CRCLEME

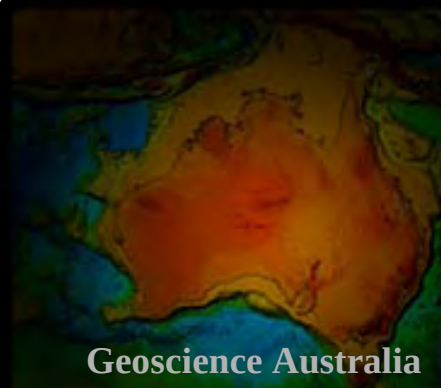
Cooperative Research Centre for
LANDSCAPE ENVIRONMENTS
and MINERAL EXPLORATION

Australian Government

Geoscience Australia

Geohealth implications for the Riverina Baseline Geochemistry Survey

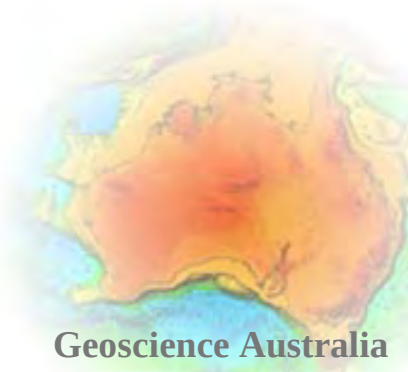
Megan Lech, Patrice de Caritat, Subhash Jaireth, John Pyke, Ian Lambert



Regional Geochemical Surveys — Background

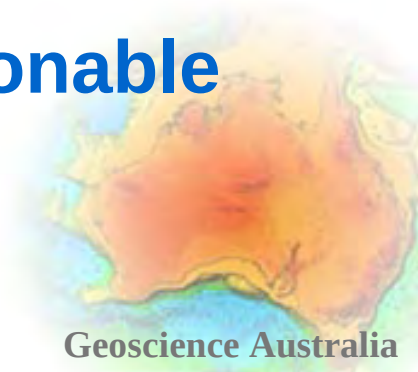
- **Composition of surficial regolith (soils, sediments, shallow groundwater, plants) is an essential layer of information for taking informed decisions**

- **Most developed and many developing countries have conducted regional geochemical surveys (RGS)**



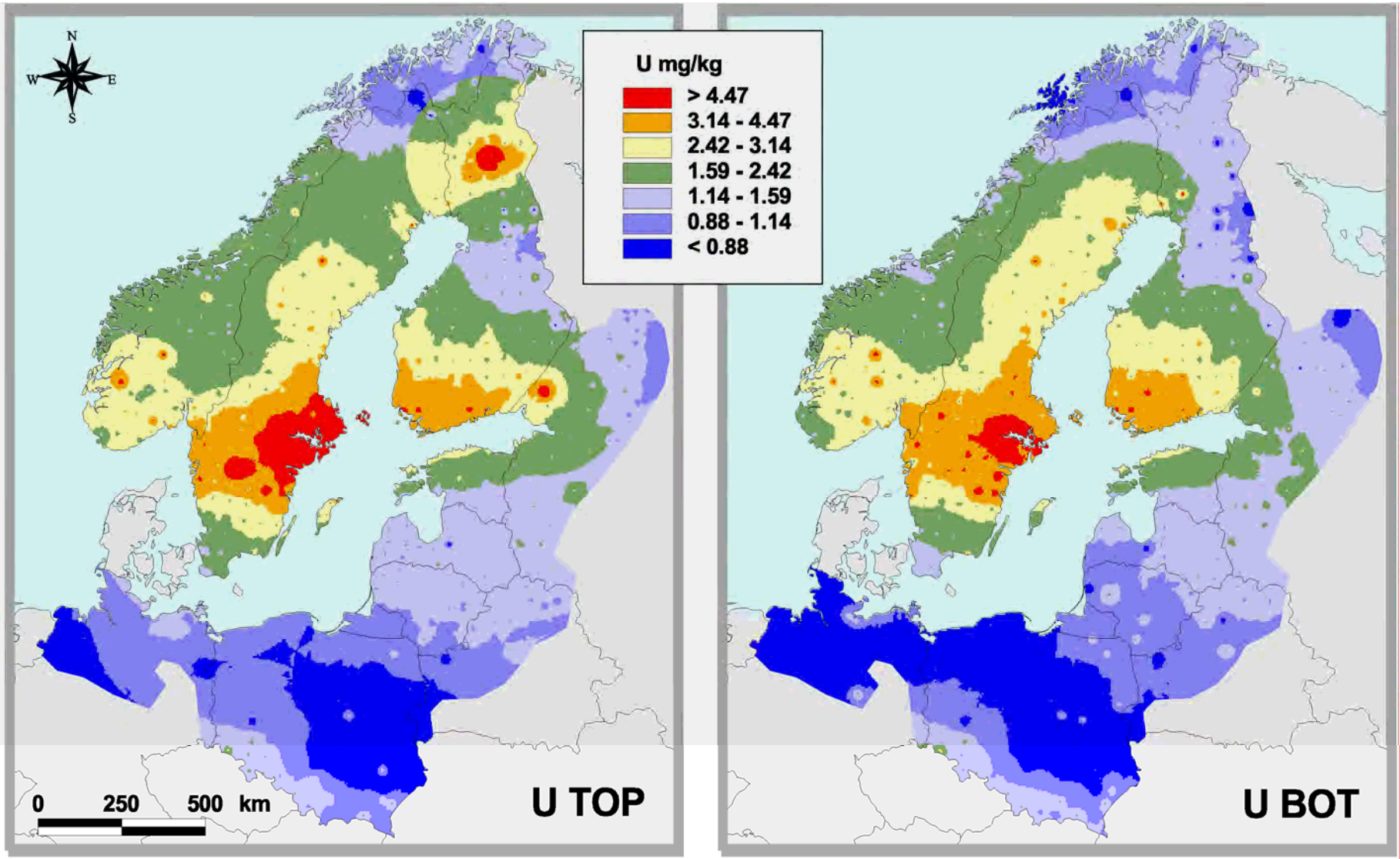
Regional Geochemical Surveys — Purposes

- Identify mineral potential (greenfields or new commodities)
- Reach decisions on land use taking into account potential geohealth and other factors
- Objectively measure future environmental change
- Take informed and geologically reasonable remediation decisions

