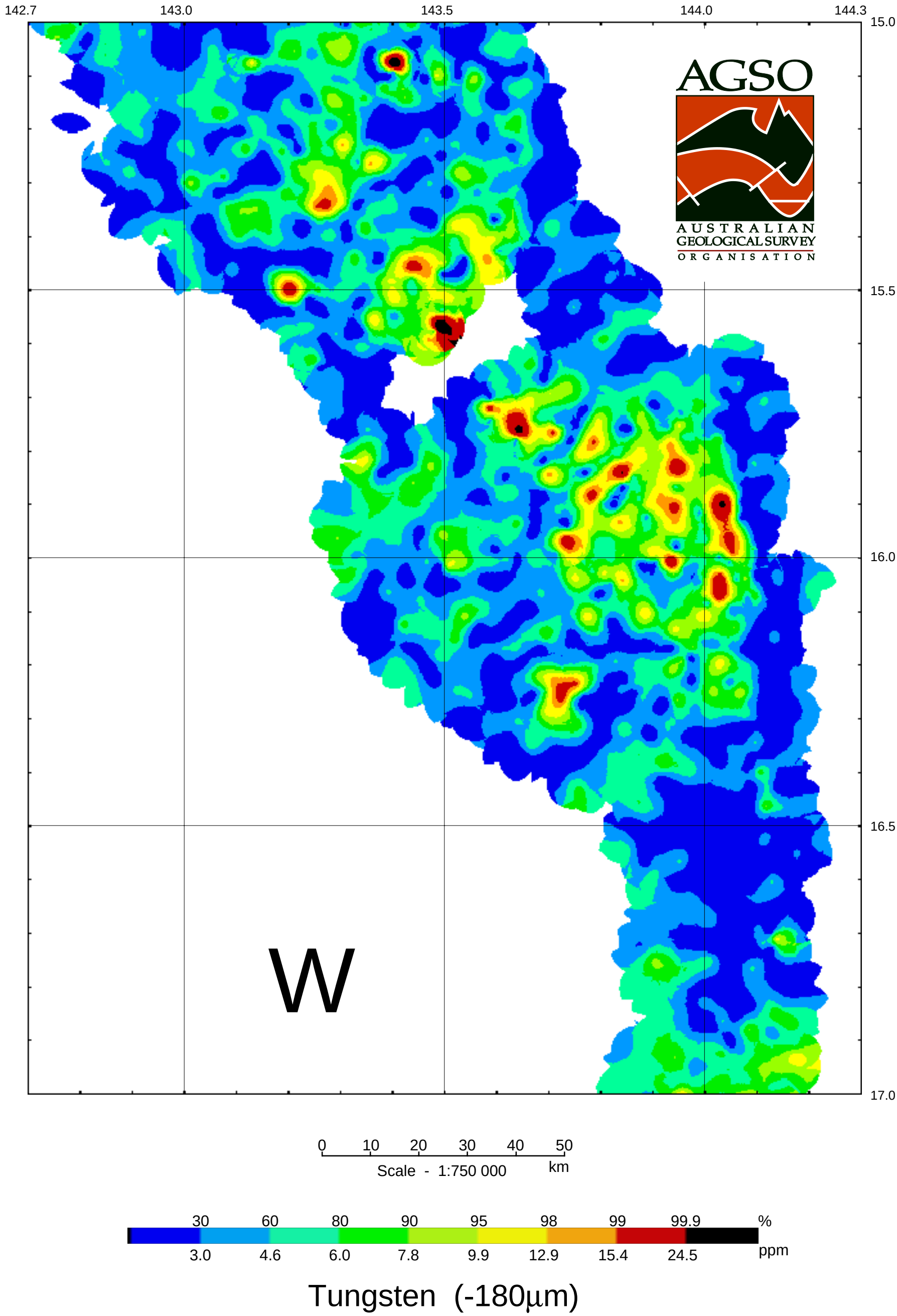

Tungsten (-180µm)

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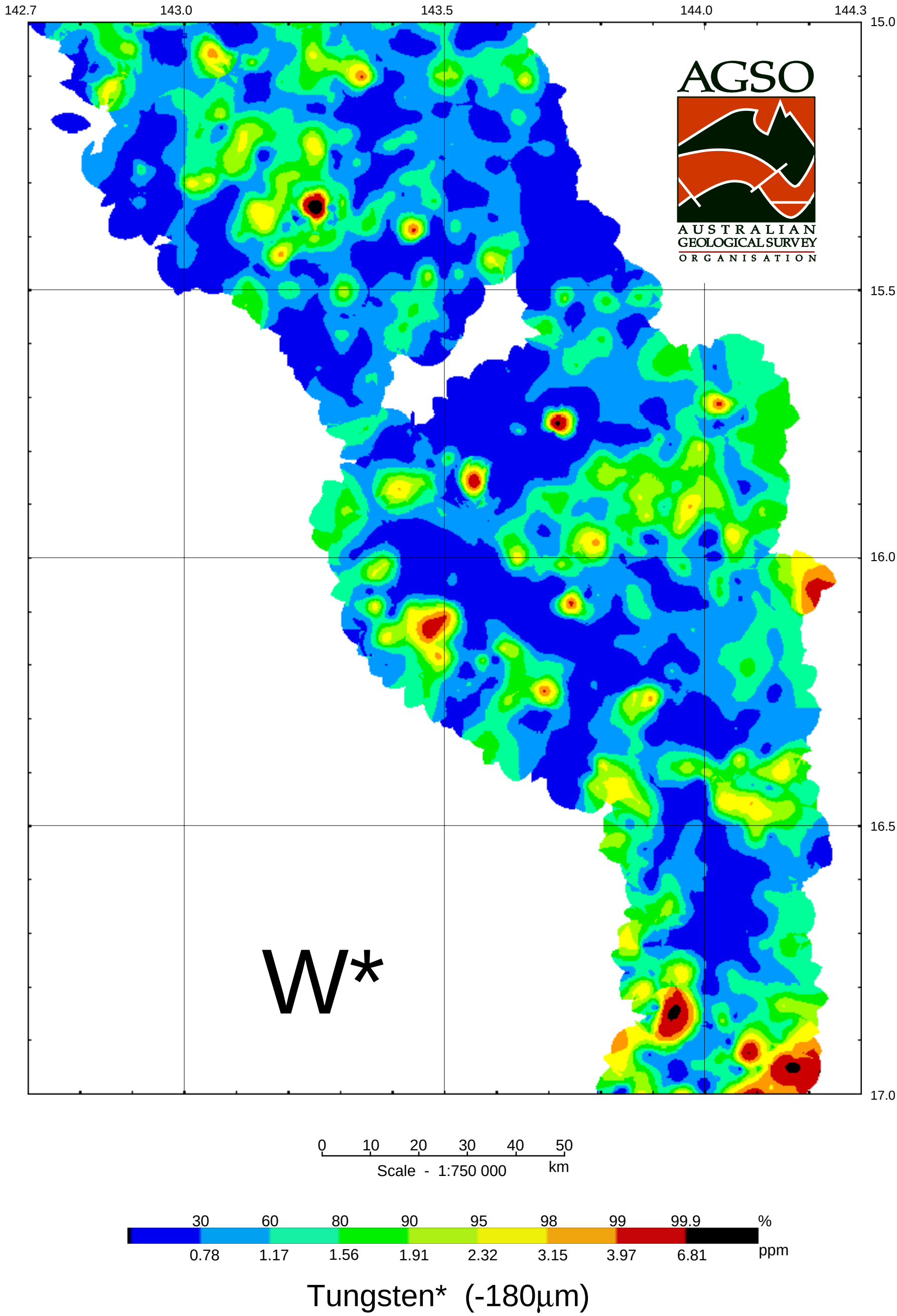

Tungsten* (-180µm)

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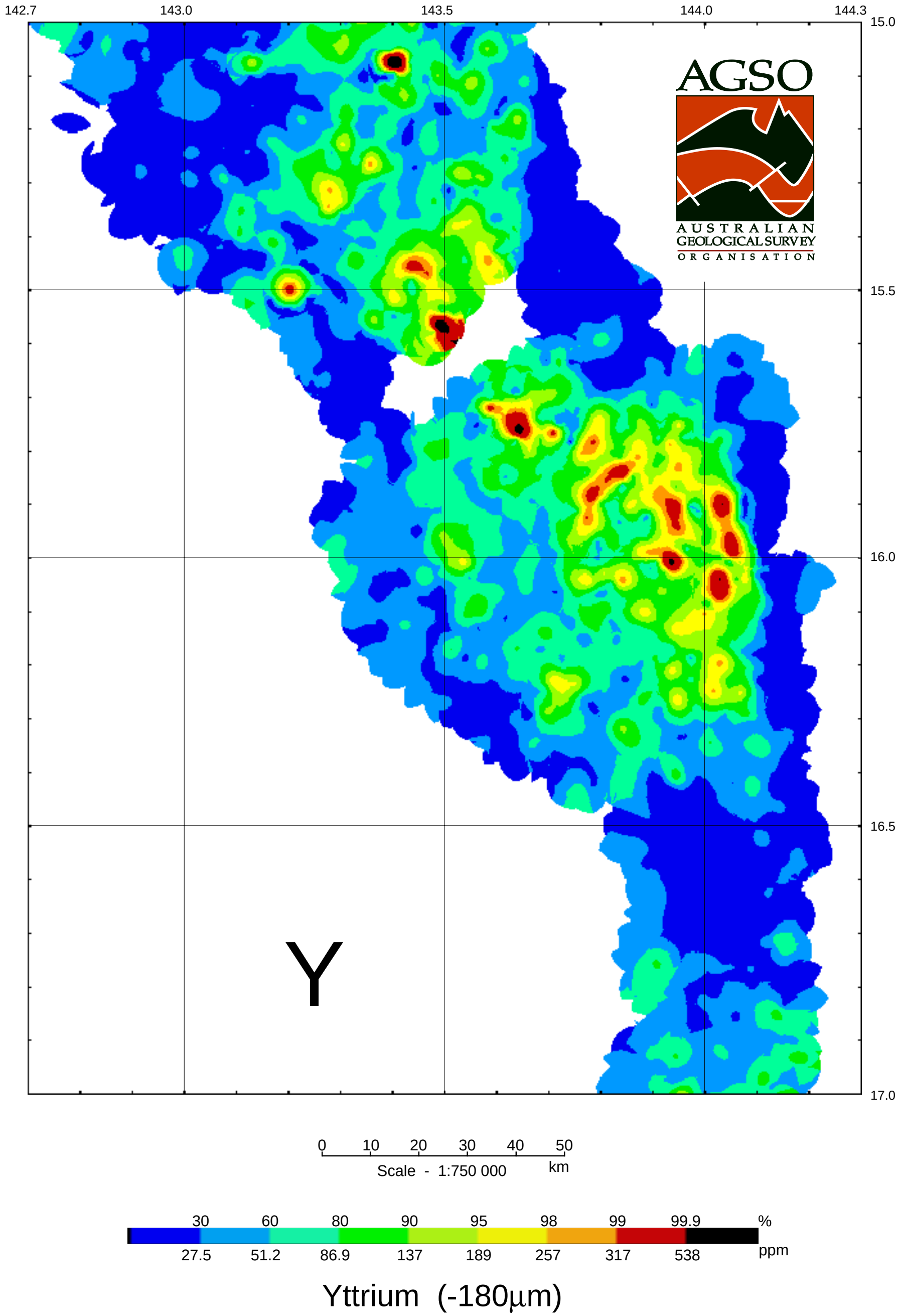

