National Geochemical Survey of Australia: Outline of a new proposal

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Geoscience Australia

Outline of Presentation

- **Introduction**
  - What are geochemical surveys?
  - Why worry about them?
- **Selected Results from Pilot Projects**
  - How we did it?
  - What they show?
- **Outline of a Proposal for Onshore Energy Security Initiative**
  - What can a National Geochemical Survey of Australia deliver?
- **Conclusions**

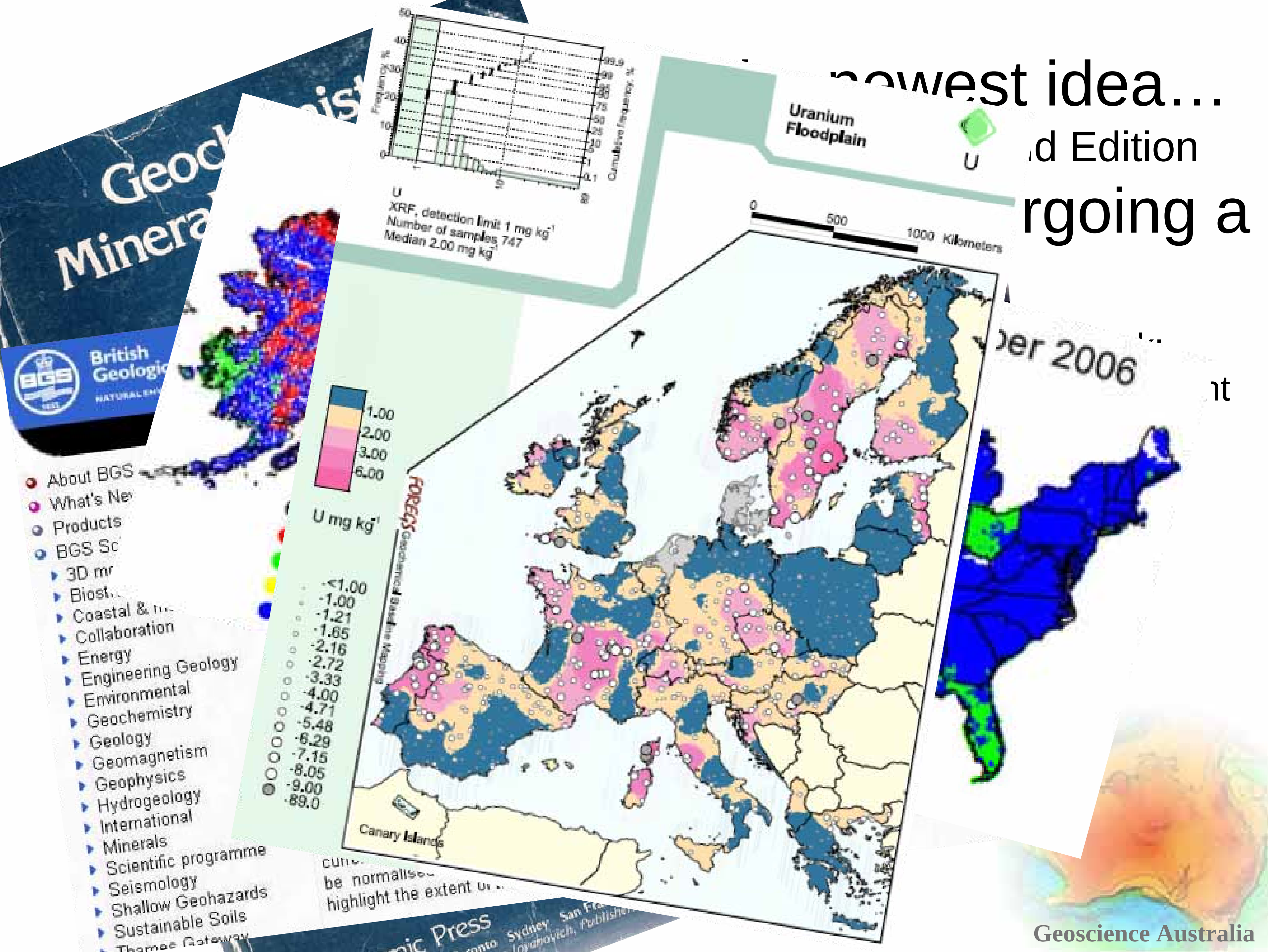
Introduction

What are geochemical surveys?