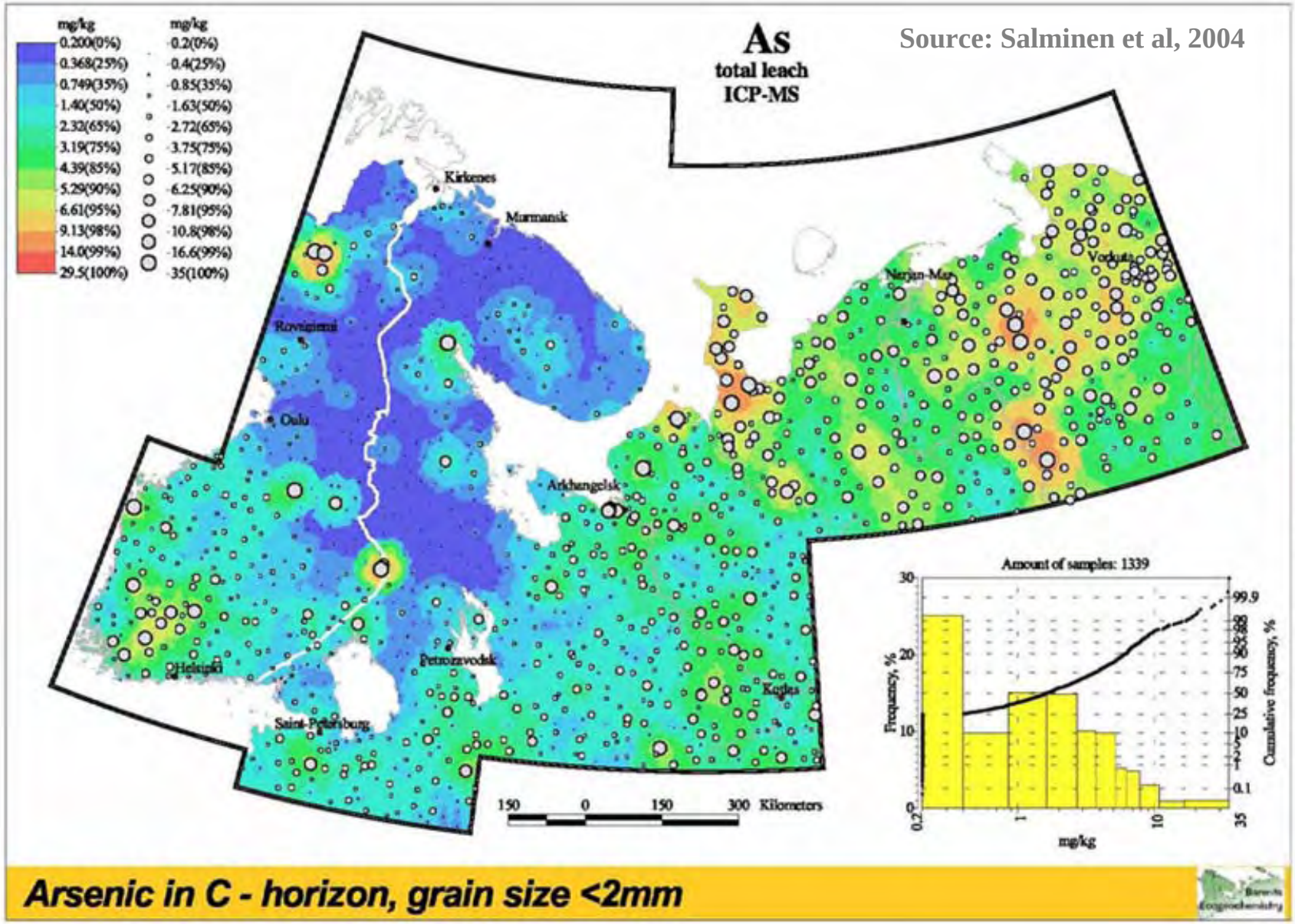


Example: U in Agricultural Soils in N Europe

Source: Reimann et al, 2003



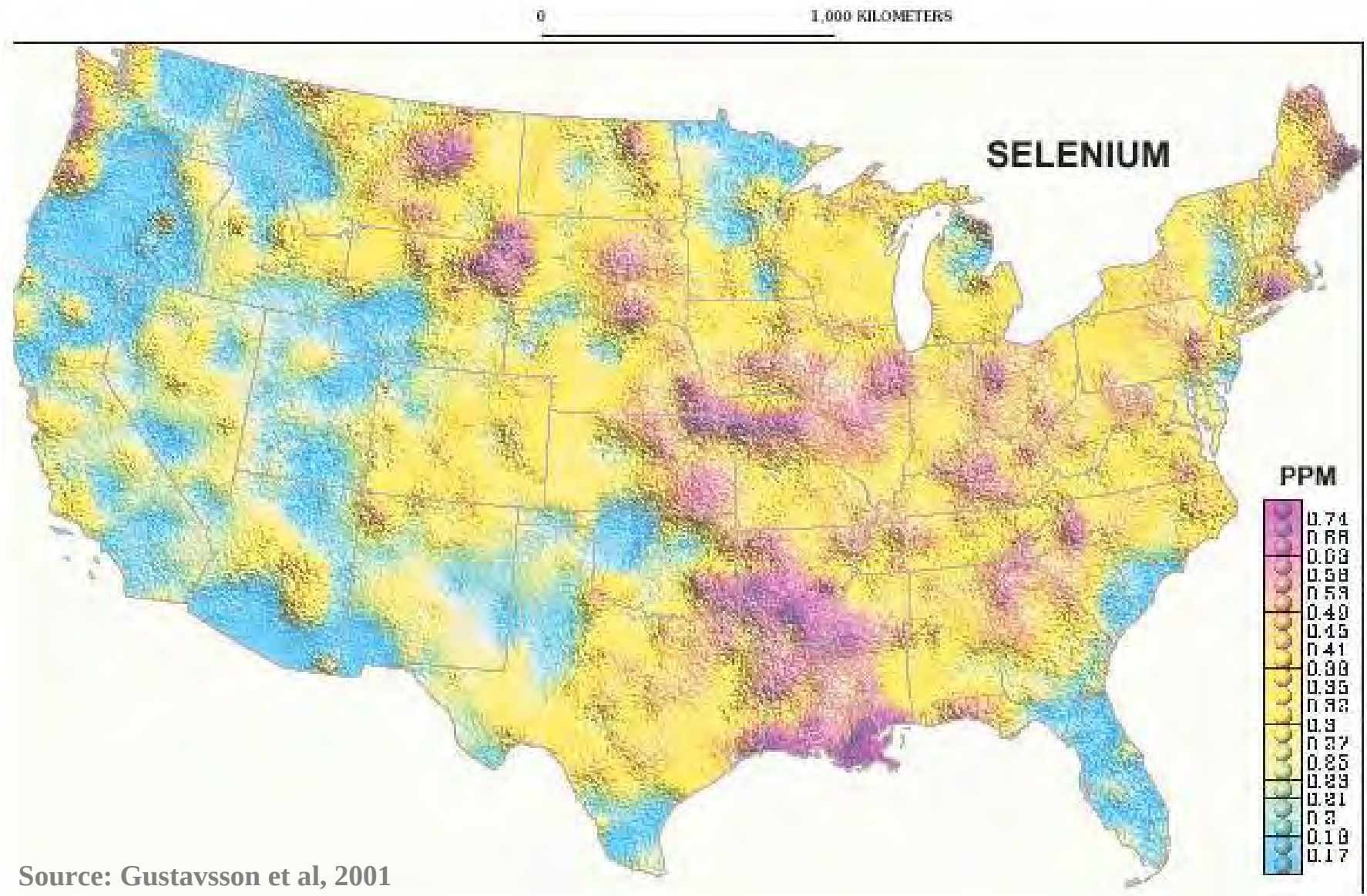
Example: As in Soils in Barents



Source: Salminen et al, 2004

R. Salminen et al. / Journal of Geochemical Exploration 83 (2004) 1–530

Example: Se in USA

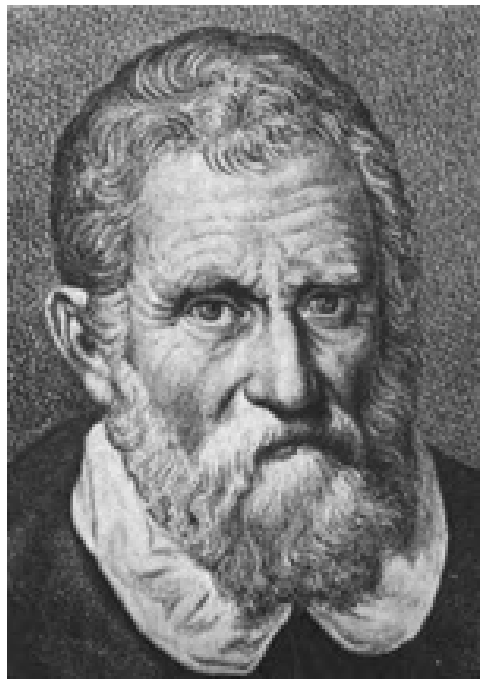


Source: Gustavsson et al, 2001

“Everything is a poison, nothing is a poison, the dose alone is the poison” P.A. Parcelus (1493-1541)

Community impact studies

(Selenium rich/poor soils - China)



Marco Polo
1254-1324

中国硒元素生态景观类型图

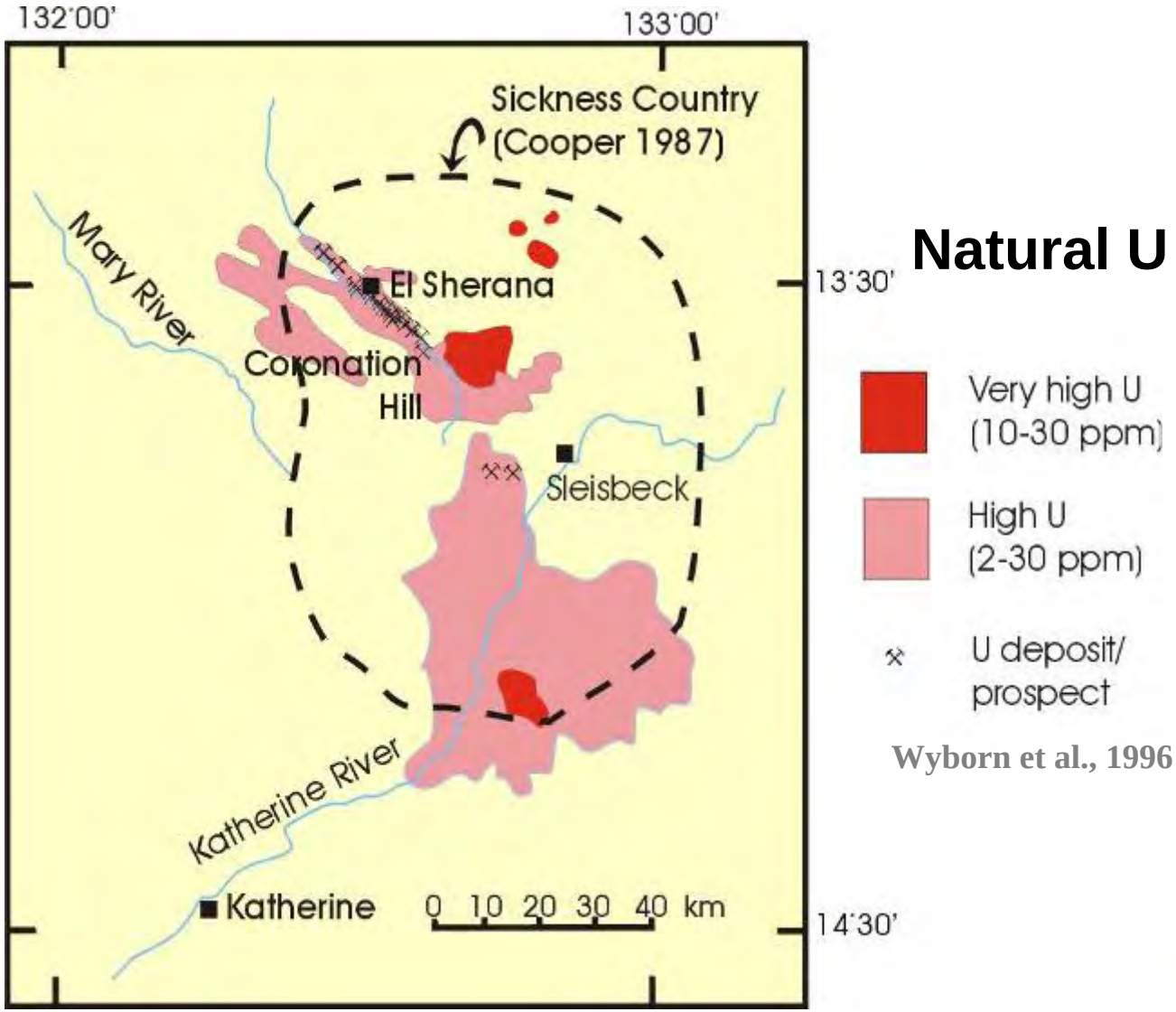
Selenium Ecological Landscape Map of China

Tan et al., 1998

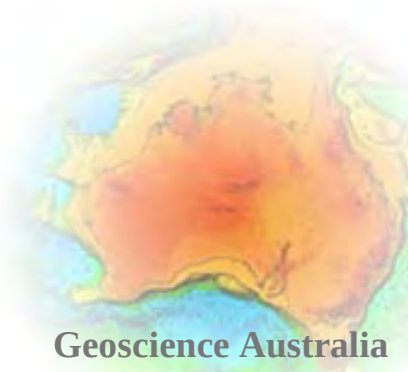
Geological Survey of Sweden http://www.sgu.se/verksamhet/tillampa/geomedi/geomed_e.htm

Community impact studies

(Sickness Country - Kakadu)