Yttrium (-180µm)

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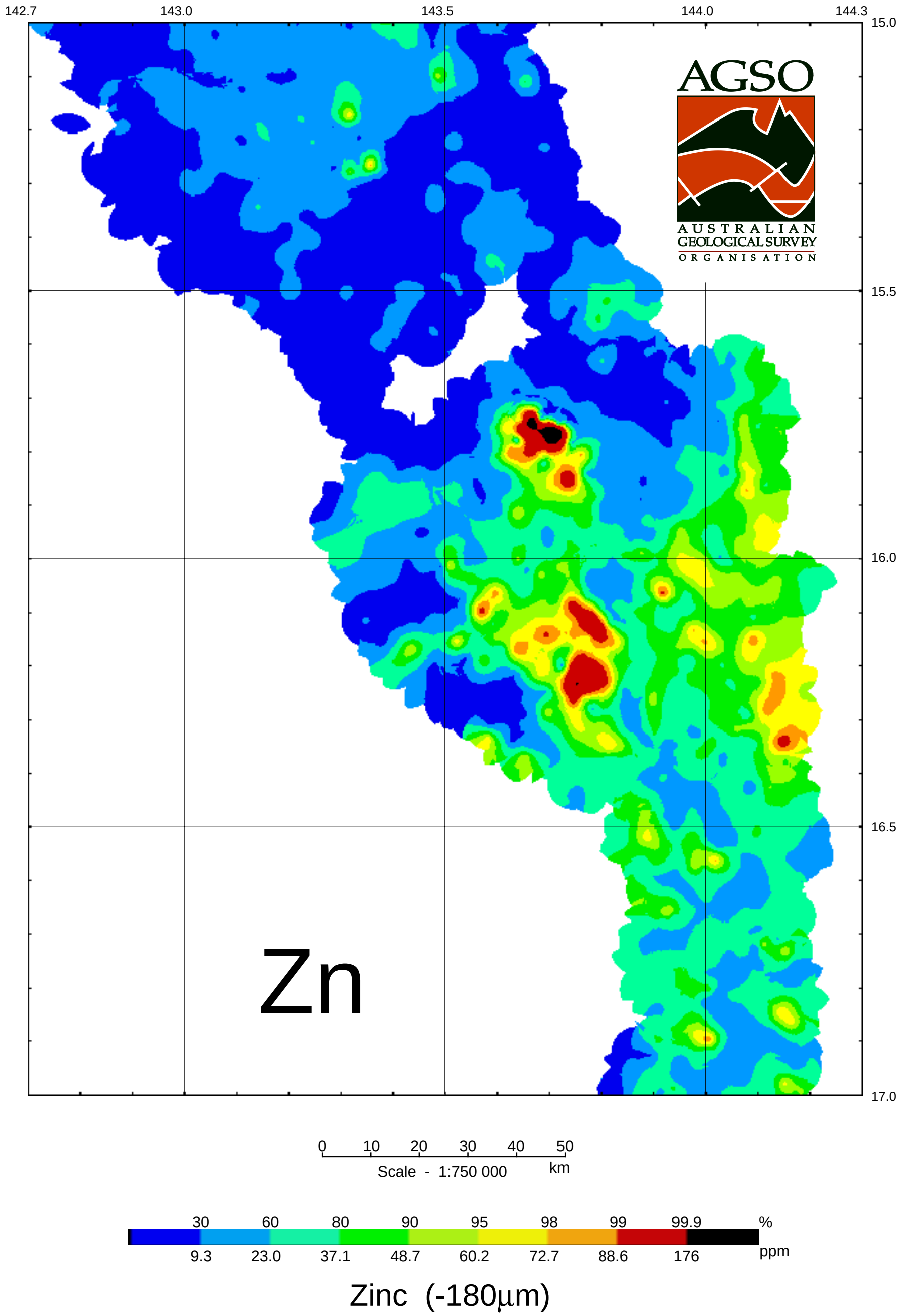
Hann River Region



Zinc (-180µm)

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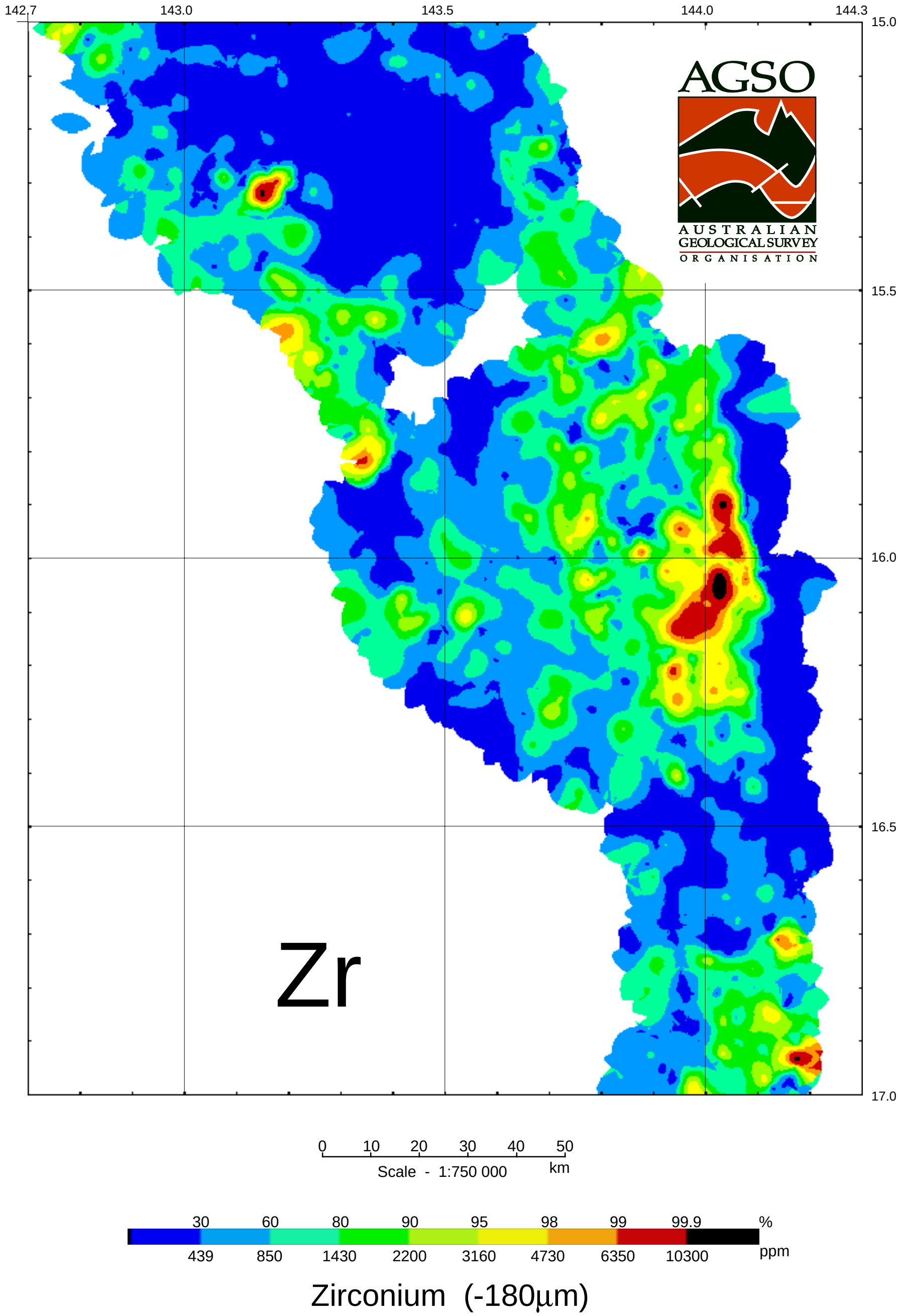

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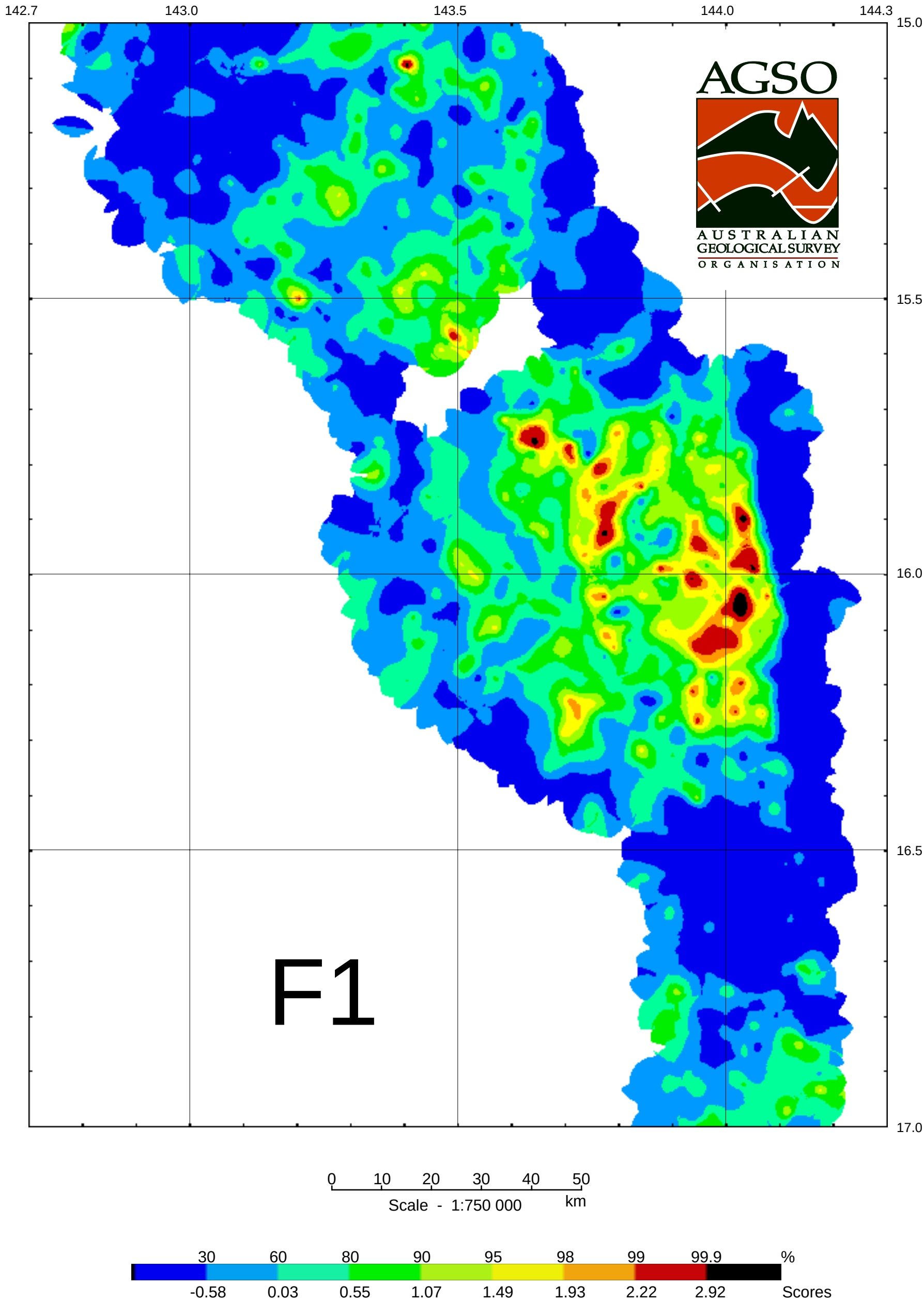