- **They are the documentation of the chemical composition of the Earth's surface**
- **Fundamental dataset**
- **Nature of end-product depends on a number of strategic decisions:**
  - **Purpose (minex, environmental, land-use, etc.)**
  - **Size of area to cover (strategic v tactical)**
  - **Sampling medium**
  - **Sampling density**
  - **Constraints: time, resources, history, etc.**

Introduction

- Initially developed for mineral exploration ("geochemical prospecting")
- Reconnaissance geochemical surveys started in the 1960's (Nichol *et al.*, 1966)
- Gained widespread popularity in many parts of the world over ensuing decades
- Variety of applications: mineral exploration, environmental baseline, geohealth
- Google search for "geochemical survey" returns 169,000 hits (Riverina study #5!)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Introduction

Why worry about low-density geochemical surveys?

- **Selected cases follow where GS have been successful**
- **Only *mineral exploration* context is considered here**
- **Numerous other cases exist where GS have added value to triple bottom line of economic, social and environmental benefits**

Introduction

Australia: **Using sequential extraction methods on soil samples collected from the Olympic Dam region, Wang *et al.* (1999) found anomalies in Cu, Au and Hg centred over the deposit despite the thick regolith cover:**

“*These results show that the […] techniques can penetrate a thick sequence of post-mineralization rocks overlain by deeply weathered overburden and give a clear expression of concealed deposits where conventional surface geochemical methods are not likely to be used. The patterns also show that this giant ore deposit has a tremendous endowment of metals which can generate large-scale superimposed geochemical anomalies up to and including the surface***”.**

Introduction

<u>China:</u> Xie and Ren (1993) report that the Chinese geochemical survey, which had covered >4.6 M km^2 by 1992, had

“*lead […] to the discovery of several hundreds of new mineral occurrences, including 400 new gold occurrences, many of which are being developed into workable mines (Xie and Ren, 1991)***”.**

Introduction

Worldwide: **A recent email from the Chief Consultant Geochemist of Rio Tinto Exploration (RTE) stated that (P. Agnew, RTE Pty Ltd, pers. comm., 2006, with permission):**

“*RTE make widespread use of existing public domain geochemical data for area and target selection and have identified new mineralisation systems on several occasions as a result. […/…] Aside from direct discoveries, these surveys invariably generate a flurry of exploration activity […/…]. We have at least three current exploration projects globally based on public domain geochem targets and have commenced an ambitious project to systematically compile public domain geochemistry on a global scale***”.**

Introduction

Canada: **The impact of the 1970's radiometrics and geochemical survey is recorded in British Columbia's 1977 Minister of Mines and Petroleum Resources Annual Report as follows (p. 28):**

"*The release of the Federal/Provincial Uranium Reconnaissance Program geochemical data in May 1977 had a significant and immediate effect on the numbers of claims recorded. The increased activity in grassroots prospecting continued throughout the year***". [http://www.em.gov.bc.ca/DL/GSBPubs/AnnualReports/AR_1977.pdf]**

Link to radiometrics surveys

Introduction

Europe: **In a recent publication, Plant *et al.* (2003) note the usefulness of the low-density pan-European geochemical survey (~1/5000 km^2) in locating areas of high geothermal energy potential:**