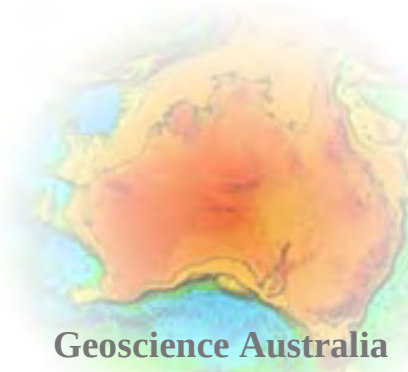


Wyborn et al., 1996

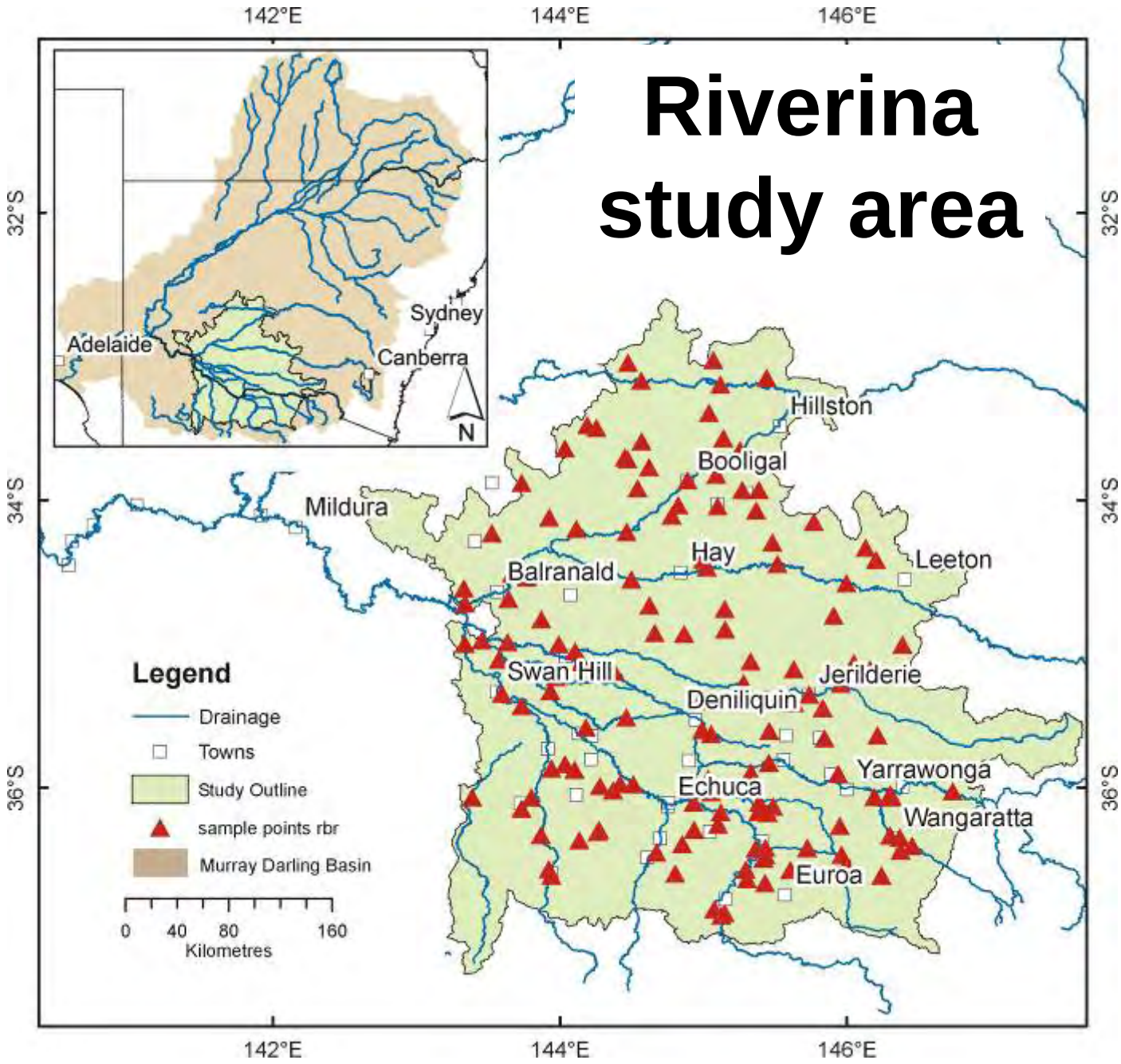


Objectives of Project

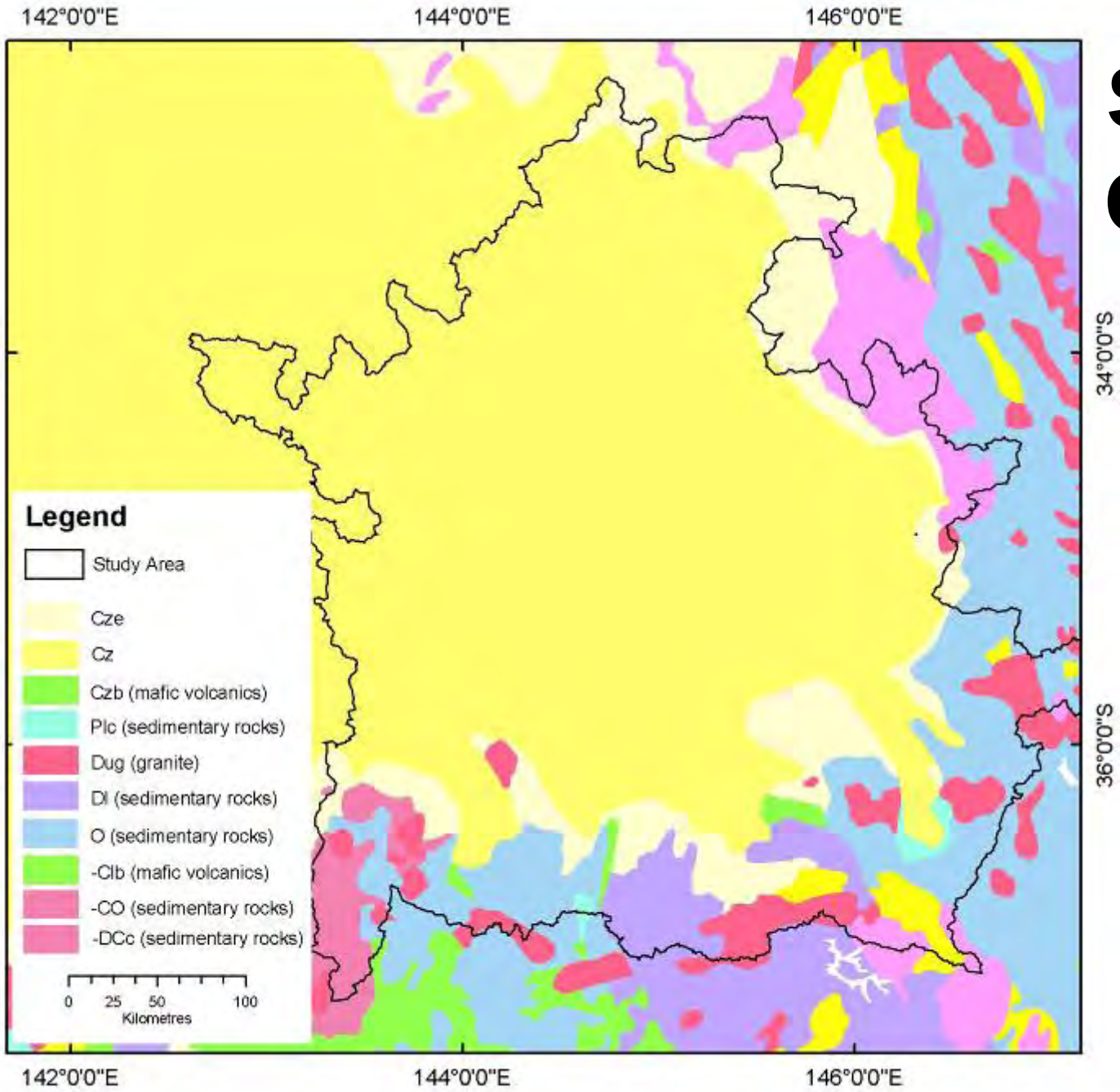
- **Develop a cost-effective geochemical mapping methodology applicable to Australia:**
  - **Low-density**
  - **Multi-media**
  - **Multi-element**
  - **Landscapes: transported regolith, low-relief, arid climate, etc.**



Riverina study area

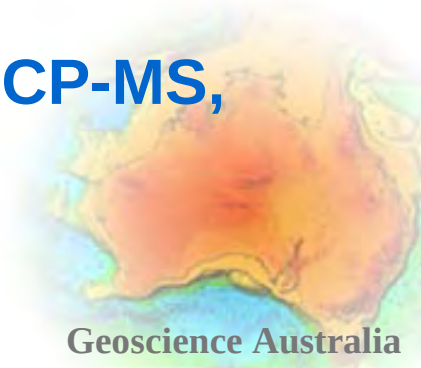


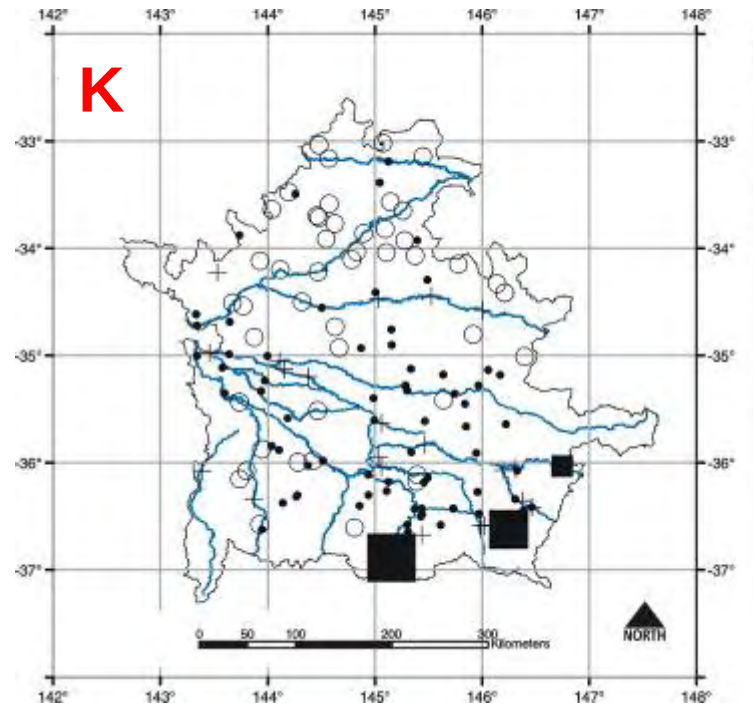
Surficial Geology

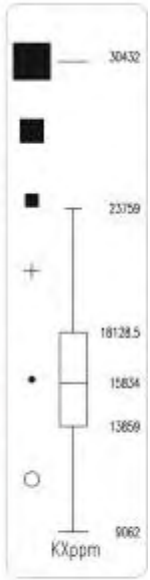


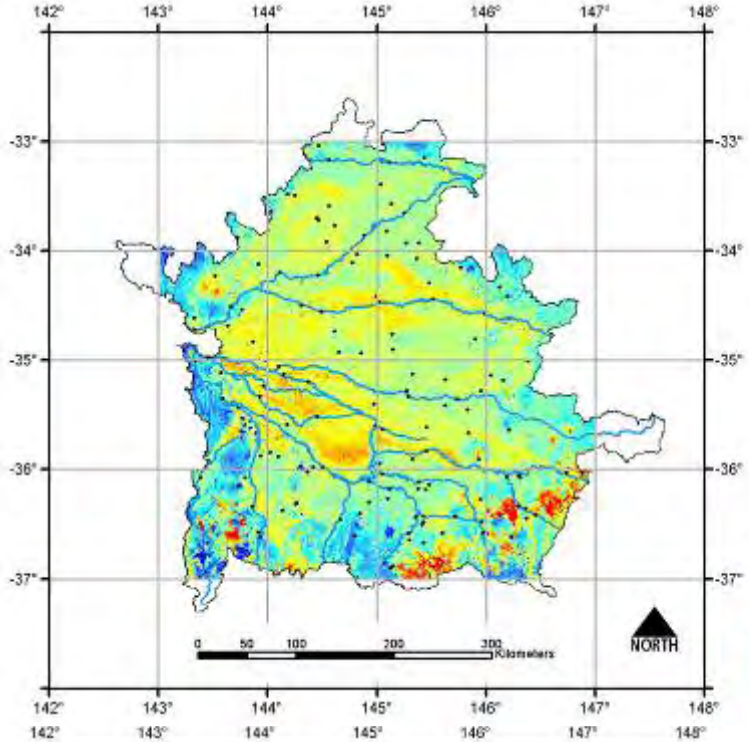
Approach

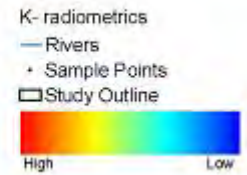
- 142 sites selected near outlets of large catchments (ArcHydro)
- Sample sites adjusted on site basis considering access, landscape position
- Top (0-10 cm) & bottom (~60-90 cm) sampled (<180um)
- Sample
  - Overbank sediments (all sites)
  - Endemic plant (River Red Gums)
  - Shallow groundwater
- Analyse with multi-element methods (XRF, ICP-MS, INAA, ISE) on bulk and selective extracts