Factor 1 (U,Ce,Th,Y,Nd,La,Nb,P*,W,Zr and Hf)

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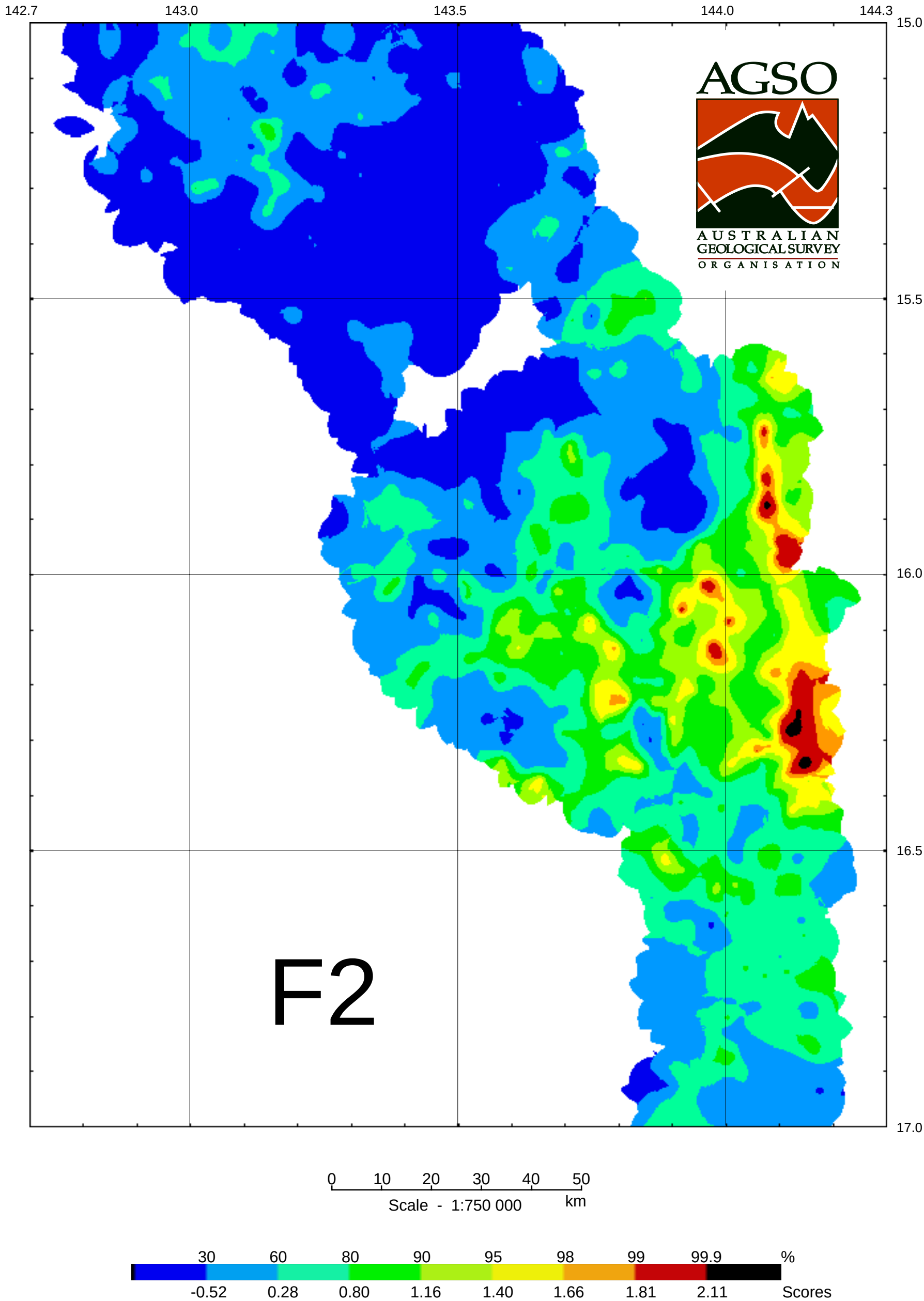

Factor 2 (Fe,V,Cu,Ni,Sc,Zn,Cr,Ti,Mn,As and Cd*)

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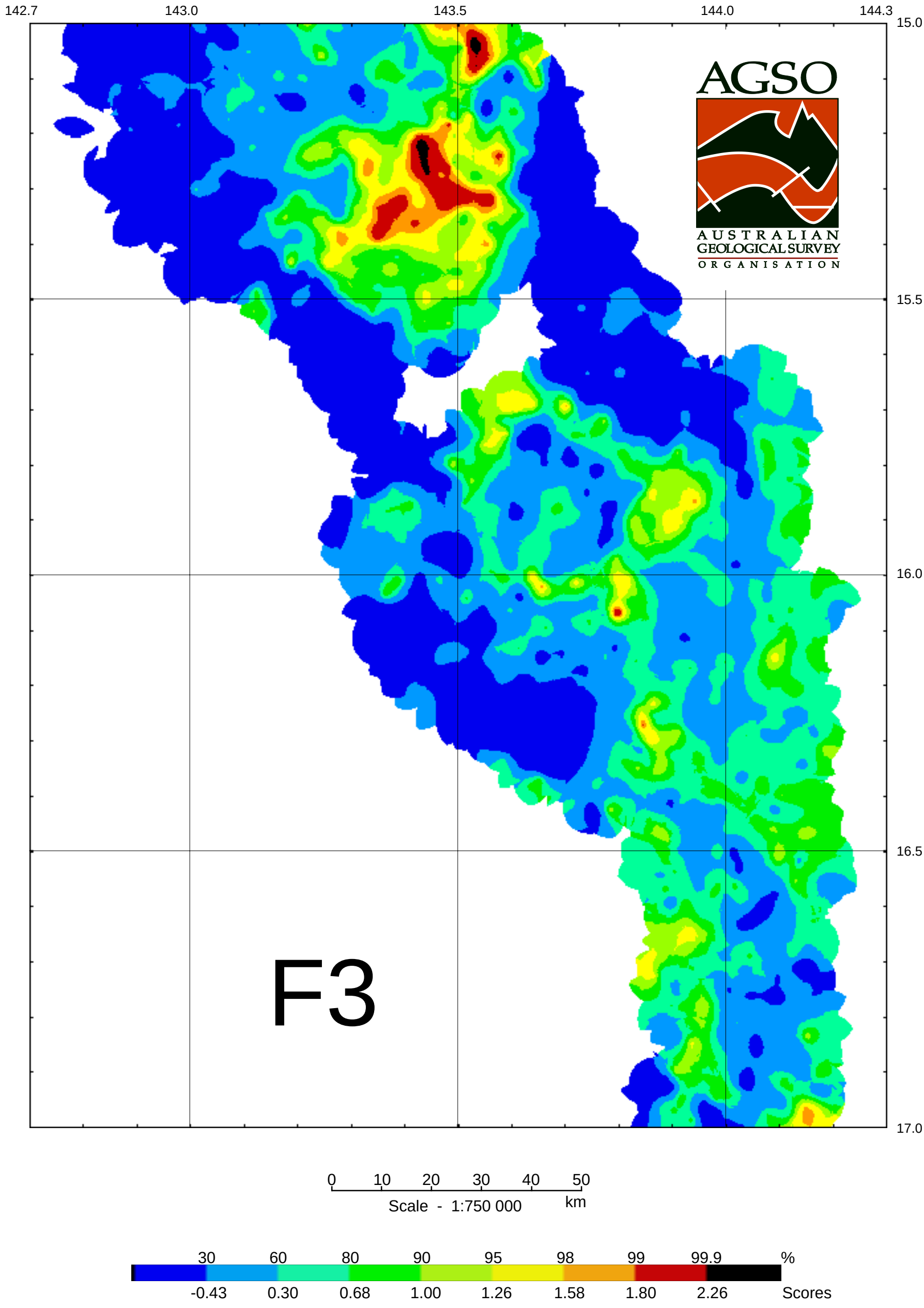

Factor 3 (Rb,Ba,Sr,Be*,Ga,Pb and Tl*)

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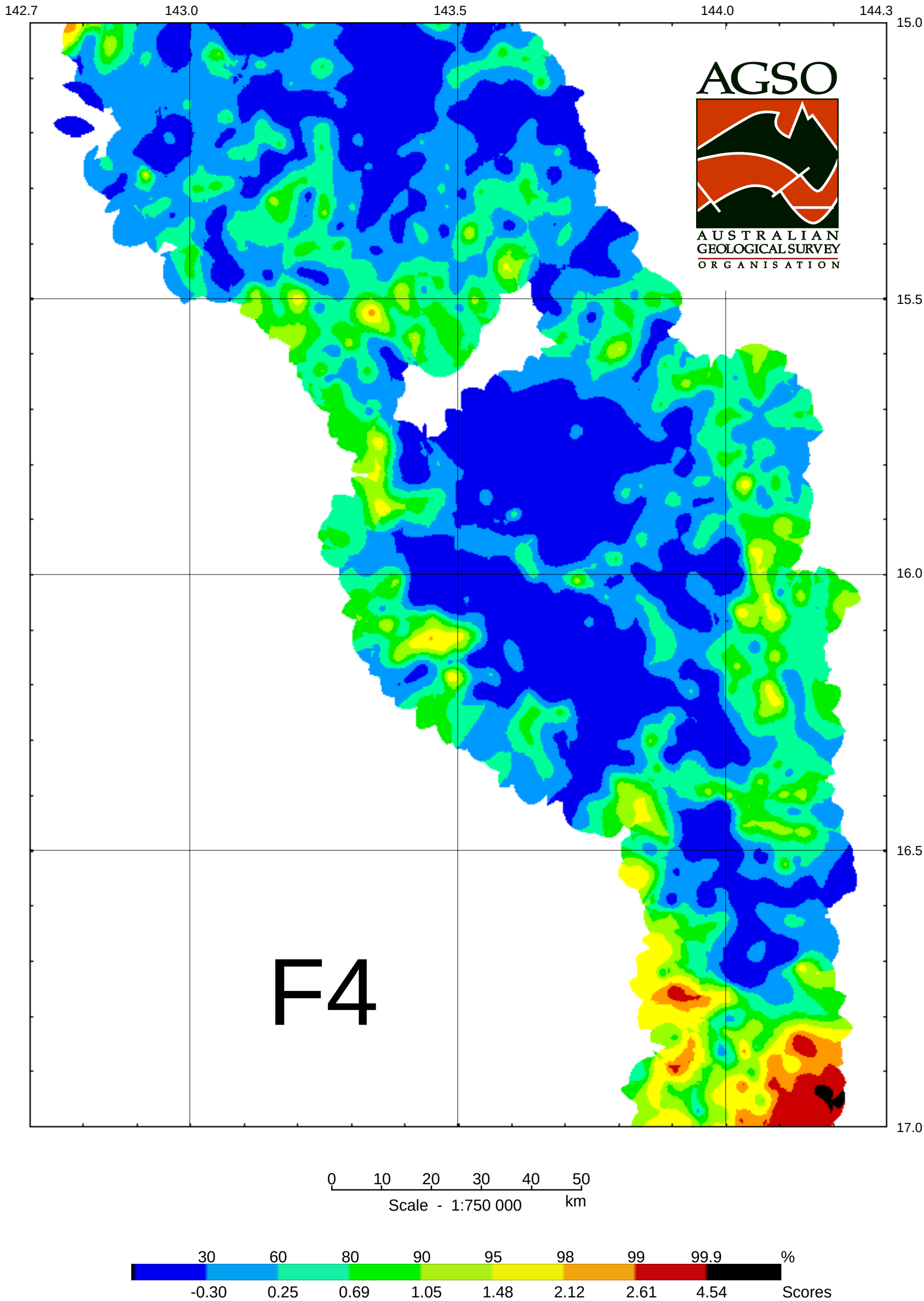
Hann River Region