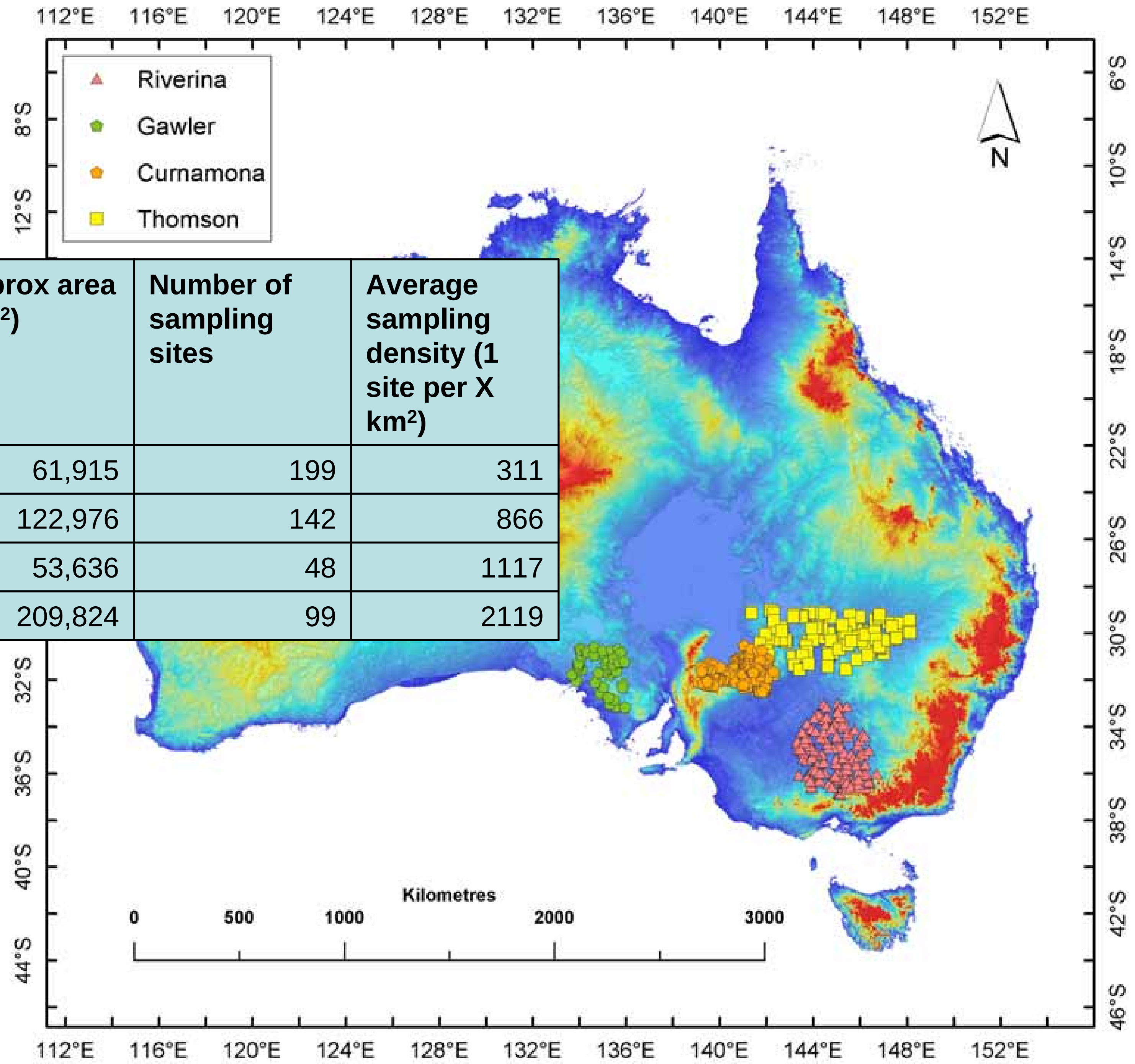
“*The most anomalous baseline levels occur over the Variscan orogen, especially areas into which late postorogenic radiothermal high heat production (HHP) granites were emplaced. Spiderdiagrams based on trace element levels and rare earth element (REE) plots, confirm the association between the highest U anomalies and evolved radiothermal granites***”.**

Link to geothermal energy

Selected Results from Pilot Projects

How we did it? (Methodology)

- **Methodology has been field-tested in recent years:**
  1. **Divide landscape into large catchments**
  2. **Find lowest point on catchment boundary (using ArcHydro™ extension)**
  3. **Locate floodplain or equivalent depositional landscape setting (fine-grained and well-mixed sediment: use Nature!)**
  4. **Adjust sampling location WRT access, land tenure and other considerations**
  5. **Go there & sample catchment outlet sediment at surface (TOS: 0-10 cm) & at depth (BOS: ~60-80 cm)**
- **4 pilot studies have demonstrated that this methodology works in a variety of Australian landscape & climate conditions**
- **We tested up to 6 size fractions, various depths/profiles, partial leaches (incl. MMI), heavy mineral fractions; also other media: soil, groundwater, plants**