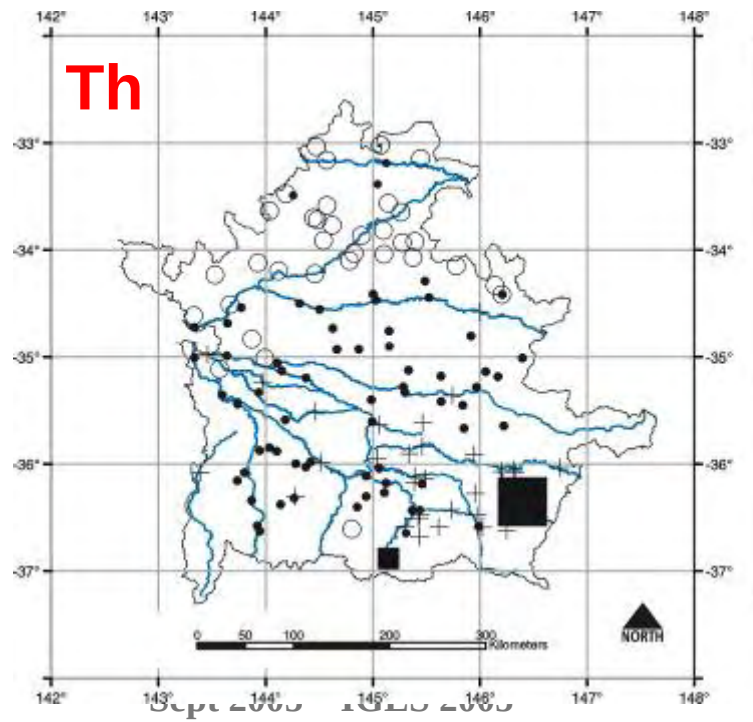


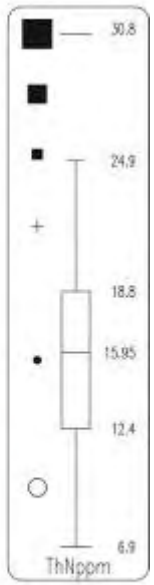

K
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH

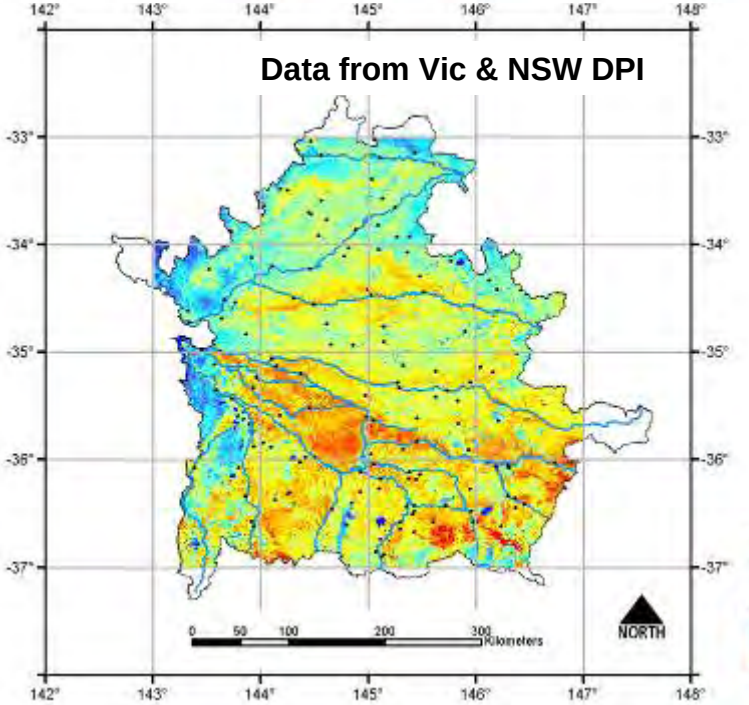

30432
23759
18128.5
15834
13659
9062
KXppm

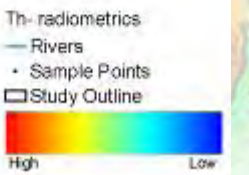

142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH

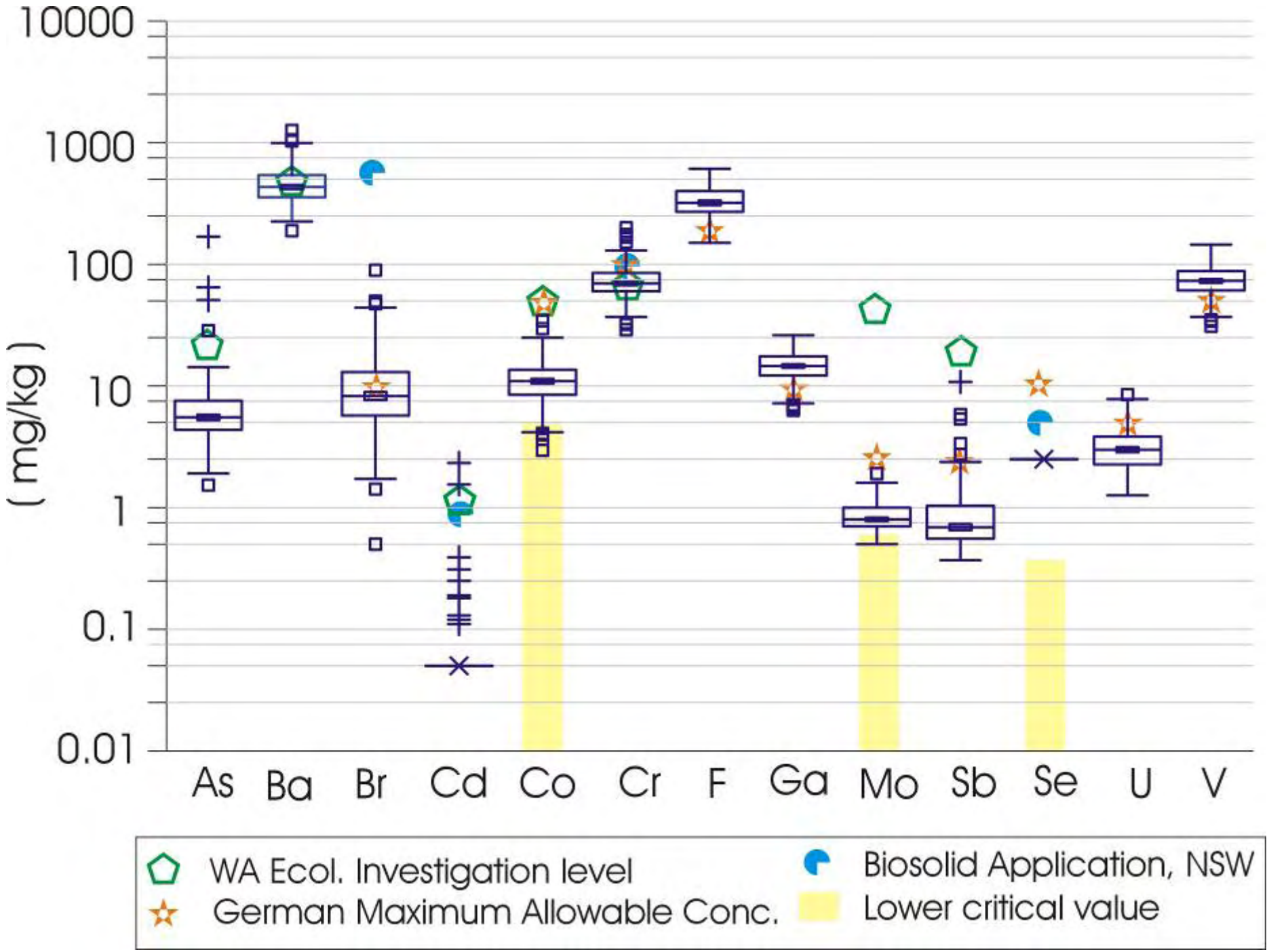

K- radiometrics
Rivers
Sample Points
Study Outline
High
Low


Th
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH


30.8
24.9
18.8
15.95
12.4
6.9
ThNppm

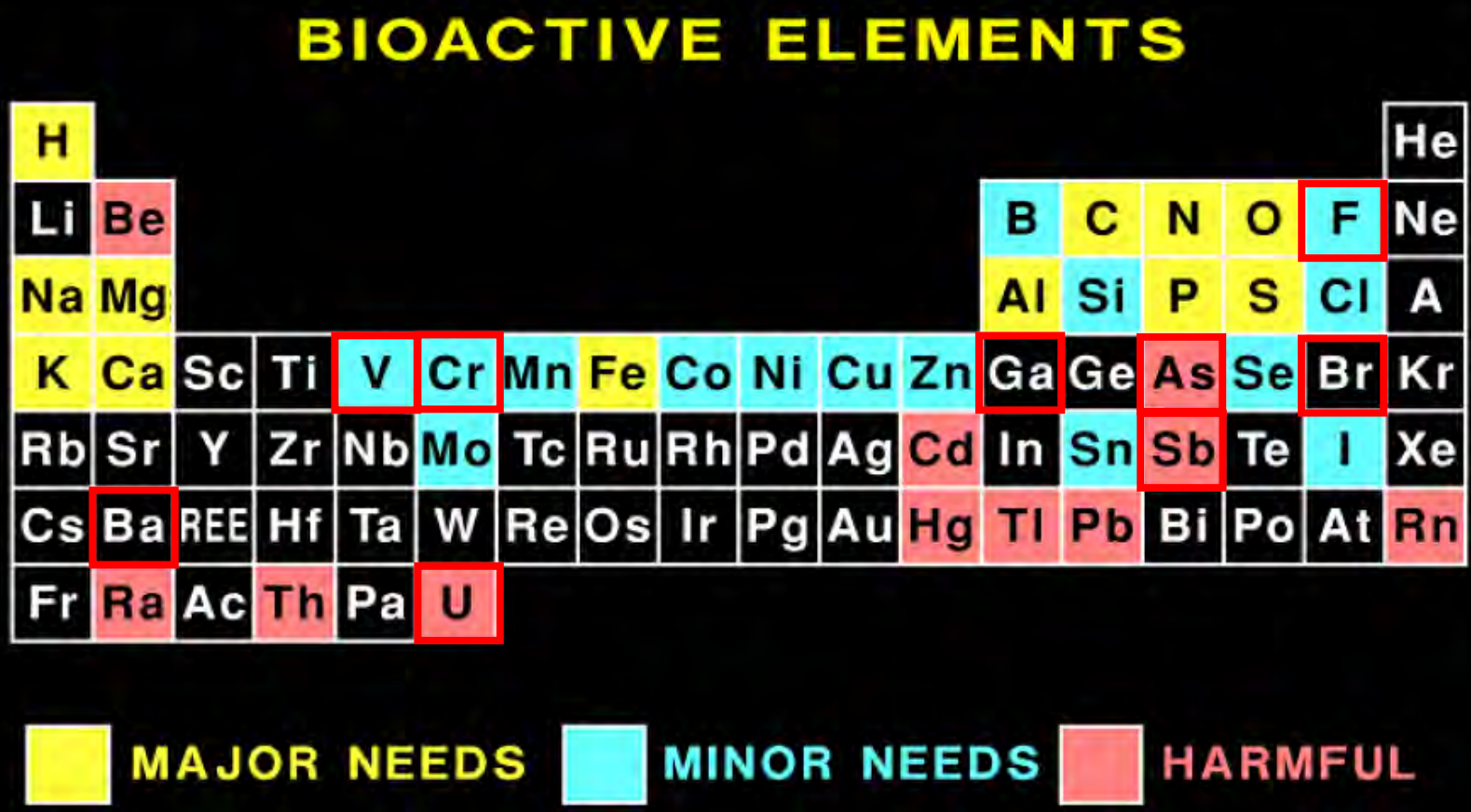

Data from Vic & NSW DPI
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH


Th- radiometrics
Rivers
Sample Points
Study Outline
High
Low

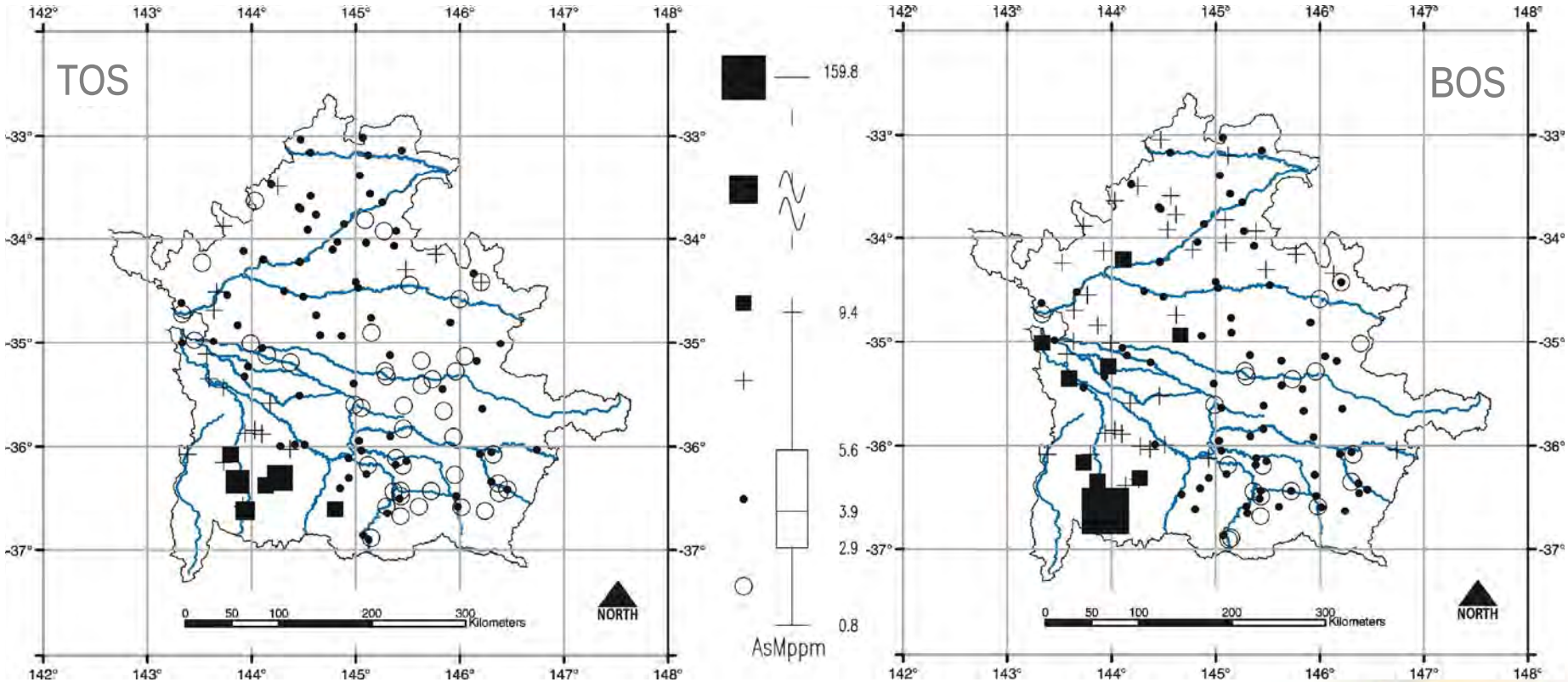

10000
1000
100
10
1
0.1
0.01
(mg/kg)
As
Ba
Br
Cd
Co
Cr
F
Ga
Mo
Sb
Se
U
V
WA Ecol. Investigation level
German Maximum Allowable Conc.
Biosolid Application, NSW
Lower critical value