Factor 4 (Sb*,W*,Sn,Mo* and Ag*)

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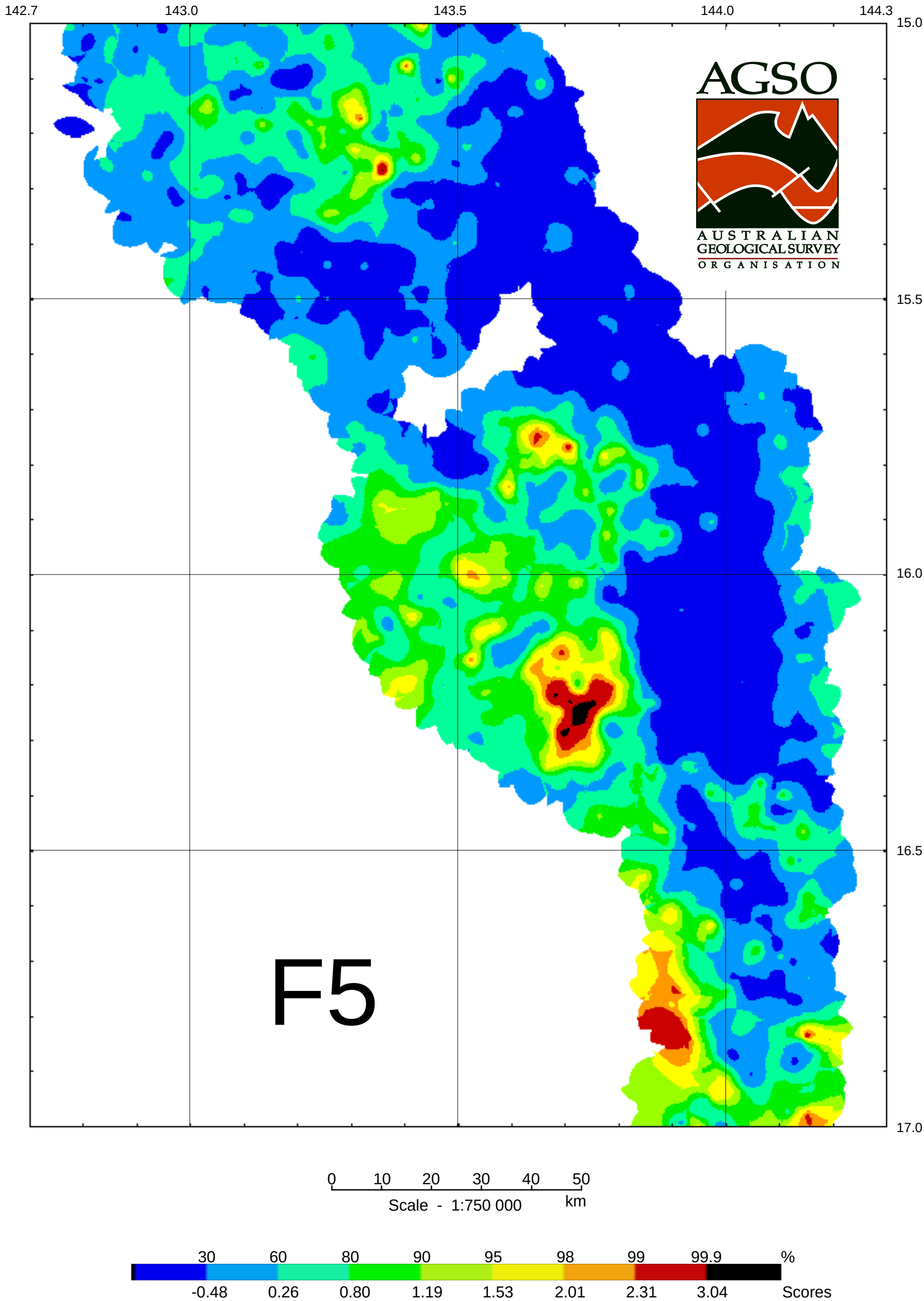

Factor 5 (Bi*)

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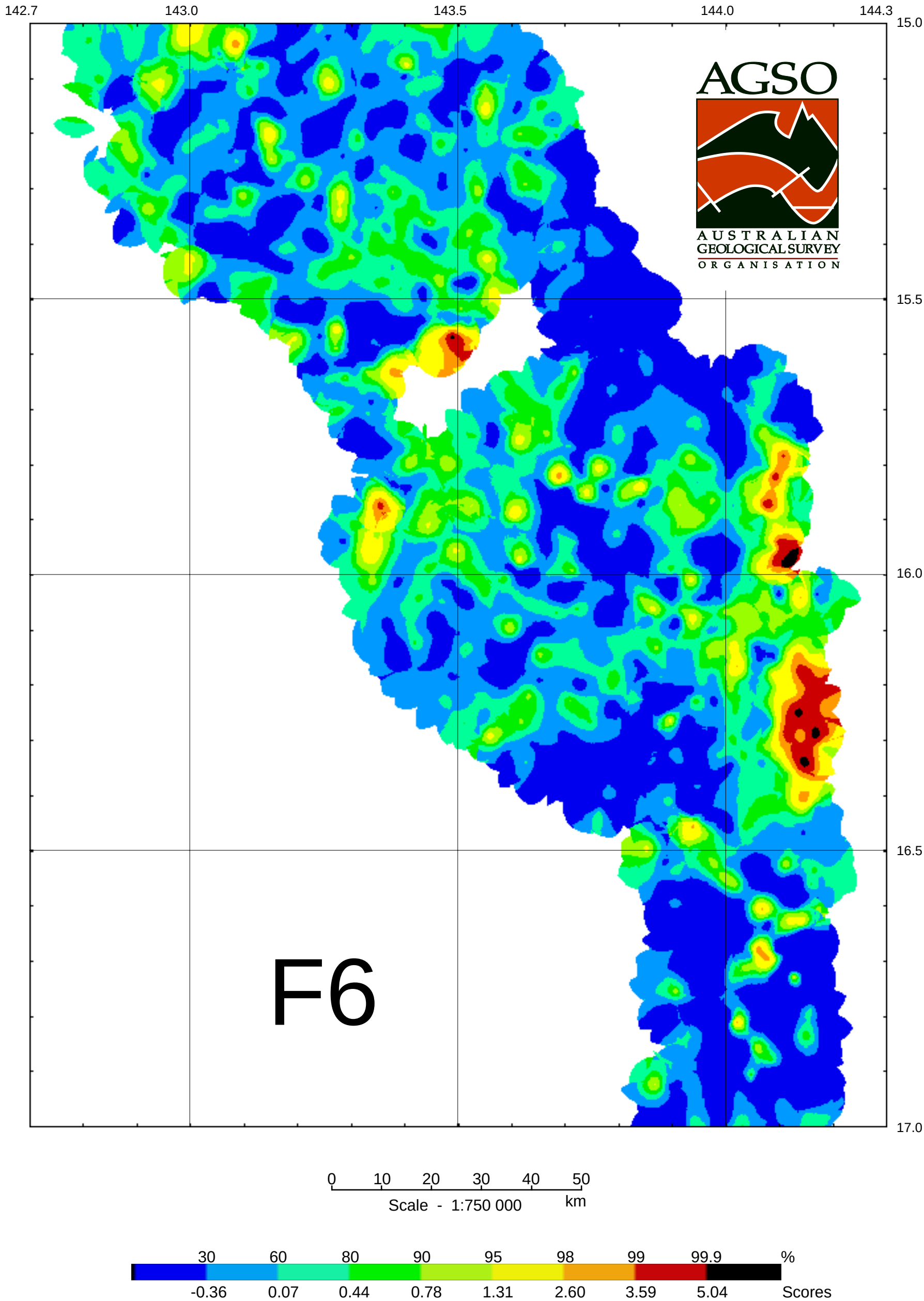

Factor 6 (Pt#,Pd# and Au#)

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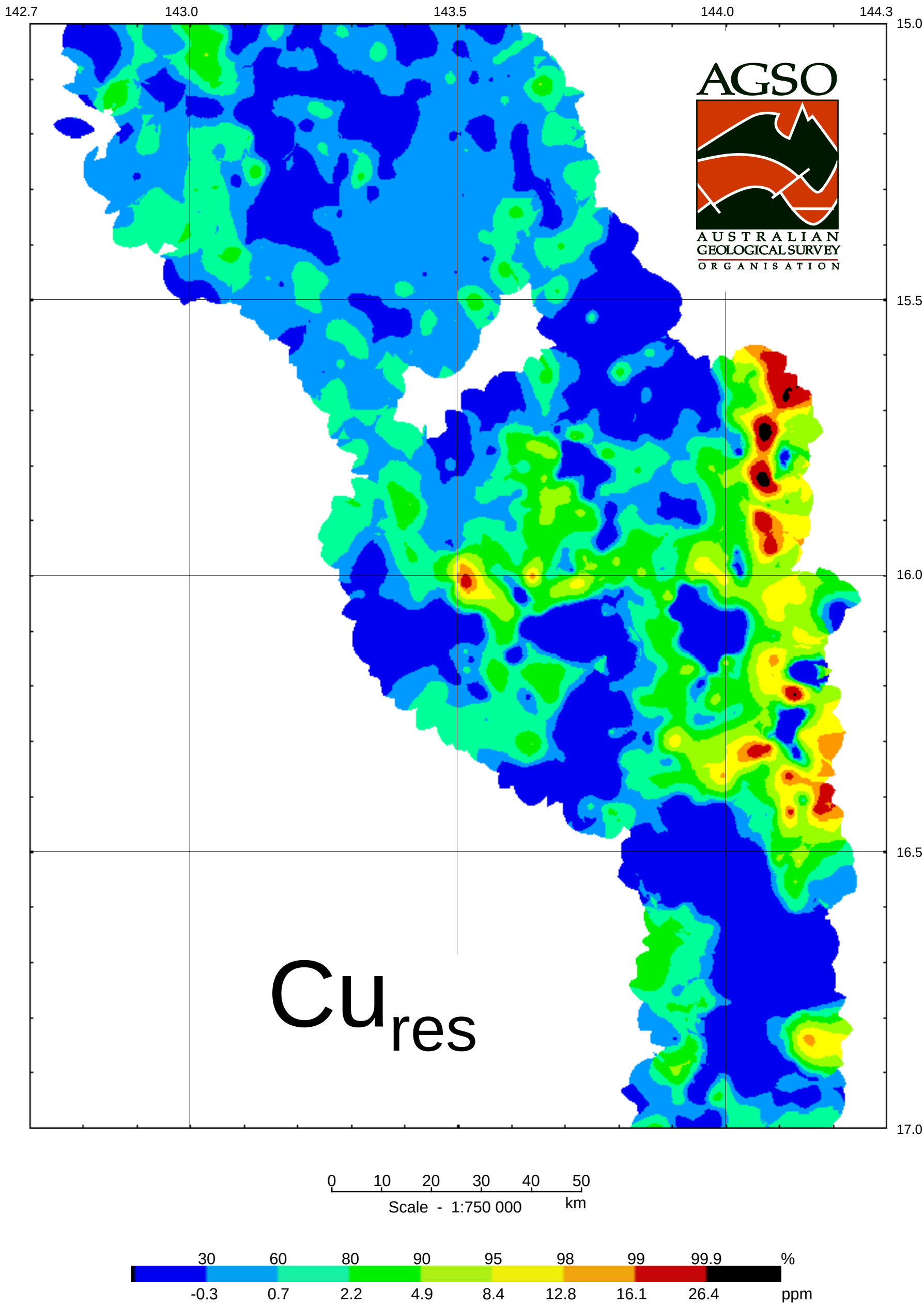