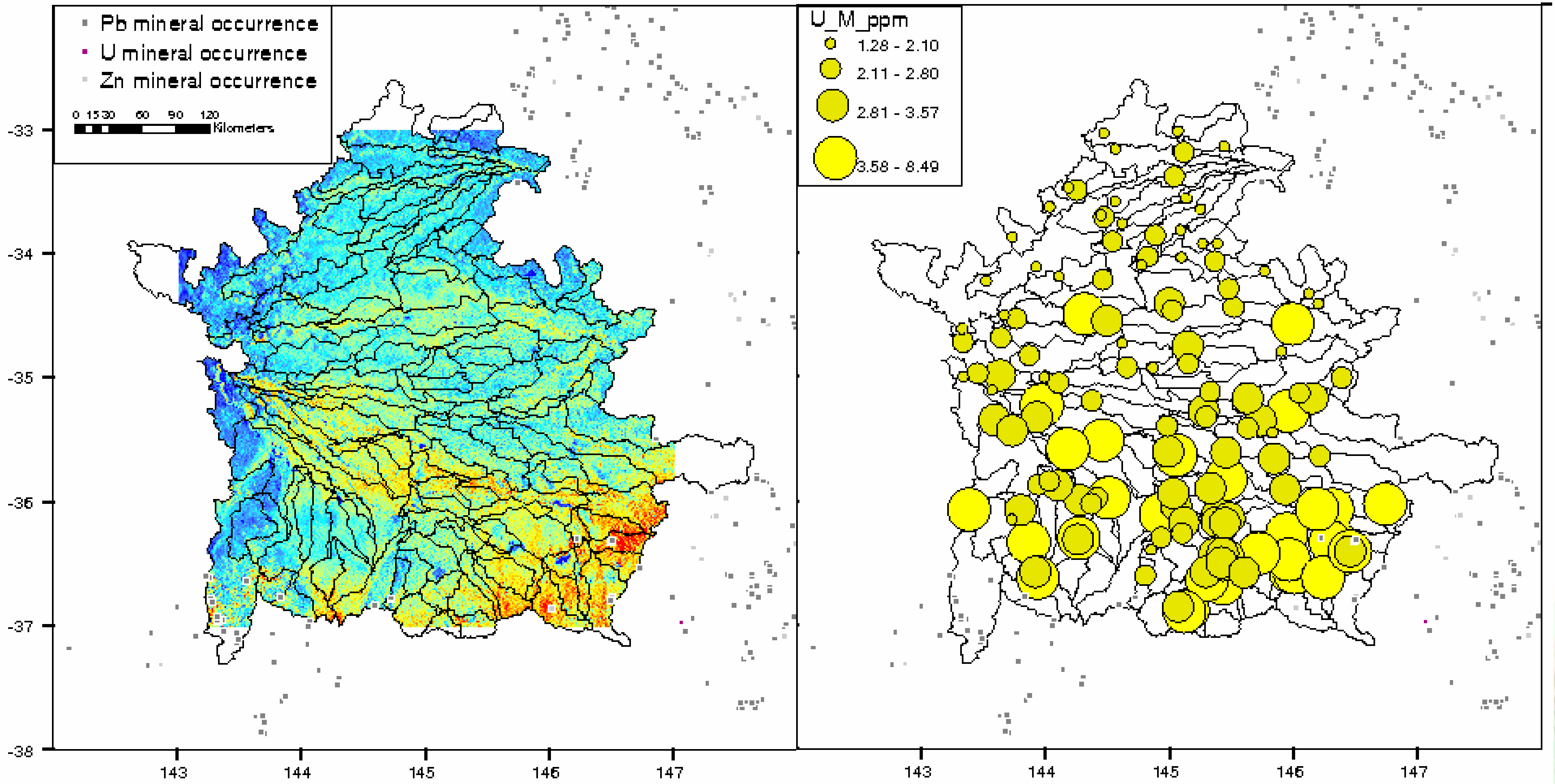
Pilot survey	Approx area (km²)	Number of sampling sites	Average sampling density (1 site per X km²)
Curnamona	61,915	199	311
Riverina	122,976	142	866
Gawler	53,636	48	1117
Thomson	209,824	99	2119