Potential Excesses

- As
- Ba
- Br
- Cr
- F
- Ga
- Sb
- U
- V

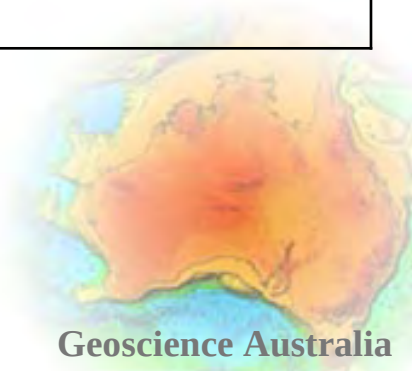


Arsenic

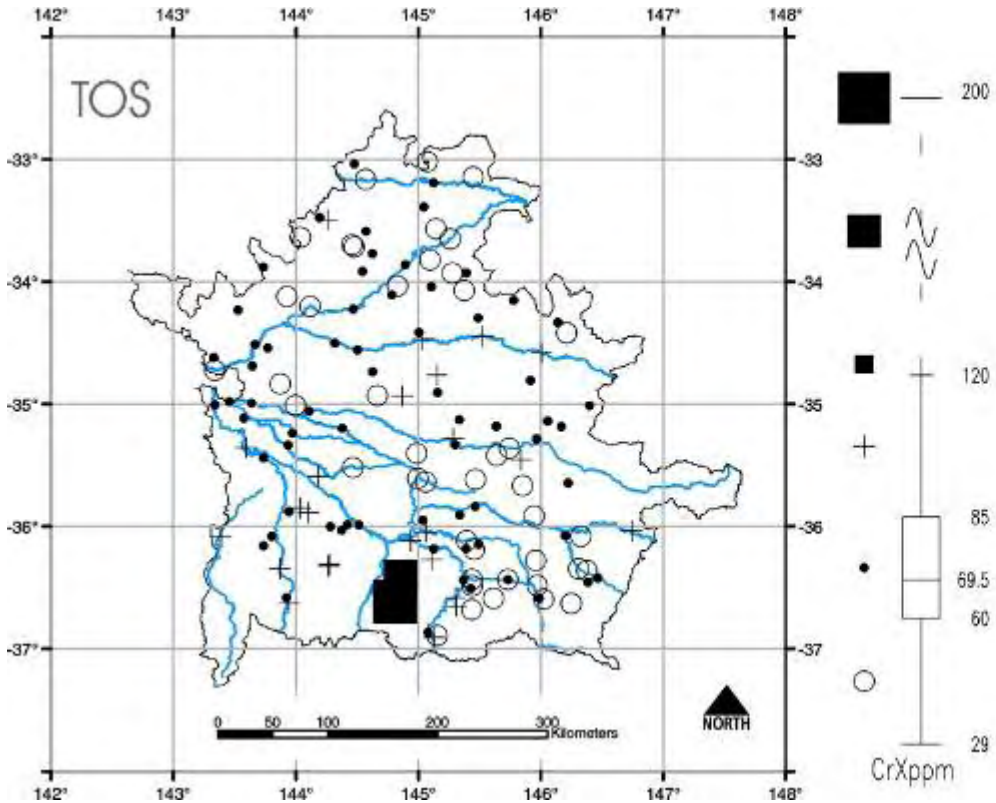

TOS
BOS
159.8
9.4
5.6
3.9
2.9
0.8
AsMppm
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH

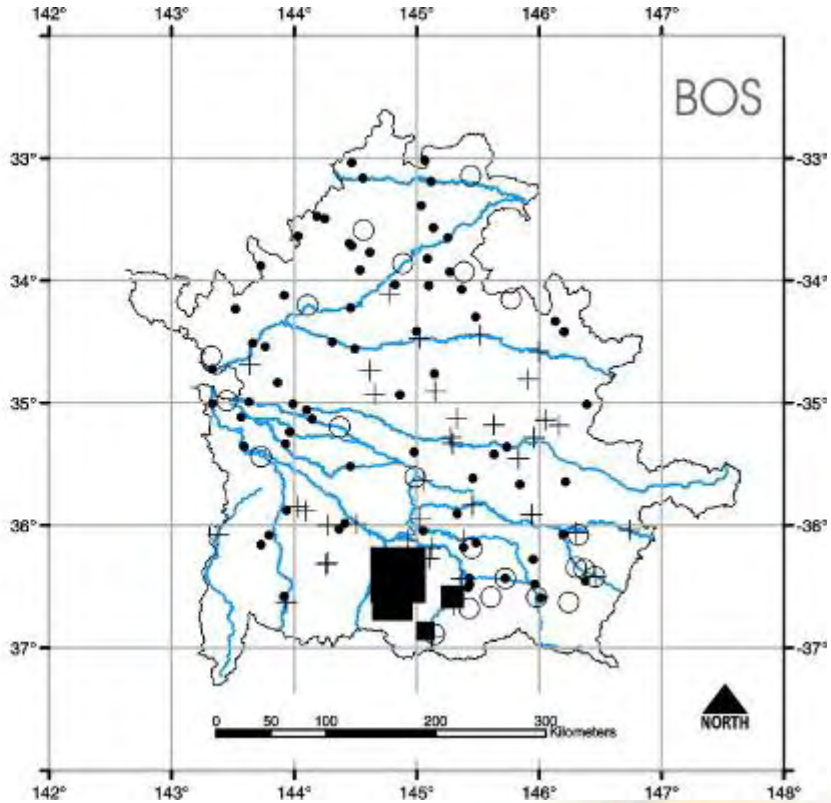
Arsenic

Symptoms	Source	Threat?
• Skin hyper-pigmentation & lesions • Liver & kidney disease • Cancer • Death	Gold fields, pesticides	• Affinity with oxides (Al, Fe) • Low risk



Chromium

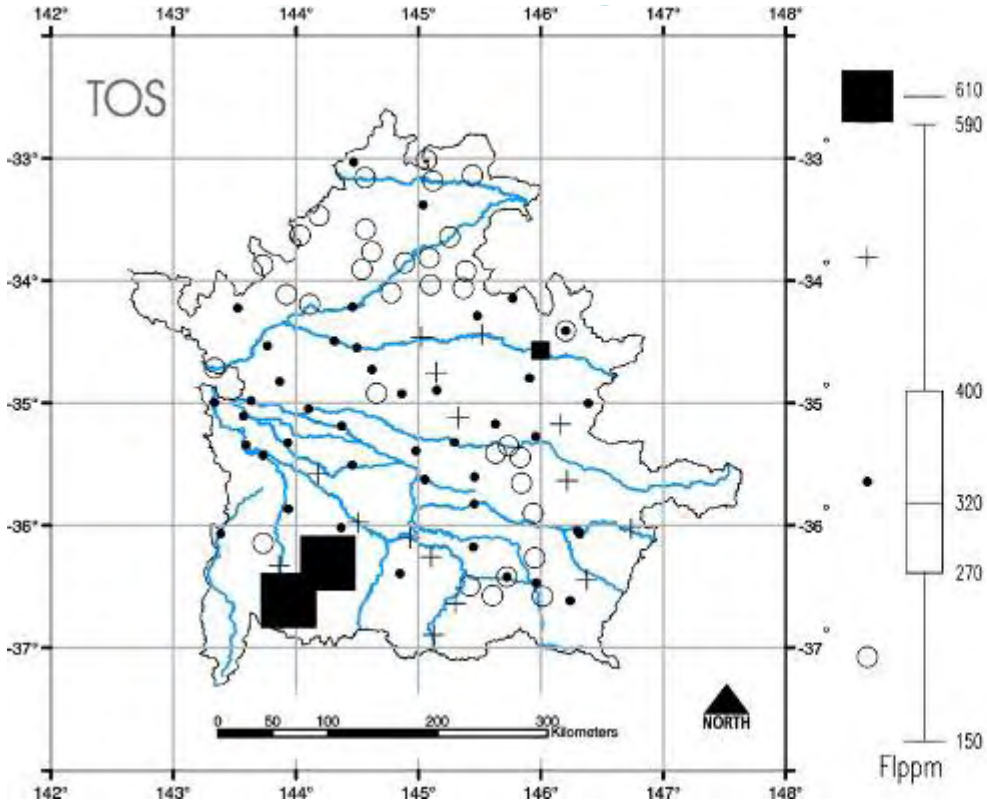

TOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH
200
120
85
69.5
60
29
CrXppm

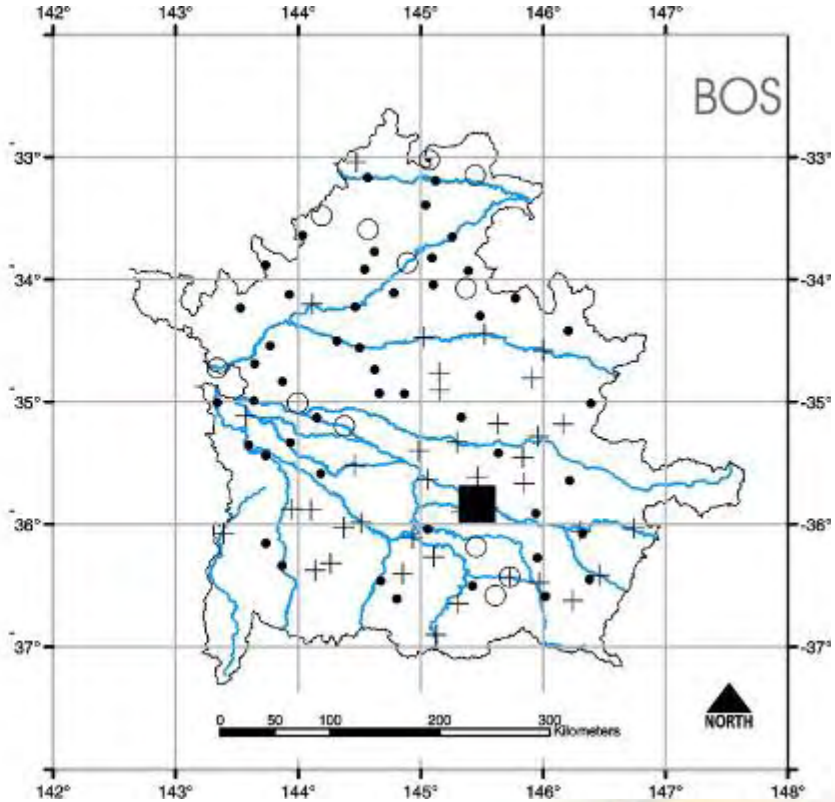

BOS
142°
143°
144°
145°
146°
147°
148°
33°
34°
35°
36°
37°
0 50 100 200 300 Kilometers
NORTH

Chromium

Symptoms	Source	Threat?
• Lung cancer • Skin irritations • Kidney, liver & circulatory problems	Mafic Volcanics	• Unlikely • Cr^{III} dominant oxidation state – Relatively non toxic – Bound to clay & heavy minerals

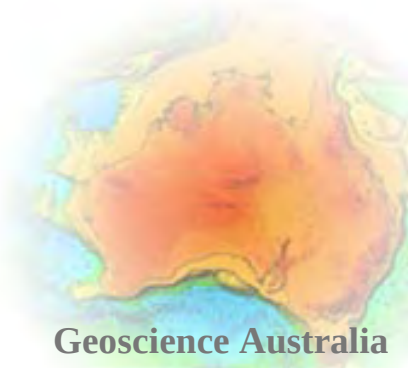
Fluorine


TOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
610
590
400
320
270
150
Flppm
0 50 100 200 300 Kilometers
NORTH