Residual Copper

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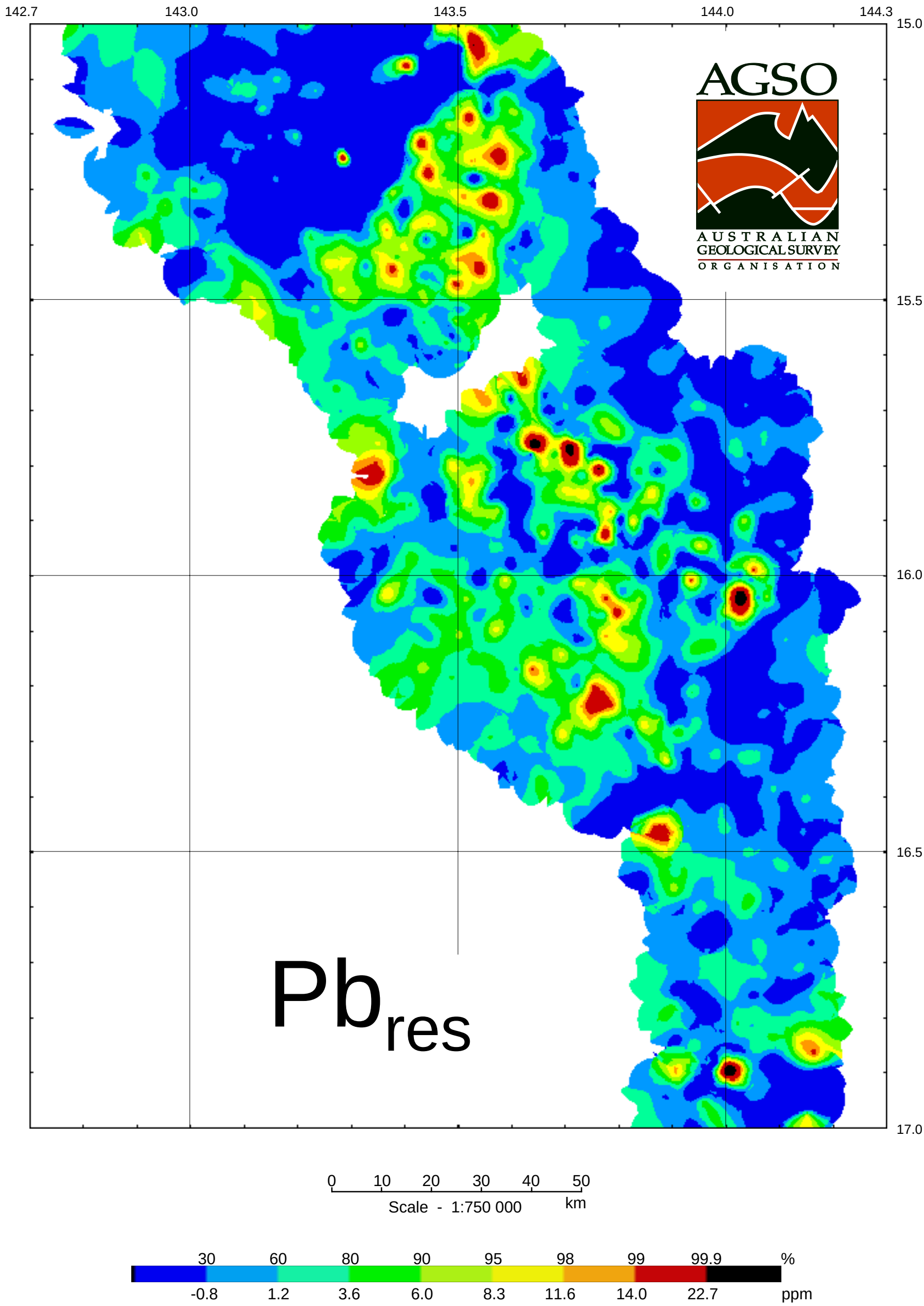
Hann River Region



Residual Lead

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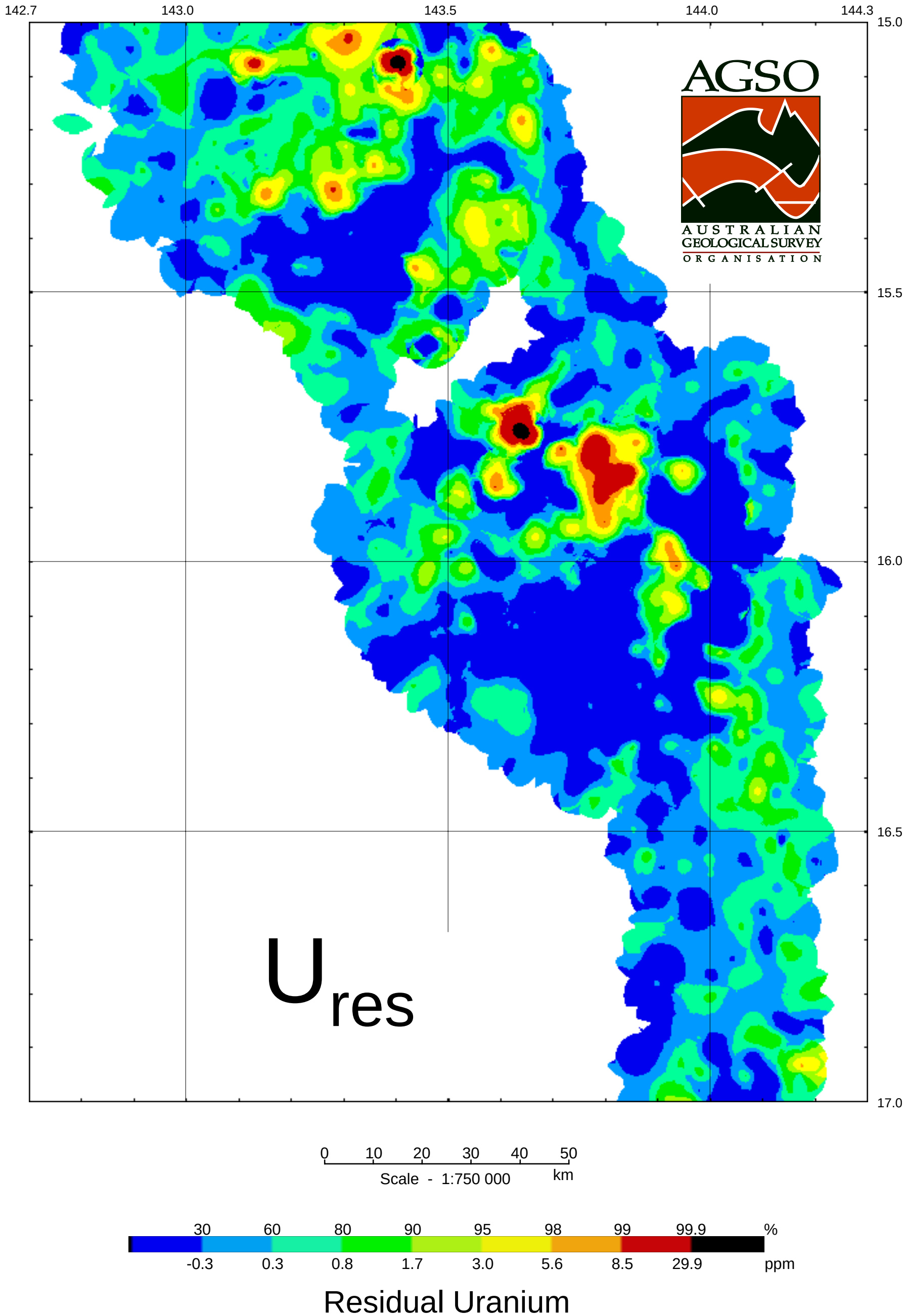
Hann River Region



Residual Uranium

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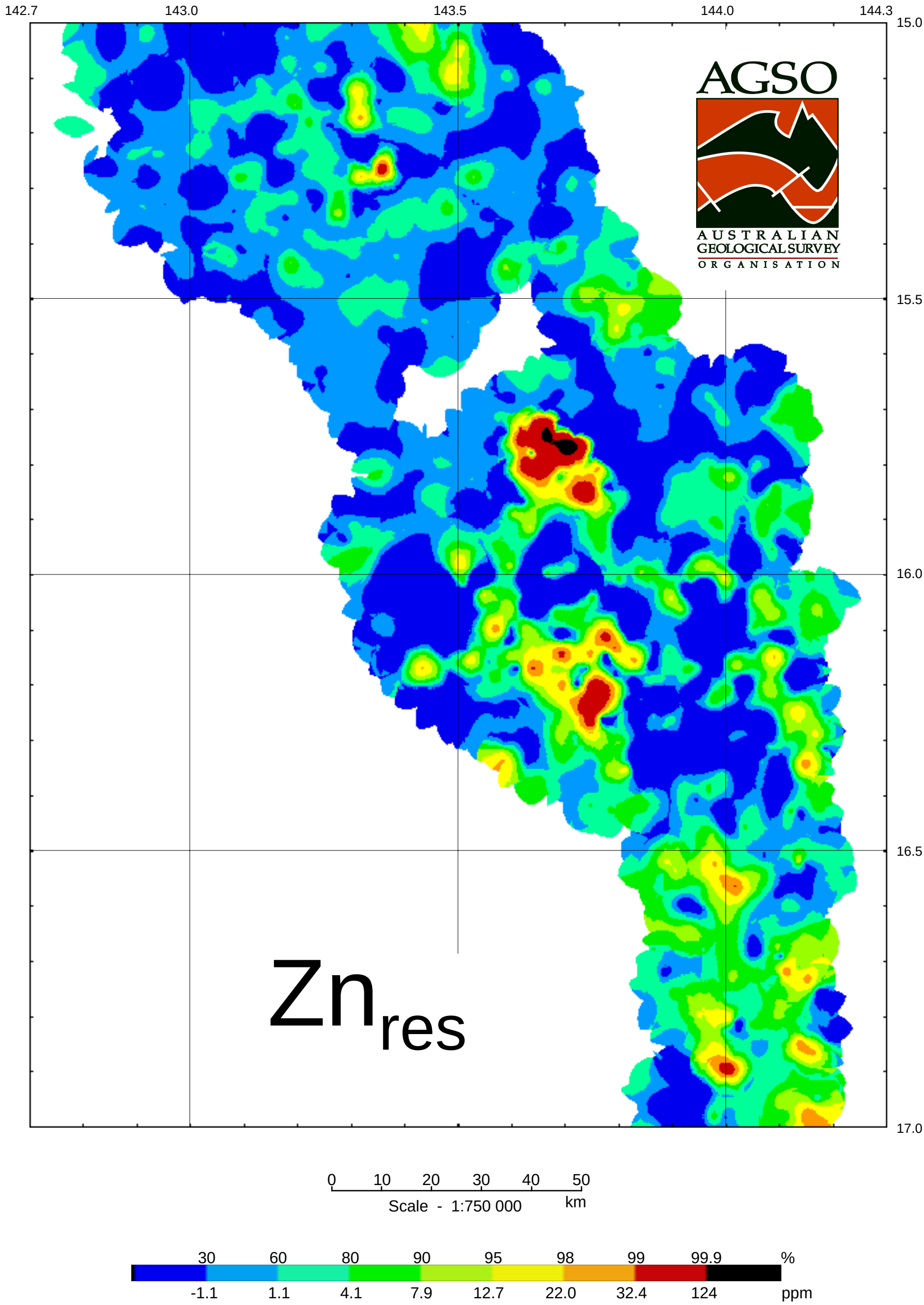
Hann River Region