Selected Results from Pilot Projects

- **Significant Results — Riverina survey**
  - **U and Th distribution largely corroborate radiometrics patterns, but details are not straightforward (disequilibrium in the radioactive decay chain ?)**
  - **Method outlines dispersion trains from Victorian goldfields**
  - **Method corroborates northern extension of the Au-rich Bendigo Zone under Murray Basin sediments**
  - **Ag concentrations in the eastern region reflect argentiferous Au and base metal deposits from adjacent (?underlying) bedrock, whereas the western region is low in Ag**

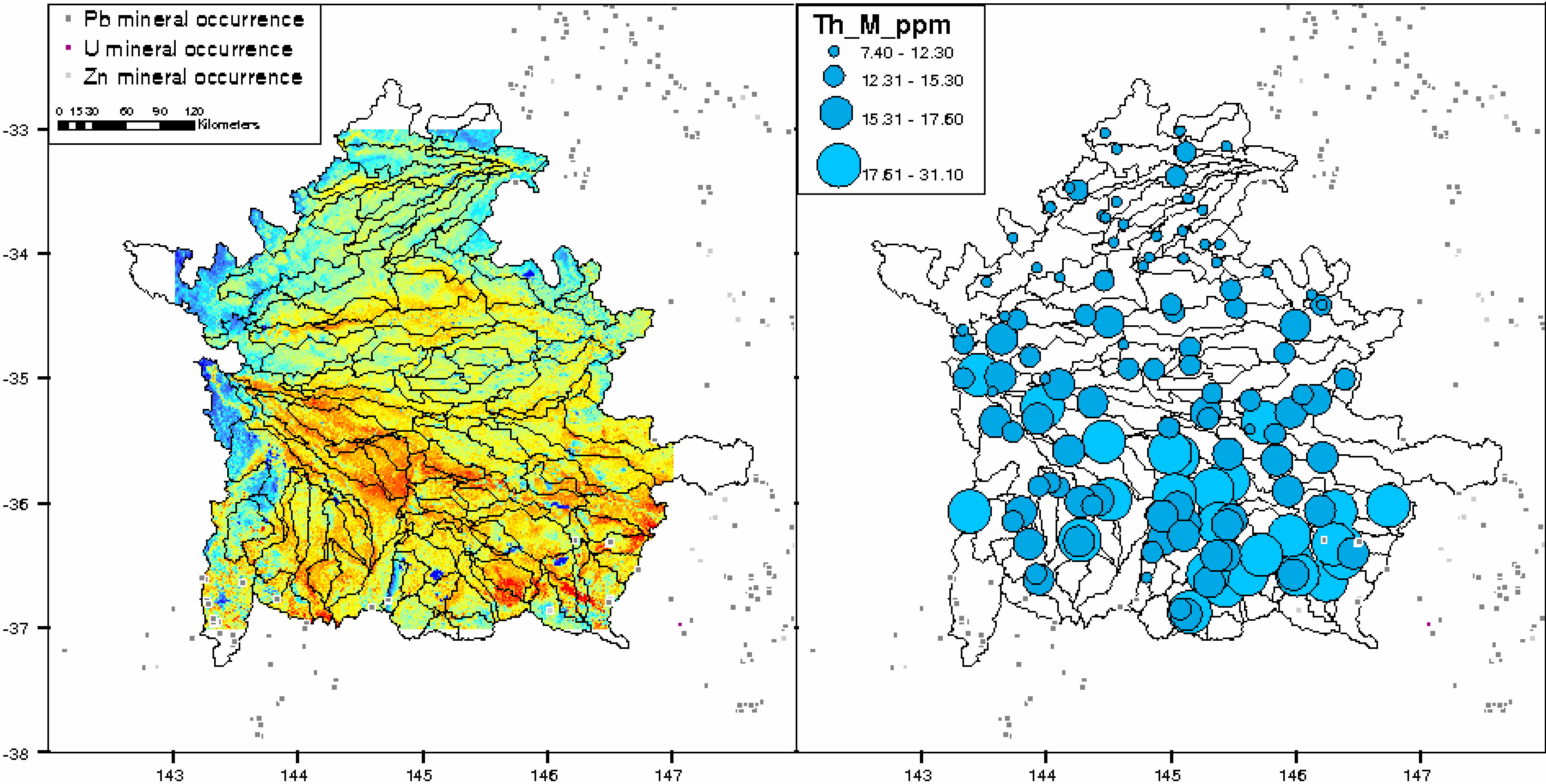