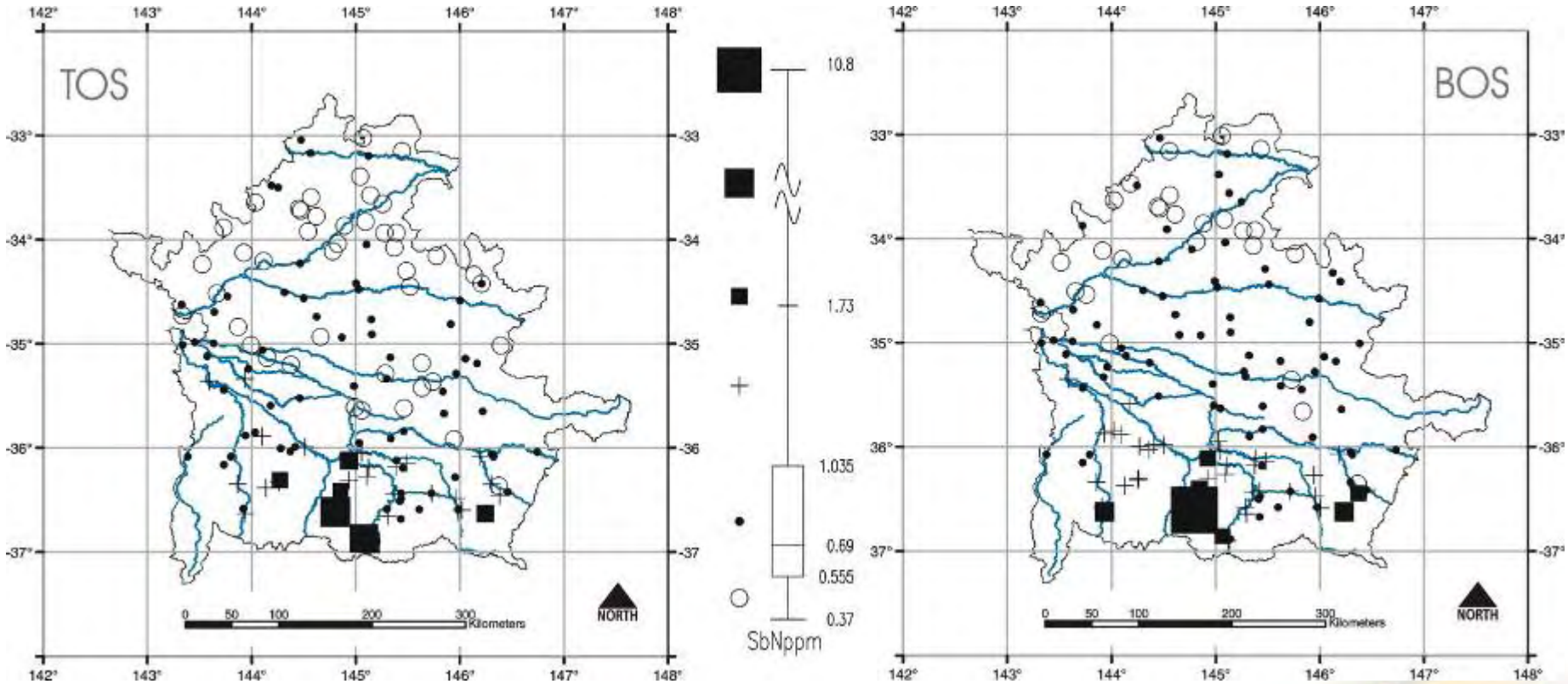

BOS
142°
143°
144°
145°
146°
147°
148°
33°
34°
35°
36°
37°
0 50 100 200 300 Kilometers
NORTH

Fluorine

Symptoms	Source	Threat?
• Fluorosis • Dental & skeletal abnormalities	• Fertilizers, apatite? • Fluorite deposits in granite	• Unlikely • Low soil-plant transfer

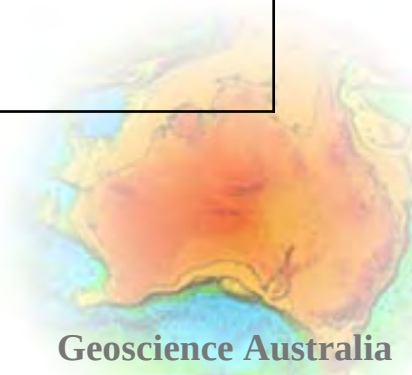


Antimony

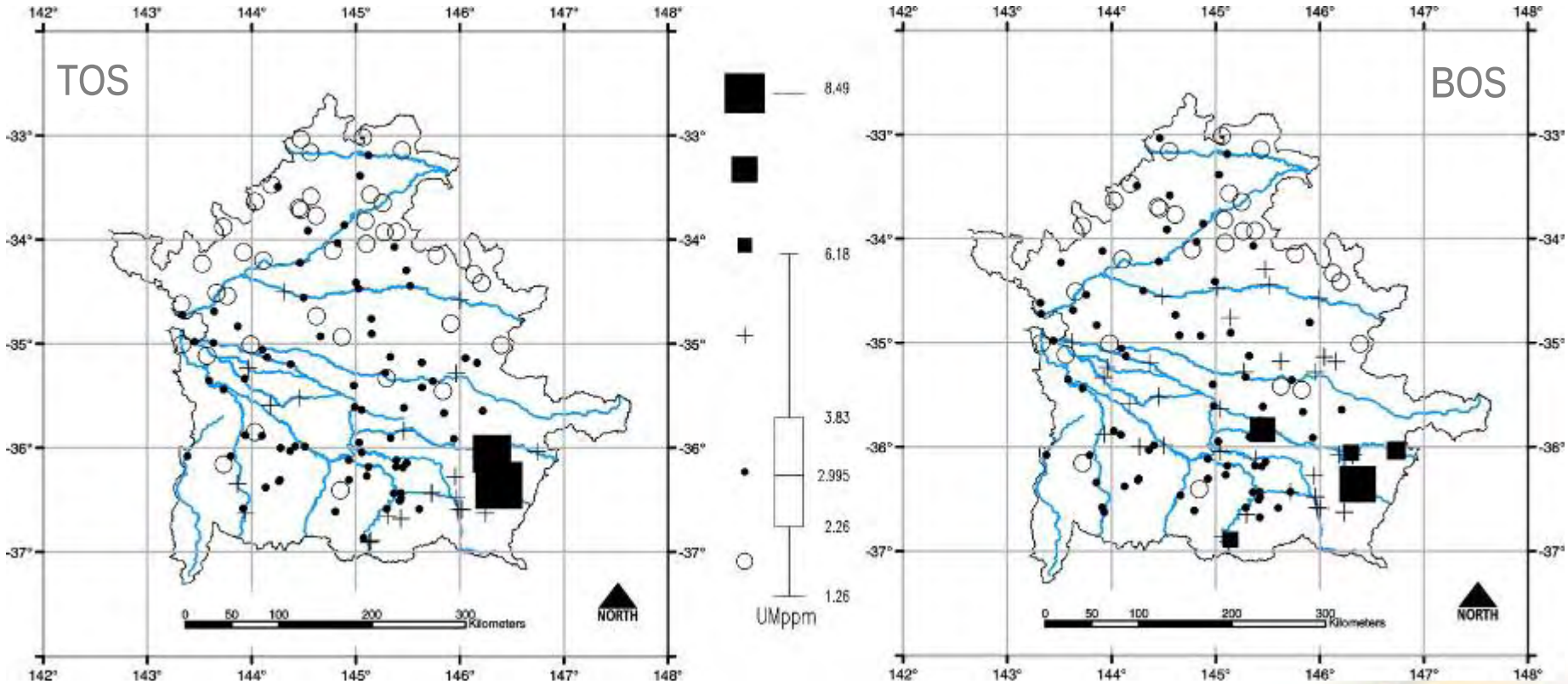

TOS
BOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH
10.8
1.73
1.035
0.69
0.555
0.37
SbNppm

Antimony

Symptoms	Source	Threat?
• Diarrhoea, muscle pain • Anaemia • Heart problems • Carcinogenic?	• Gold fields	• Unlikely • Low plant uptake



Uranium

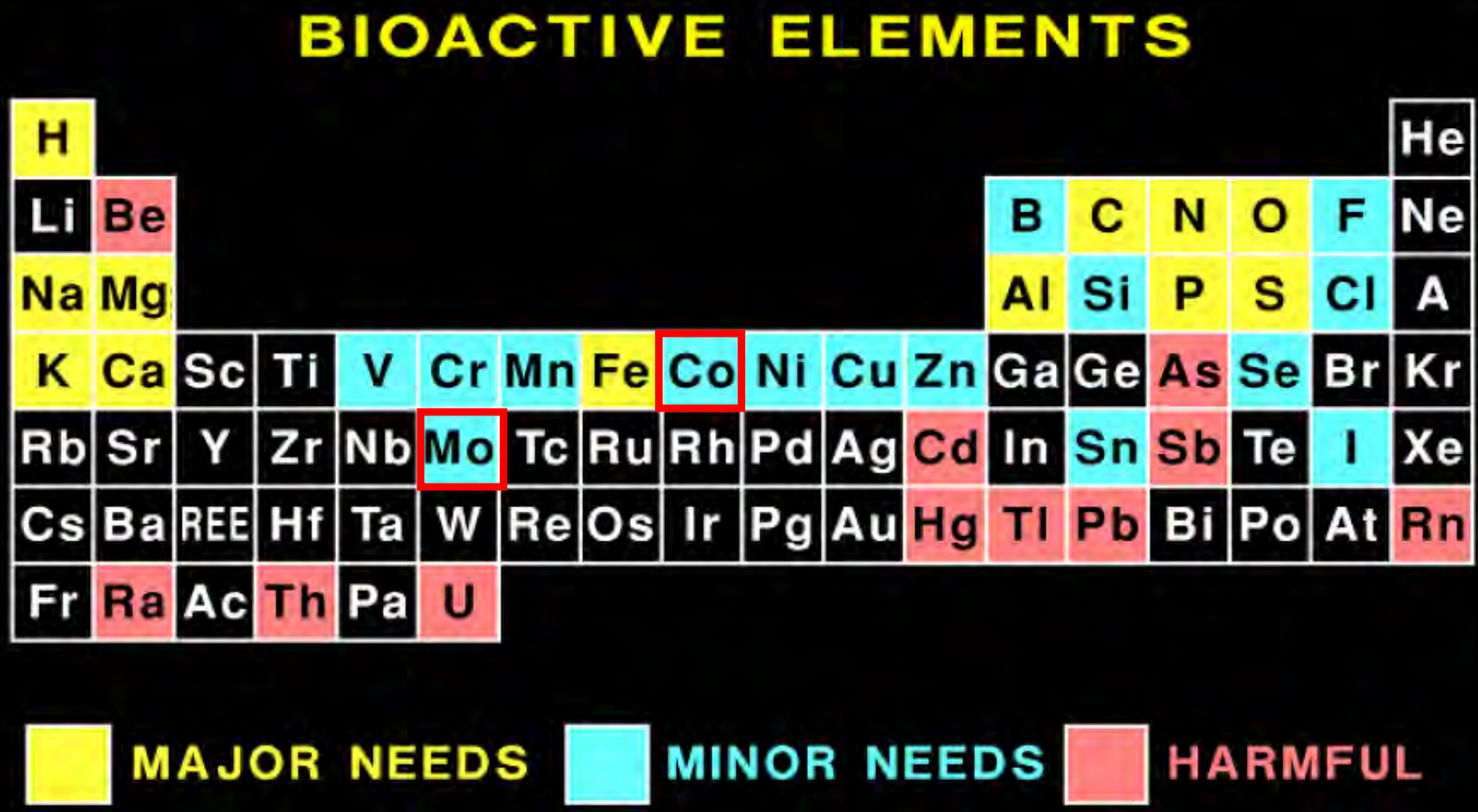

TOS
BOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
8.49
6.18
3.83
2.995
2.26
1.26
UMppm
0 50 100 200 300 Kilometers
NORTH