Residual Zinc

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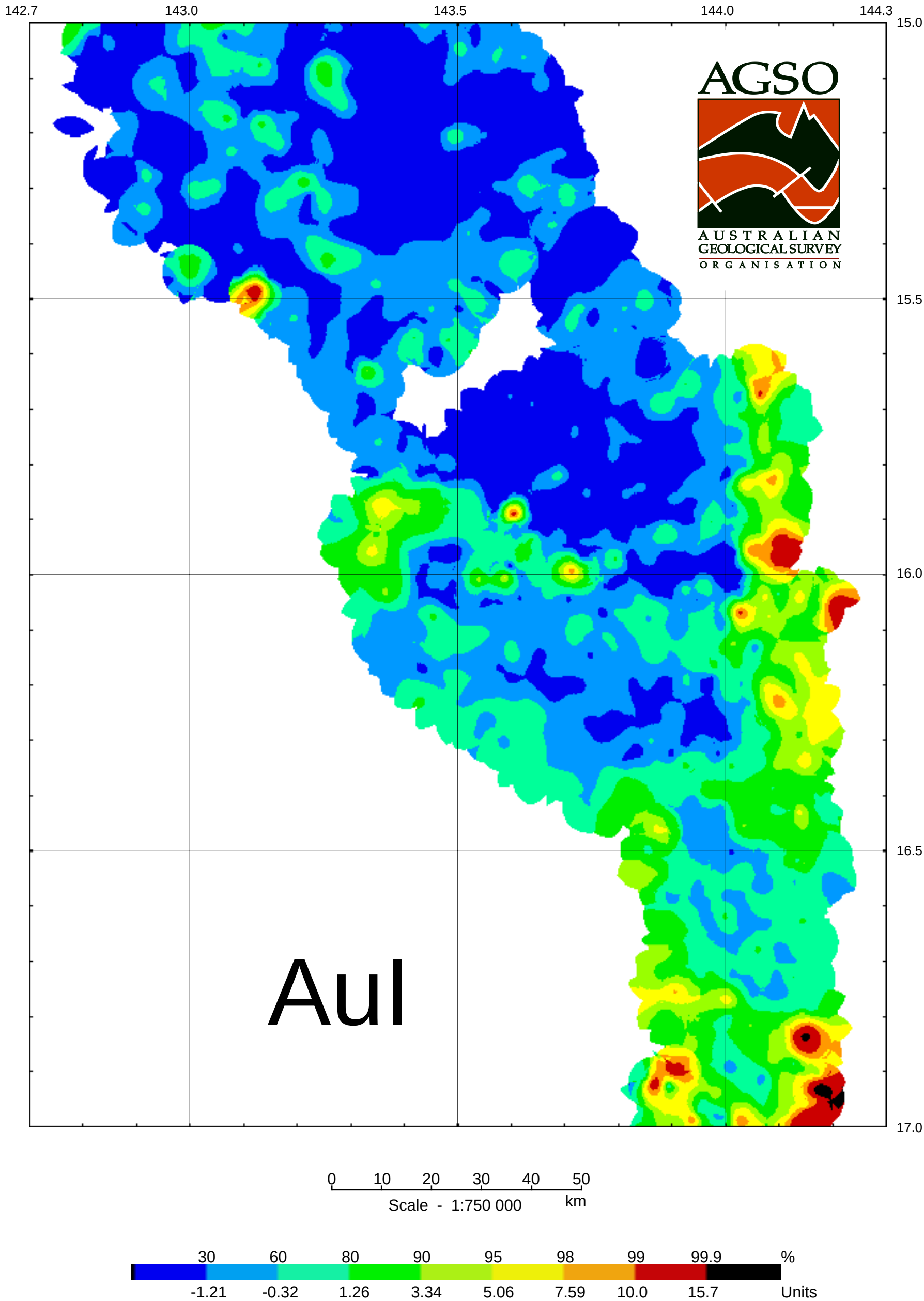

Gold Index (Ag* + As + Au# + Sb*)

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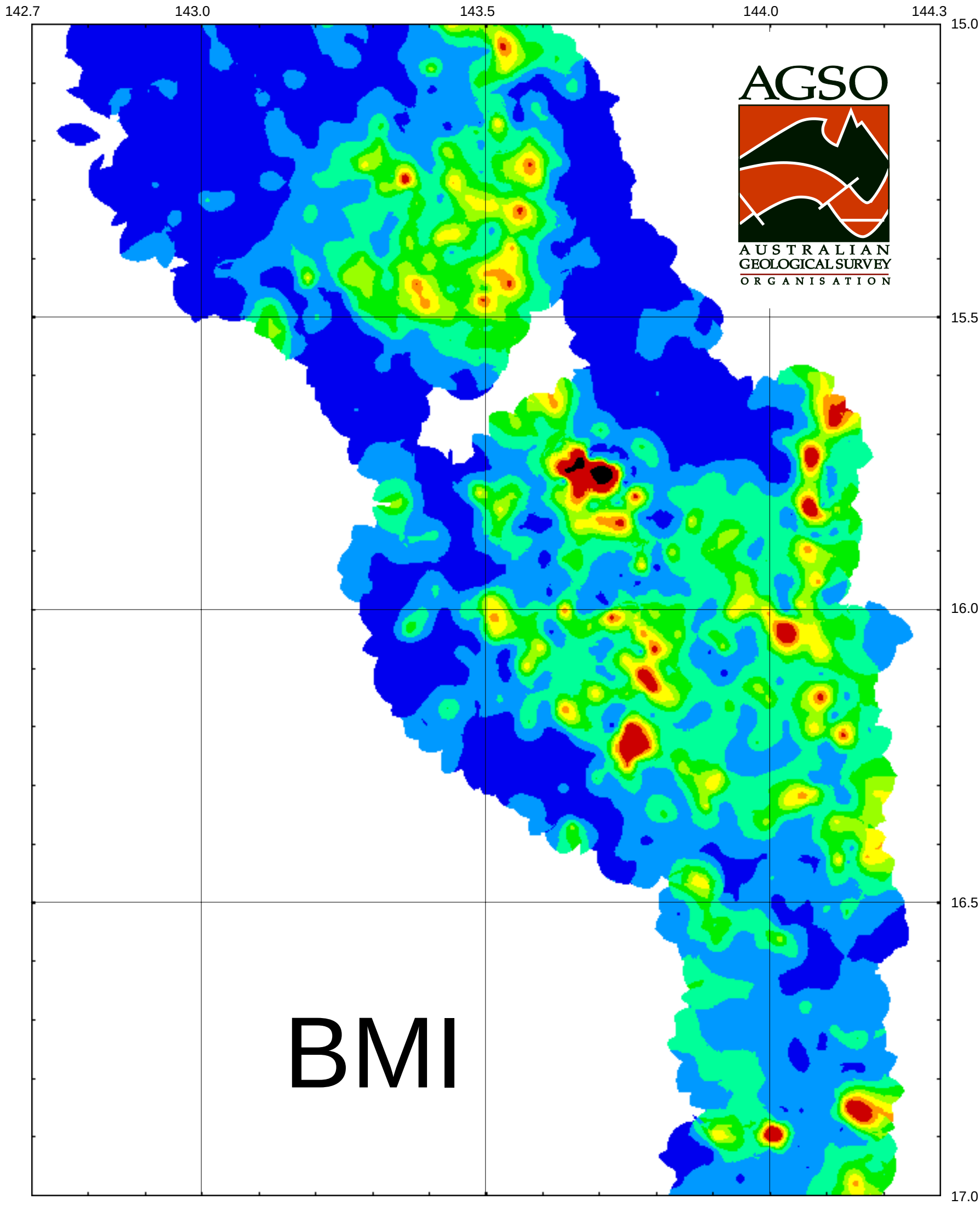
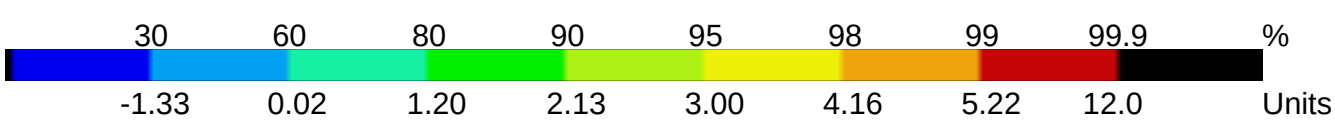


0 10 20 30 40 50 km

Scale - 1:750 000



Base Metal Index $(Ba + Cu_{res} + Pb_{res} + Zn_{res})$

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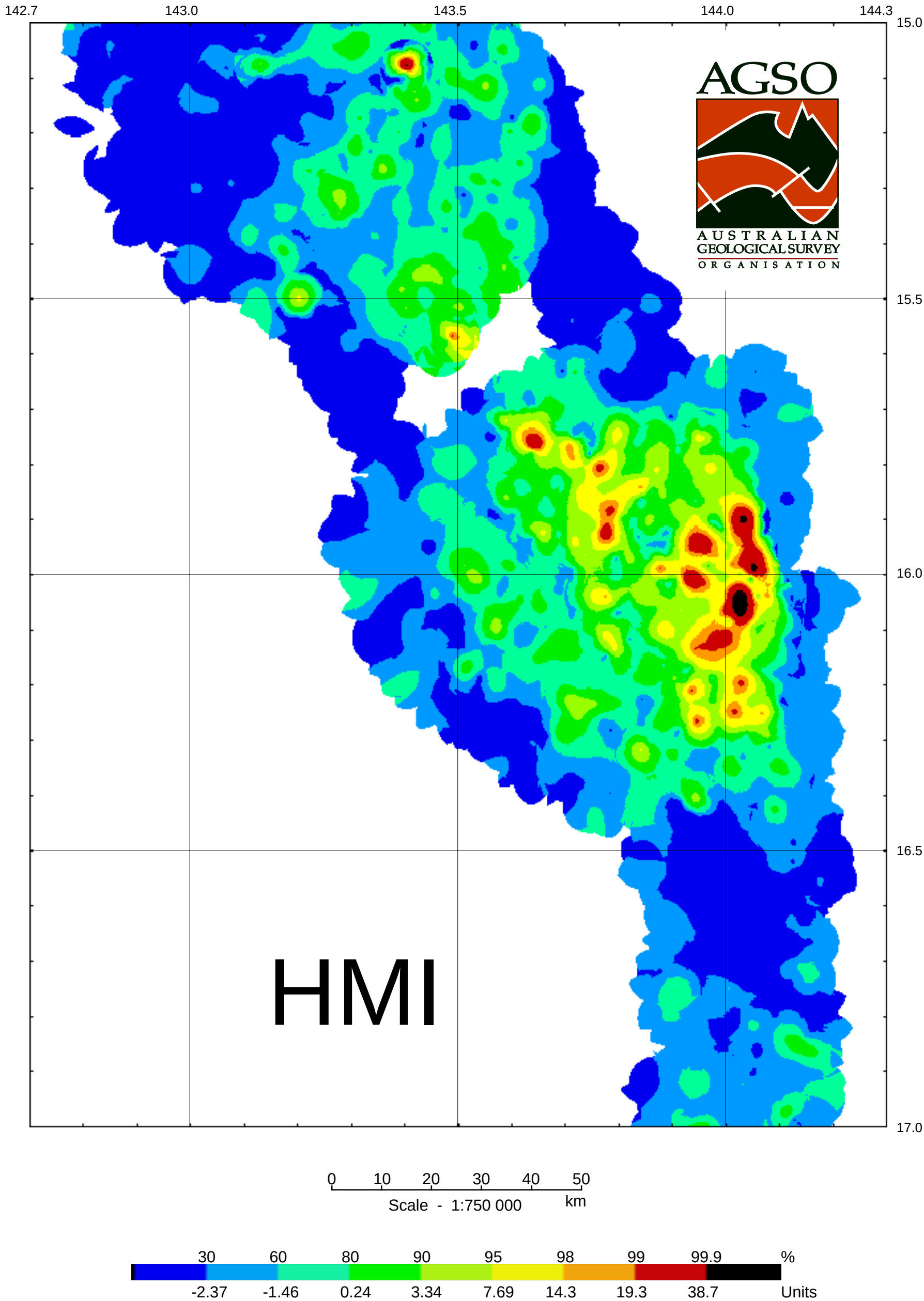