Selected Results from Pilot Projects

Riverina: U channel airborne radiometrics vs U (ppm) in <180 um TOS

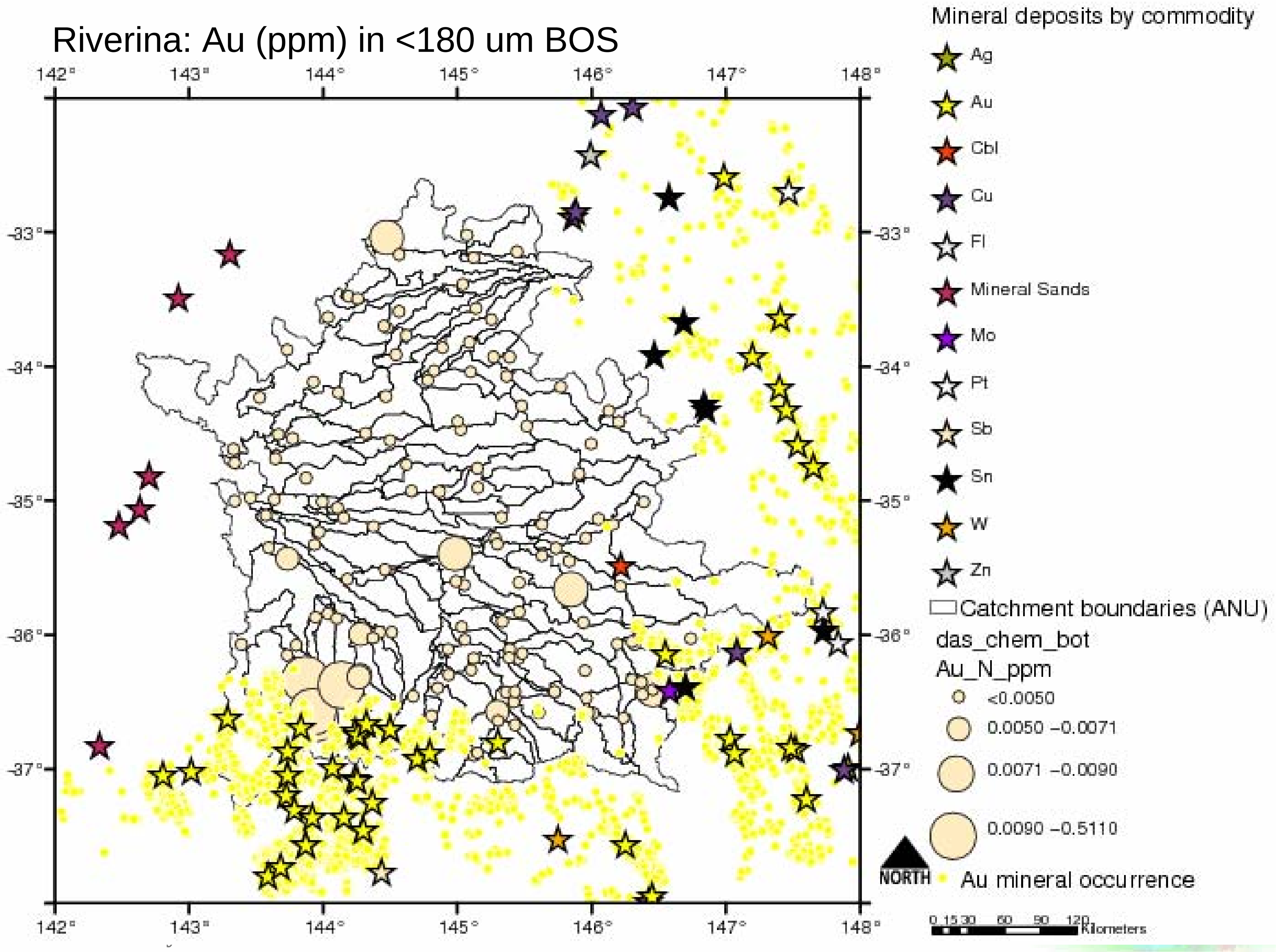


Selected Results from Pilot Projects

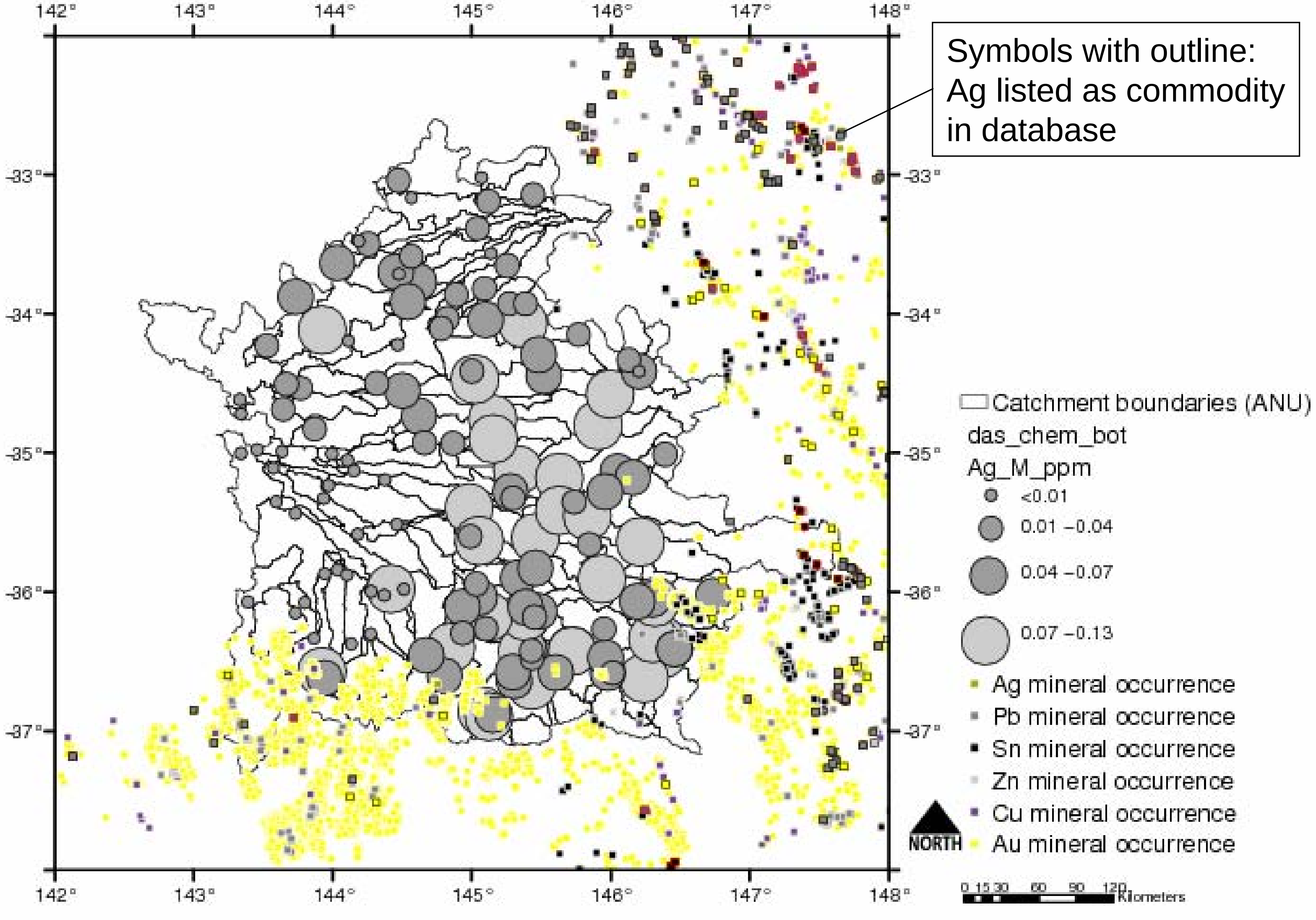
Riverina: Th channel airborne radiometrics vs Th (ppm) in <180 um TOS