Uranium

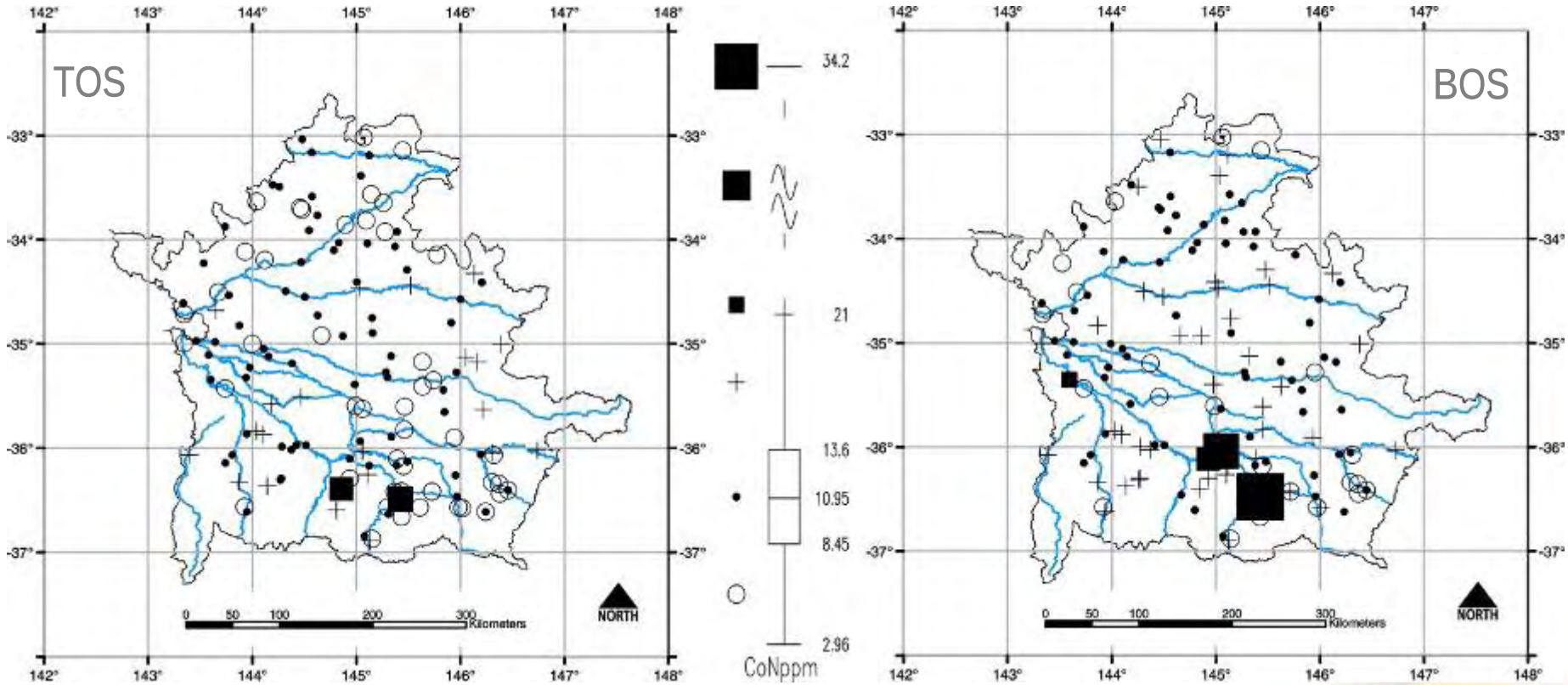
Symptoms	Source	Threat?
• Carcinogenic (lung, kidney, liver, bone)	• Granites • Phosphate fertilizers	• Depends on dosage rates • Clay brick – ~8.2 mg/kg (Major, 2001) • Unlikely

Potential Deficiencies

- Co
- Mo

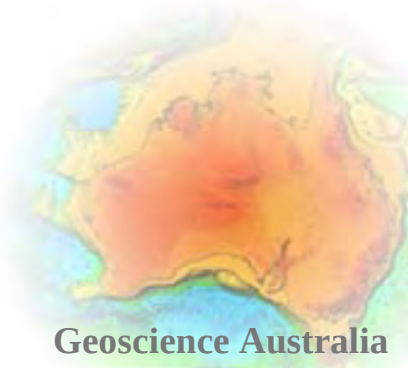


Cobalt

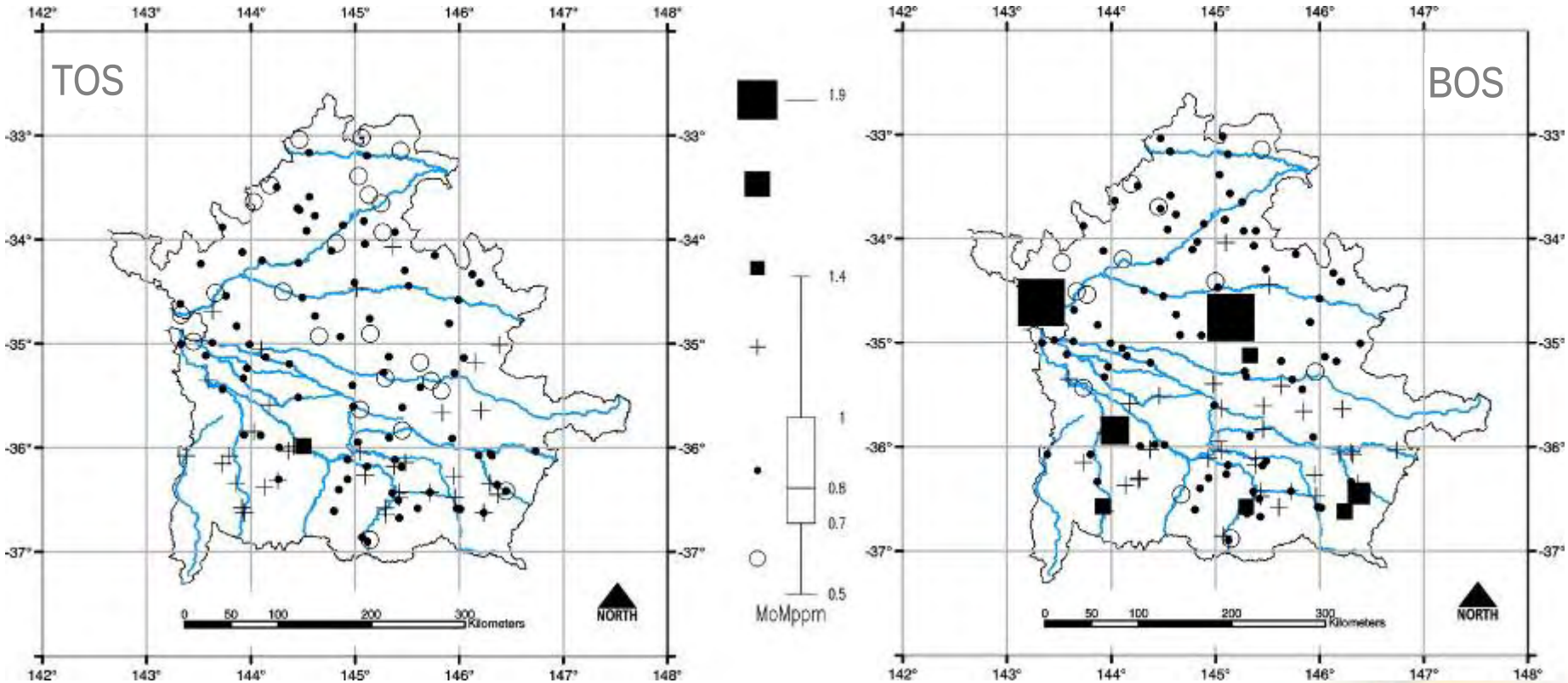

TOS
BOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH
34.2
21
13.6
10.95
8.45
2.96
CoNppm

Cobalt

Symptoms	Reason	Remediation
• Anaemia • White liver disease	• Affinity with Fe (clays) • Deficiencies in calcareous and coarse textured soils	• Addition of Co fertilizer

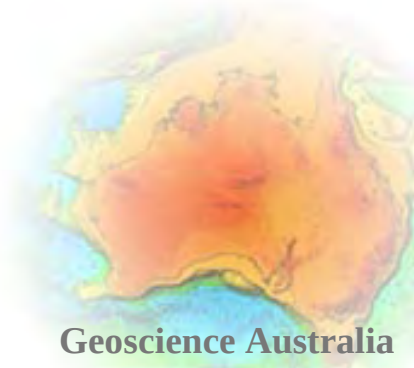


Molybdenum


TOS
BOS
142°
143°
144°
145°
146°
147°
148°
-33°
-34°
-35°
-36°
-37°
0 50 100 200 300 Kilometers
NORTH
1.9
1.4
1
0.8
0.7
0.5
MoMppm

Molybdenum

Symptoms	Reason	Remediation
• None in humans? • Essential for crops	• Lower avail. in acid soils	• Mo fertilizer

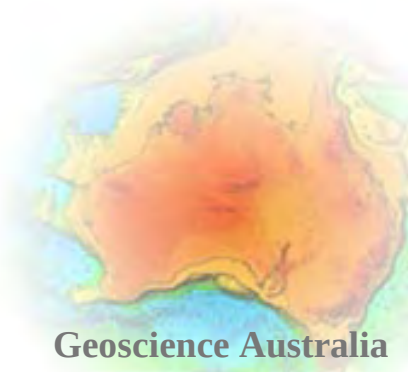


Concluding remarks

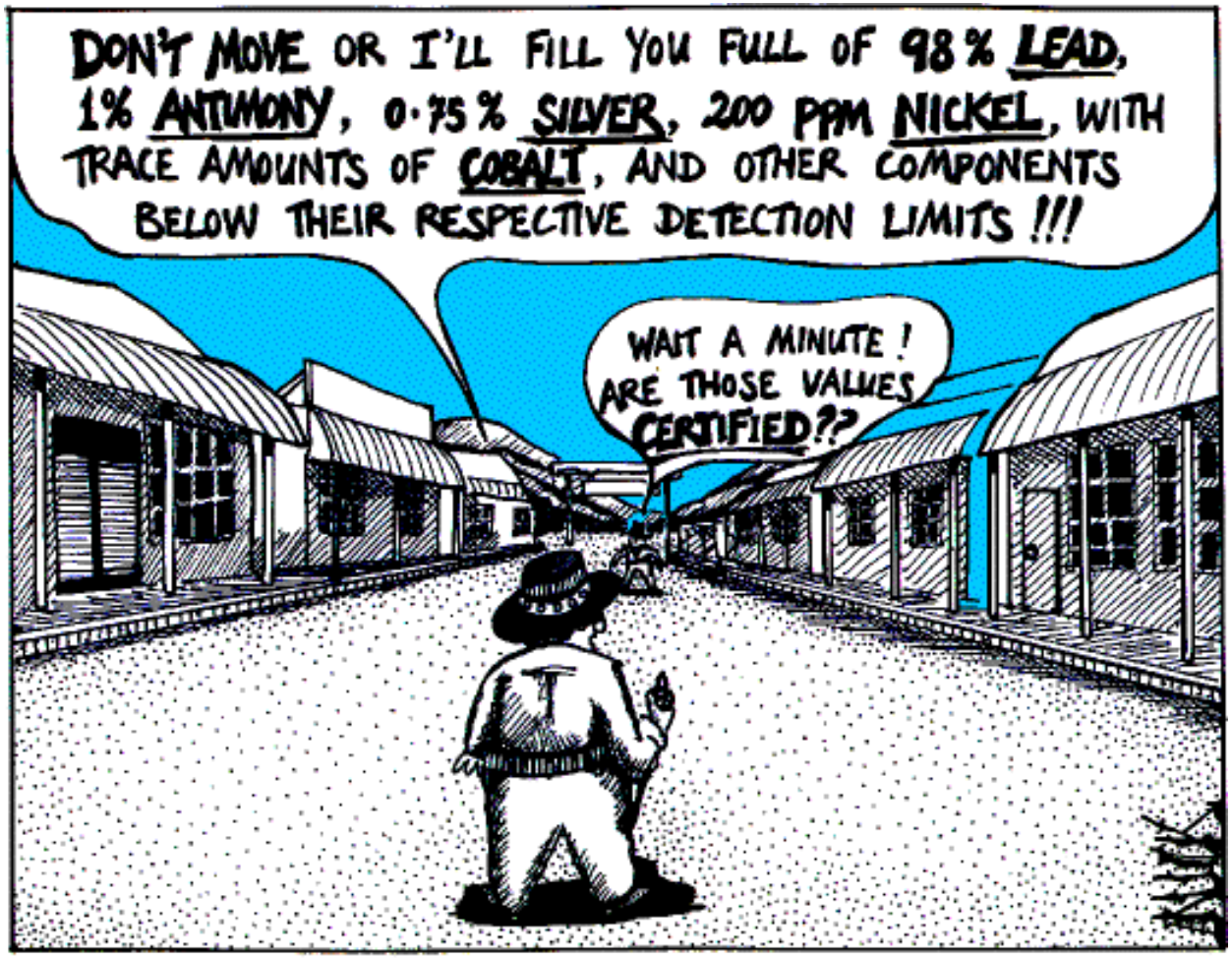
- Balance between elemental deficiencies and excesses is essential for healthy plant and animal development
- Pose no immediate threat to humans
  - Crops and stock an issue?
- Existing guidelines are patchy
  - Limited for Australia
  - None use bioavailability
- Total concentration does not reliably measure bioavailability

WHY? Elements vary with environmental conditions

- Sequential leach extractions to be interpreted



Questions?