Heavy Mineral Index (Ce + La + Nd + P* + Th + Y)

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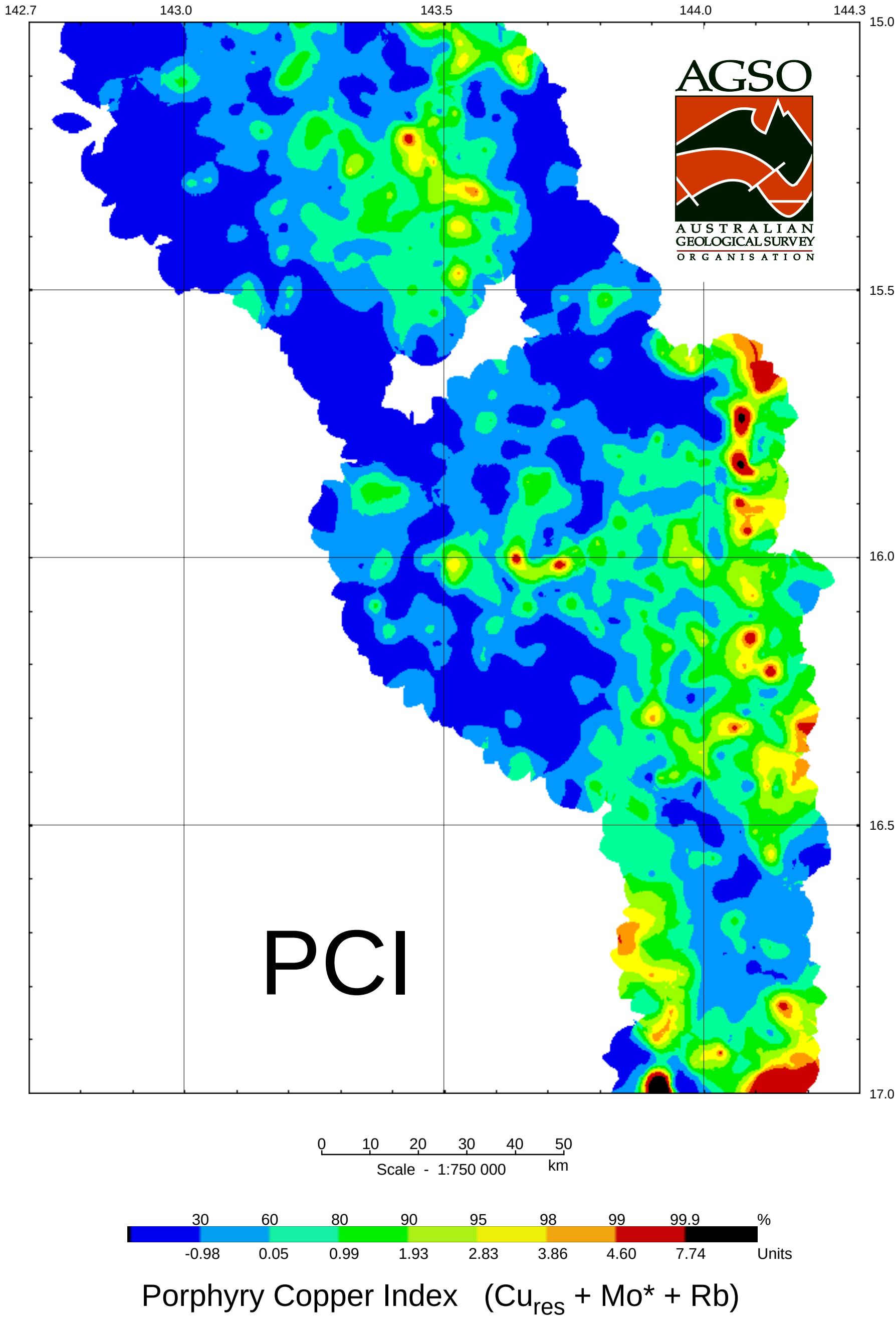

Porphyry Copper Index (Cu_{res} + Mo* + Rb)

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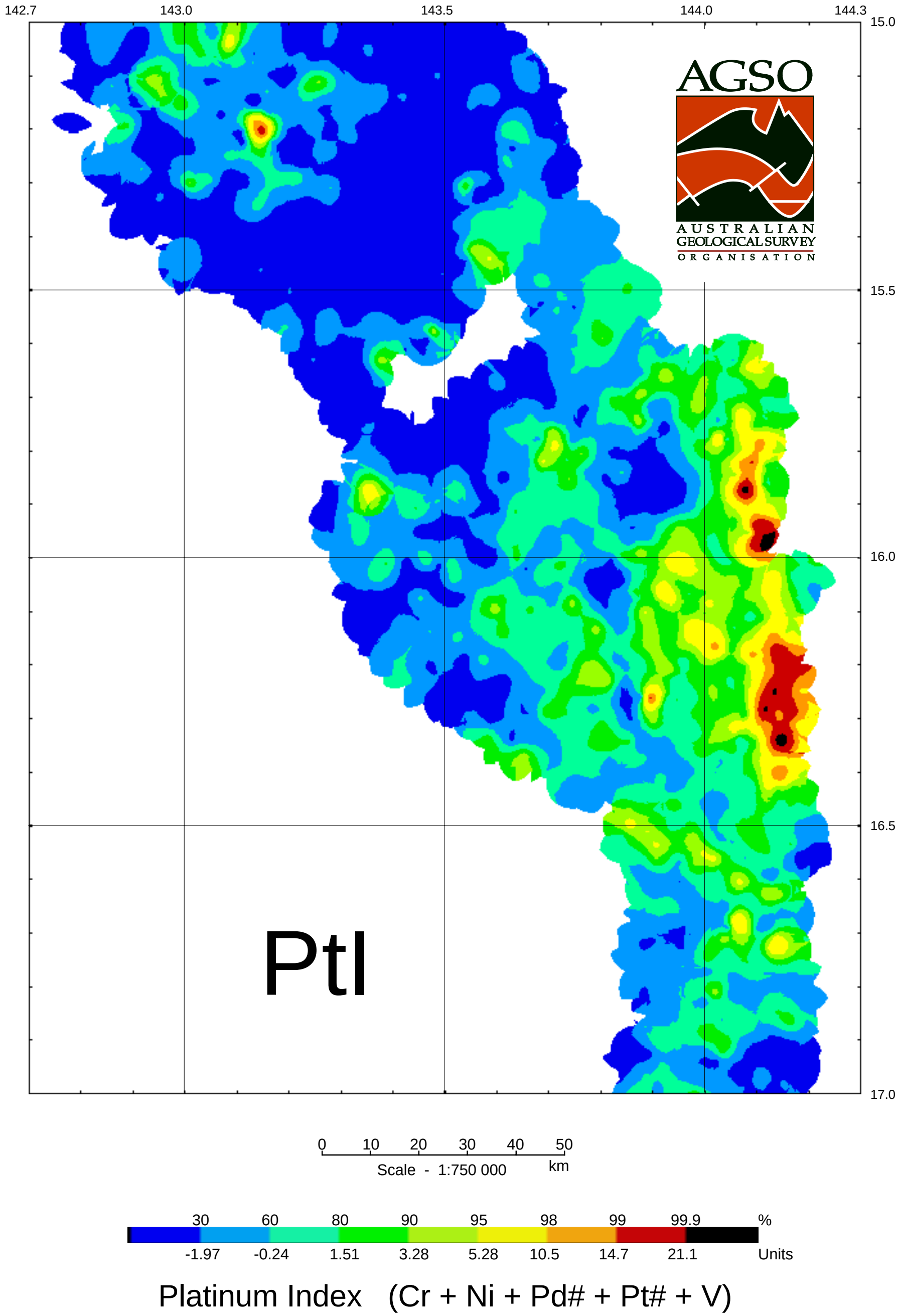

Platinum Index (Cr + Ni + Pd# + Pt# + V)

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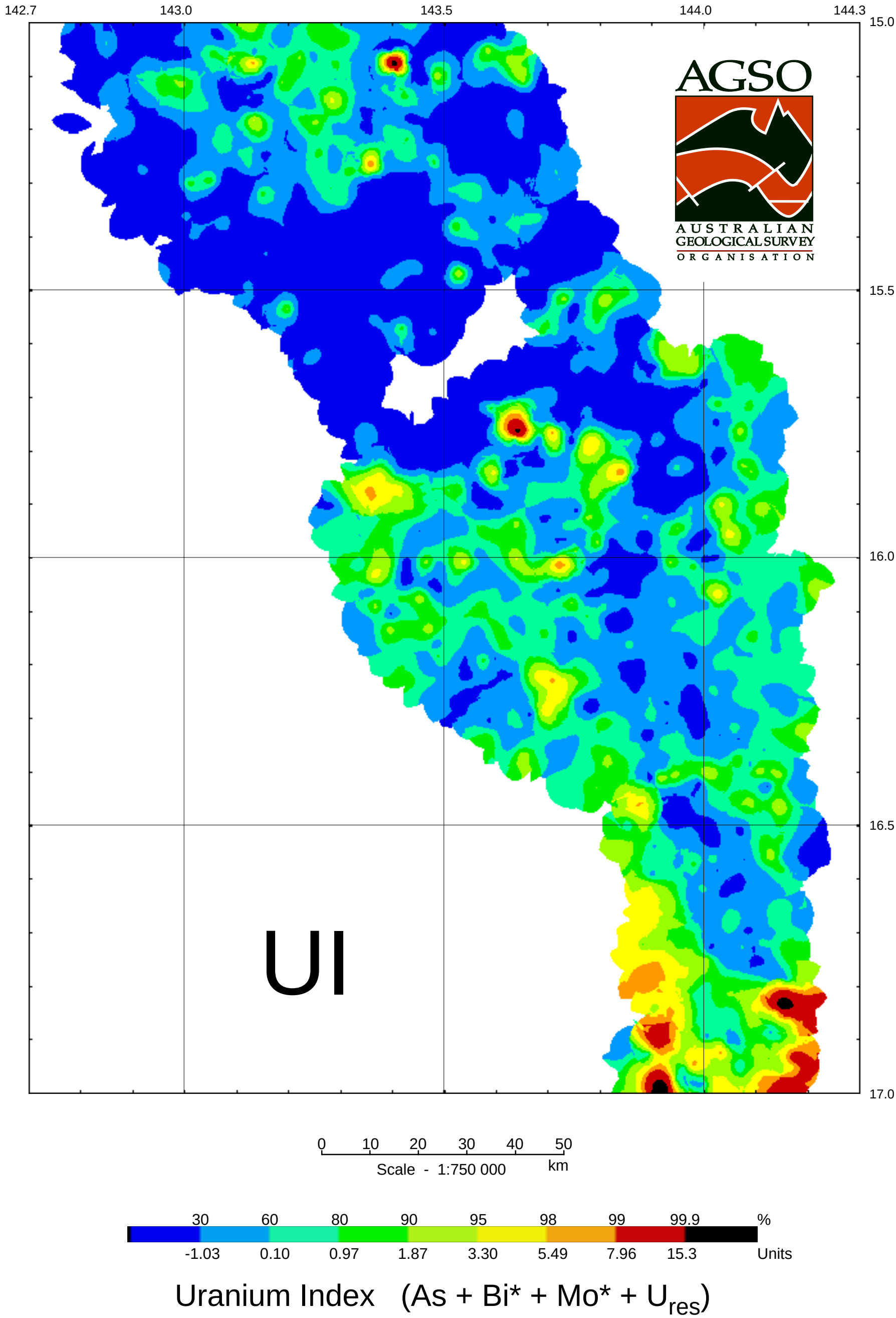

Uranium Index (As + Bi* + Mo* + U_{res})

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APPENDIX 1

Basic statistical parameters for HANN RIVER Region data (N=1191). Concentrations are in 'ppm' (parts per million) except for Au#, Pd# and Pt# which are in 'ppb' (parts per billion).

Element	Min.	Max.	Median	Raw data Mean	Raw data Stand. Devn	Log-transformed data Mean	Log-transformed data Geom. Devn
Ag*	-0.1	0.5	-0.1				
As	-0.5	29.5	1.5	2.45	2.91	1.28	3.386
Au#	-0.05	5.0	0.10	0.18	0.31	0.10	2.891
Ba	26	1298	319	351.4	224.0	278.8	2.072
Be*	0.1	13.3	1.0	1.17	0.84	0.94	1. 999
Bi	-2	9	-2				
Bi*	-0.10	2.30	0.20	0.21	0.17	0.17	1.943
Cd*	-0.10	3.10	0.05	0.11	0.15	0.08	1.978
Ce	10	4951	78	211.5	430.7	97.1	3.001
Cr	-1	787	47	61.9	63.8	41.2	2.636
Cu	-1	159	5	9.10	13.4	4.49	3.467
Fe	1000	99000	13000	17020	14180	12110	2.369
Ga	-1	29	5	5.45	3.37	4.29	2.186
Ge	-0.5	96.5	1.5	1.63	3.82	1.45	1.339
Hf	-2	480	14	24.9	40.8	15.1	2.461
La	2	2560	37	106.2	225.7	45.5	3.188
Mn	6	2863	237	335.9	338.0	203.9	3.014
Mo	-2	5	-2				
Mo*	-0.10	10.5	0.30	0.35	0.41	0.26	2.124
Nb	-2	167	13	19.9	20.8	14.3	2.158
Nd	5	2173	33	92.4	188.7	41.9	3.034
Ni	-1	60	5	8.34	8.83	5.00	2.930
P*	-20	4770	212	366.5	532.9	207.8	2.851
Pb	2	103	16	18.6	11.4	15.5	1.842
Pd#	-0.05	1.44	0.12	0.15	0.11	0.13	1.613
Pt#	-0.1	0.30	0.05	0.06	0.02	0.05	1.273
Rb	1	246	40	46.9	37.2	32.2	2.675
Sb*	-0.05	6.89	0.28	0.45	0.55	0.28	2.741
Sc	-1	46	6	7.61	6.14	5.73	2.169
Se	-1	1	-1				
Sn	-2	3299	2	16.4	117.5	3.09	3.877
Sr	3	209	41	46.4	33.3	33.4	2.474
Ta	-2	132	-2				
Th	-2	1381	18	52.9	111.0	20.5	3.623
Ti	208	99999	3704	6354	9399	4029	2.408
Tl*	-0.5	17.8	0.25	0.35	0.54	0.31	1.528
U	-0.5	187.5	4	7.41	11.4	4.31	2.712
V	-2	403	42	58.6	51.6	40.5	2.552
W	-2	44	4	4.72	3.93	3.66	2.026
W*	-0.10	13.9	0.90	1.15	0.94	0.92	1.950
Y	6	1148	42	69.0	85.8	45.7	2.343
Zn	2	392	17	24.5	25.2	16.4	2.518
Zr	44	14280	622	1098	1488	672.1	2.528

- signifies element analysed by Bulk Cyanide Leach method (Australian Laboratory Services, Brisbane)

* - signifies element analysed by ICP-MS (Analabs, Perth)

All other elements analysed by AGSO (formerly BMR) laboratories in Canberra

APPENDIX 2

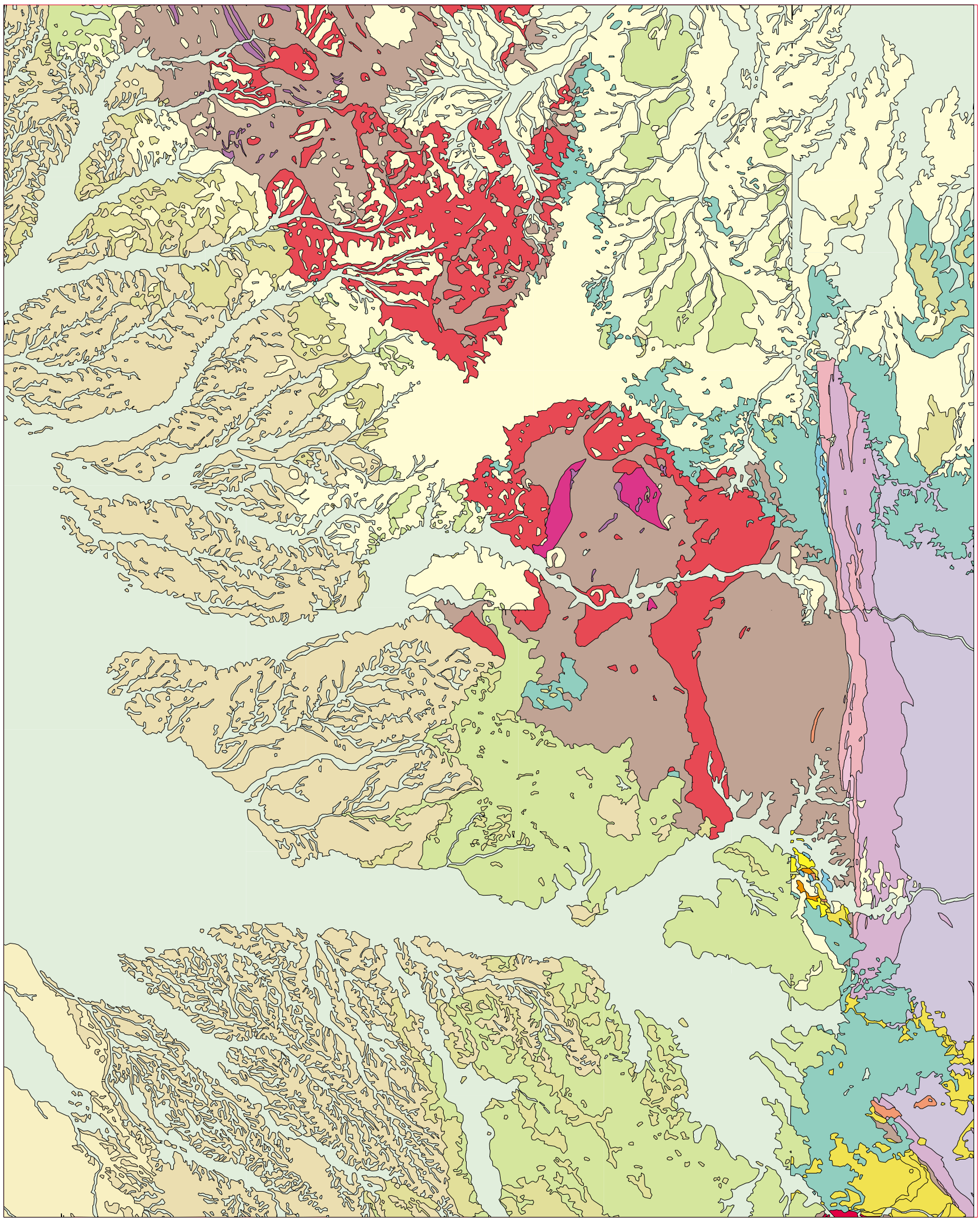
Rotated factor loadings, eigenvalues and communalities for HANN RIVER Region log-transformed data (N=1191).

	Communalities	F1	F2	F3	F4	F5	F6
Ag*	0.212				0.383		
As	0.718		0.643				
Au#	0.547		0.409				0.487
Ba	0.844			0.863			
Be*	0.786		0.312	0.756			
Bi*	0.863					0.912	
Cd*	0.212		0.399				
Ce	0.969	0.926					
Cr	0.717		0.800				
Cu	0.874		0.921				
Fe	0.939		0.951				
Ga	0.788		0.471	0.732			
Ge	0.319						-0.463
Hf	0.818	0.655		-0.408			
La	0.962	0.915					
Mn	0.827		0.677	0.516			
Mo*	0.517		0.348		0.471		
Nb	0.832	0.719	0.461				
Nd	0.967	0.921					
Ni	0.884		0.912				
P*	0.822	0.711		0.438			
Pb	0.838	0.586		0.655			
Pd#	0.512		0.400				0.551
Pt#	0.555						0.682
Rb	0.908			0.923			
Sb*	0.700	-0.335			0.758		
Sc	0.865		0.902				
Sn	0.540			-0.449	0.519		
Sr	0.871			0.861			
Th	0.951	0.925					
Ti	0.929	0.508	0.713				
Tl*	0.636		-0.389	0.568	0.329		
U	0.911	0.936					
V	0.927		0.939				
W	0.604	0.706					
W*	0.490				0.650		
Y	0.914	0.923					
Zn	0.894		0.809	0.355			
Zr	0.858	0.696		-0.442			
Eigenvalues		12.26	6.64	5.22	2.28	1.61	1.31
Proportion of original variance (%)		31.4	17.0	13.4	5.9	4.1	3.3
Cumulative (%)		30.8	48.4	61.8	67.7	71.8	75.1

Primary intercorrelations for Factors above.

	F1	F2	F3	F4	F5	F6
F1						
F2	0.278					
F3	0.282	0.174				
F4	-0.022	0.070	0.039			
F5	0.004	0.038	0.054	0.185		
F6	-0.019	0.287	0.2.4	-0.215	-0.219	

CY93 SAMPLE SITES



MINERAL OCCURRENCES

○ Au　　＋ Cu　　× Pb-Zn　　+ Sb