ANALYTICAL CHEMISTS IN THE WILD WEST

References

Gustavsson, N. et al., 2001. Geochemical Landscapes of the Conterminous United States - New Map Presentations for 22 Elements. US Department of the Interior, US Geological Survey Professional Paper 1648.

Major, R. 2001. Natural radioactivity, hazards. Wastes and the environment in Australia In: Gostin, V. (Ed). Gondwana to Green House, p 111-124.

Reimann, C. et al., 2003. Agricultural Soils in Northern Europe: A Geochemical Atlas, 279pp.

Salminen, R. et al., 2004. Special Issue - Geochemical atlas of the eastern Barents region. *Journal of Geochemical Exploration* 83(vii), 523 pp.

Tan et al., 1998. The atlas of endemic diseases and their environments in the People's Republic of China. Beijing: Science Press, 194pp.

Tukey, 1977. Exploratory data analysis. Addison-Wesley, Reading, 506pp.

Wyborn, L. at al., 1996. Environmental geochemistry in the southern Kakadu region and the “sickness country concept”. In: Geological Society of Australia abstracts Vol41, 483pp.

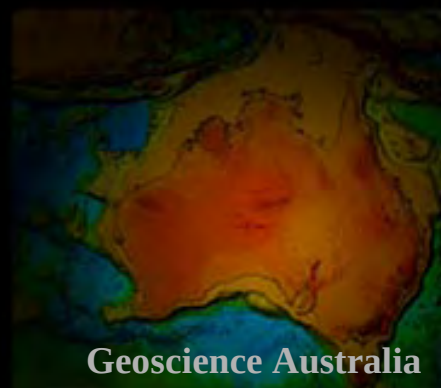
Australian Government

Geoscience Australia

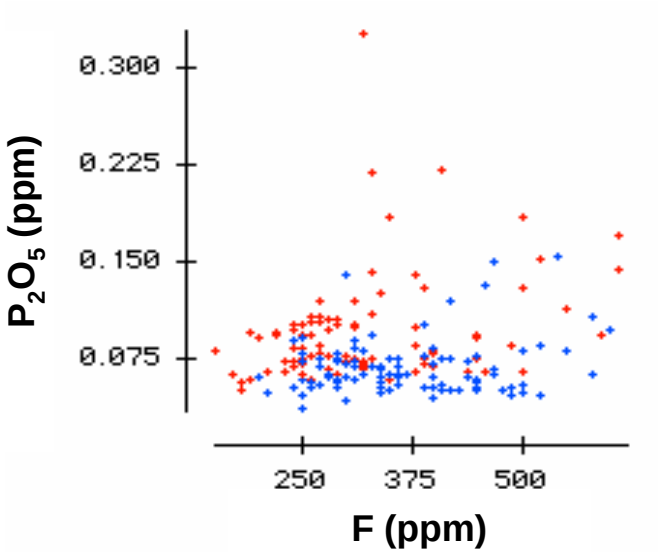
Geohealth implications for the Riverina Baseline Geochemistry Survey

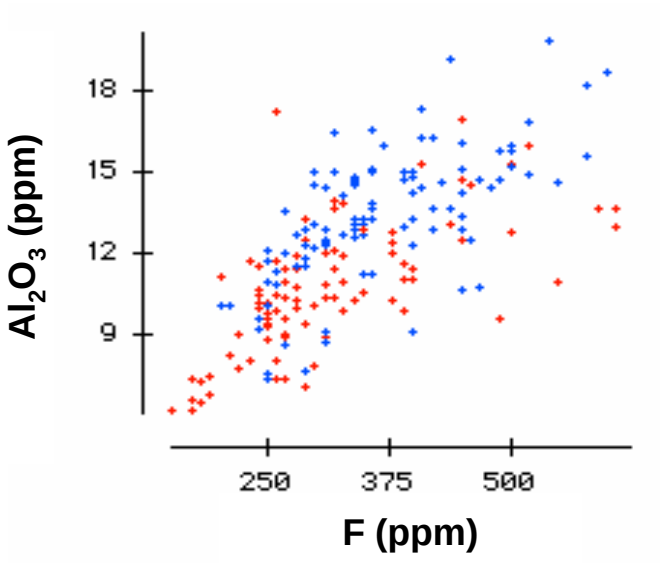
Megan Lech

ANU GEOL 3008



Fluorine



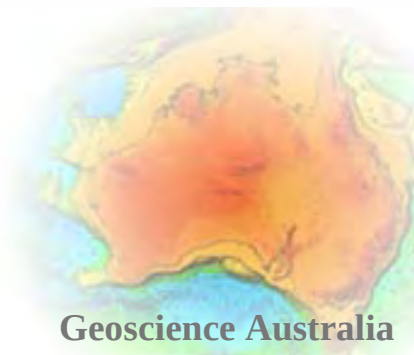


TOS

BOS

	Riverina, Australia (this report)		US (Shacklette & Boerngen, 1984)#		Northern Europe (Reimann et al, 2003)+				China (Li Jiaxi and Wu Gongjian, 1999		World soils (Bowen, 1979)	
Element	Median	Range	Average	Range	Top (0-25cm) Median	Top Range	Bot (50-75cm) Median	Bot Range	Mean ± standard deviation	Range*	Median	Range
As	3.9	0.8-159.8	7.2	<0.1-97	4	<2-30	4	<2-34	11.31±6.61	2.28-38.5	6	0.1-40
Ba	432	189-1263	580	10-5000	404	26-2007	419	6-2920	----------	----------	500	100-3000
Br	8.27	<1-89.5	0.85	<0.5-11	----------	----------	----------	----------	----------	----------	----------	----------
Cd	<0.05	<0.05-2.33	----------	----------	0.13[i]	<0.005-1.1[i]	0.06[i]	<0.005-2.5[i]	0.14±0.13	0.01-0.7	0.35	0.01-2
Cr	69.5	29-200	54	1-2000	32	<3-614	36	<3-269	58±24.68	11.10-143.19	70	5-1500
F	320	150-610	430	<10-3700	----------	----------	----------	----------	465±145	175-980	200-300	20-700
Ga	14.6	6.3-26.1	17	<5-70	10	<3-25	11	<3-29	----------	----------	----------	----------
Sb	0.69	0.37-10.8	0.66	<1-8.8	----------	----------	----------	----------	----------	----------	1	0.2-10
U	3	1.26-8.49	2.7	0.29-11	1.4	<0.1-56	1.3	<0.1-13	----------	----------	----------	----------
V	73	31-145	9.1	<3-70	37	0.7-258	43	0.7-259	78.19±34.97	3.00-248.37	90	3-500
Co	10.95	2.96-34.2	----------	----------	5.3[ii]	0.4-42[ii]	6.4[ii]	<0.2-42[ii]	12.52±5.70	1.09-40.03	8	0.05-65
Mo	0.8	0.5-1.9	0.97	<3-15	<0.6[ii]	<0.6-72[ii]	<0.6[ii]	<0.6-42[ii]	1.08±0.67	0.10-3.65	1,2	0.1-40
Se	<5	<5	0.39	<0.1-4.3	0.14[i]	0.02-7.6[i]	0.08[i]	<0.01-6.7[i]	----------	----------	0.4	<5000

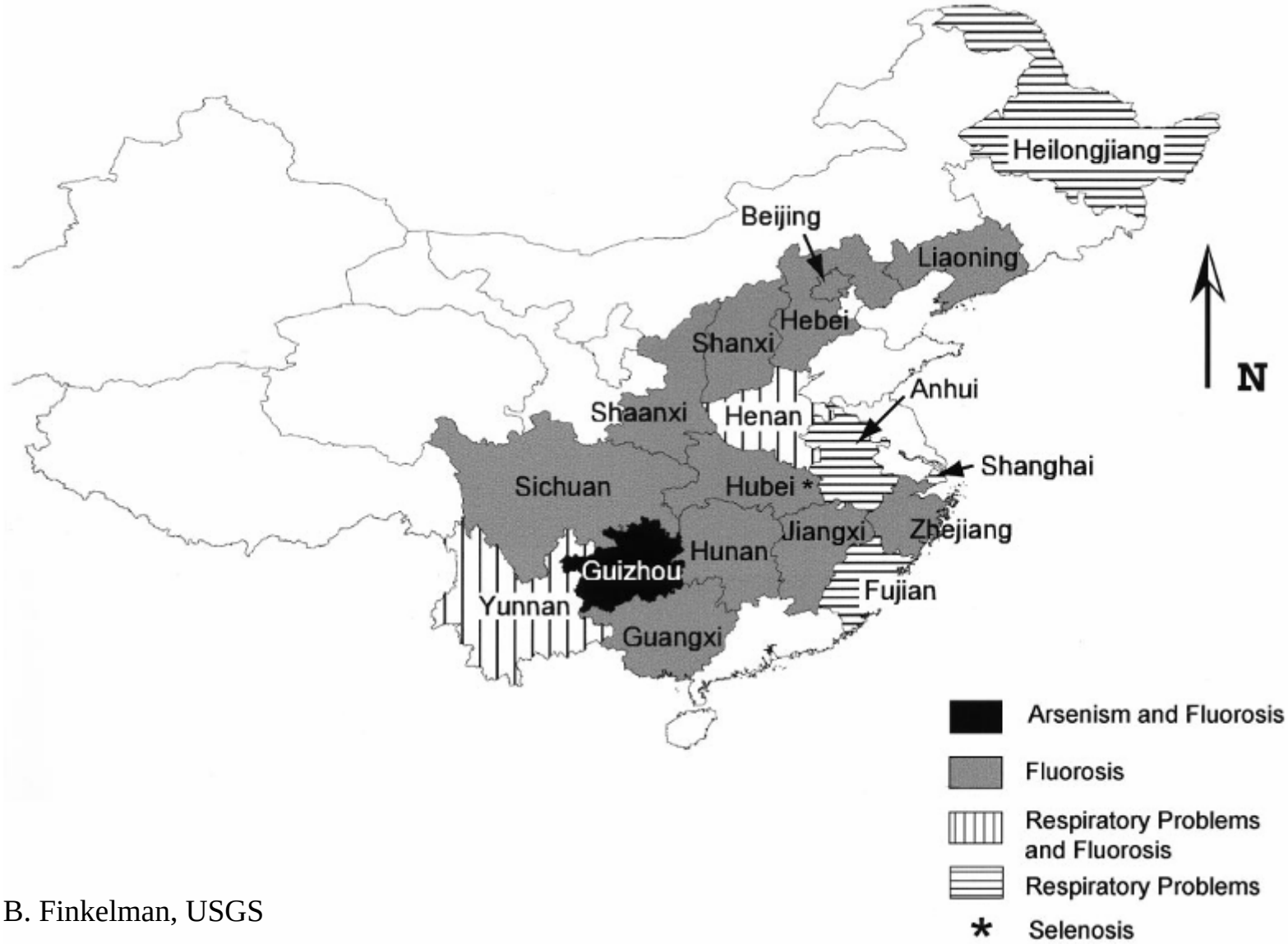
#	roadside soils
+	agricultural soils (<2mm)
*	Krig interpolated range
i	Aqua regia as apposed to total concentration
ii	HF- extraction



Element (Detection limit, mg/kg)	Eastern Riverina Survey			WA Interim Ecol. Investig. Level	GMTLAS	Biosolid application (NSW)	Remed. level (Ned)	Lower critical values
	Min	Med	Max					
As (0.5)	0.8	3.9	159.8	20		20		
Ba (2)	189	432	1263	400			625	
Br (1)	<1	8.27	89.5		10			
Cd (0.1)	<0.1	<0.1	2.33	3		1	12	
Co (1)	*2.96*	11.0	34.2	50	50		240	<2-5;0.02-0.3 AA
Cr (4)	29	69.5	200	50	100	100	380	
F (20)	150	320	610		200			
Ga (0.1)	6.3	14.6	26.1		10			
Mo (0.01)	*0.5*	0.8	1.9	40	5		200	<0.1 (HW); 0.01-0.6 (AO)
Sb (0.01)	0.37	0.69	10.8	20	5		15	
Se (5)	*<5*	*<5*	*<5*		10	5		<0.04 (T)
U (0.07)	1.26	3	8.49		5			
V (6)	31	73	145		50			

All geochem in mg/kg

As/F toxicity from coal combustion



Source: B. Finkelman, USGS