Riverina: Au (ppm) in <180 um BOS



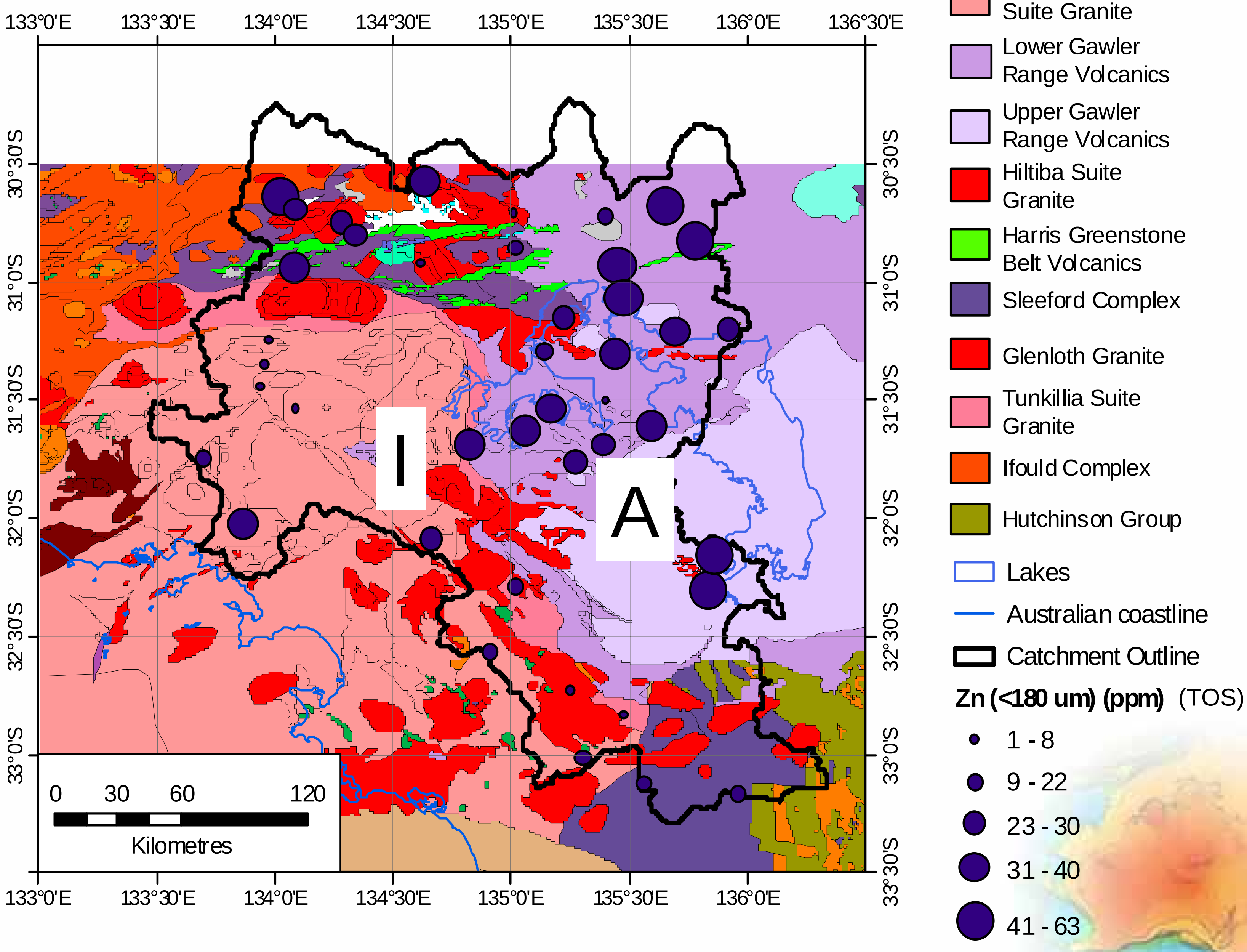
Riverina: Ag (ppm) in <180 um BOS



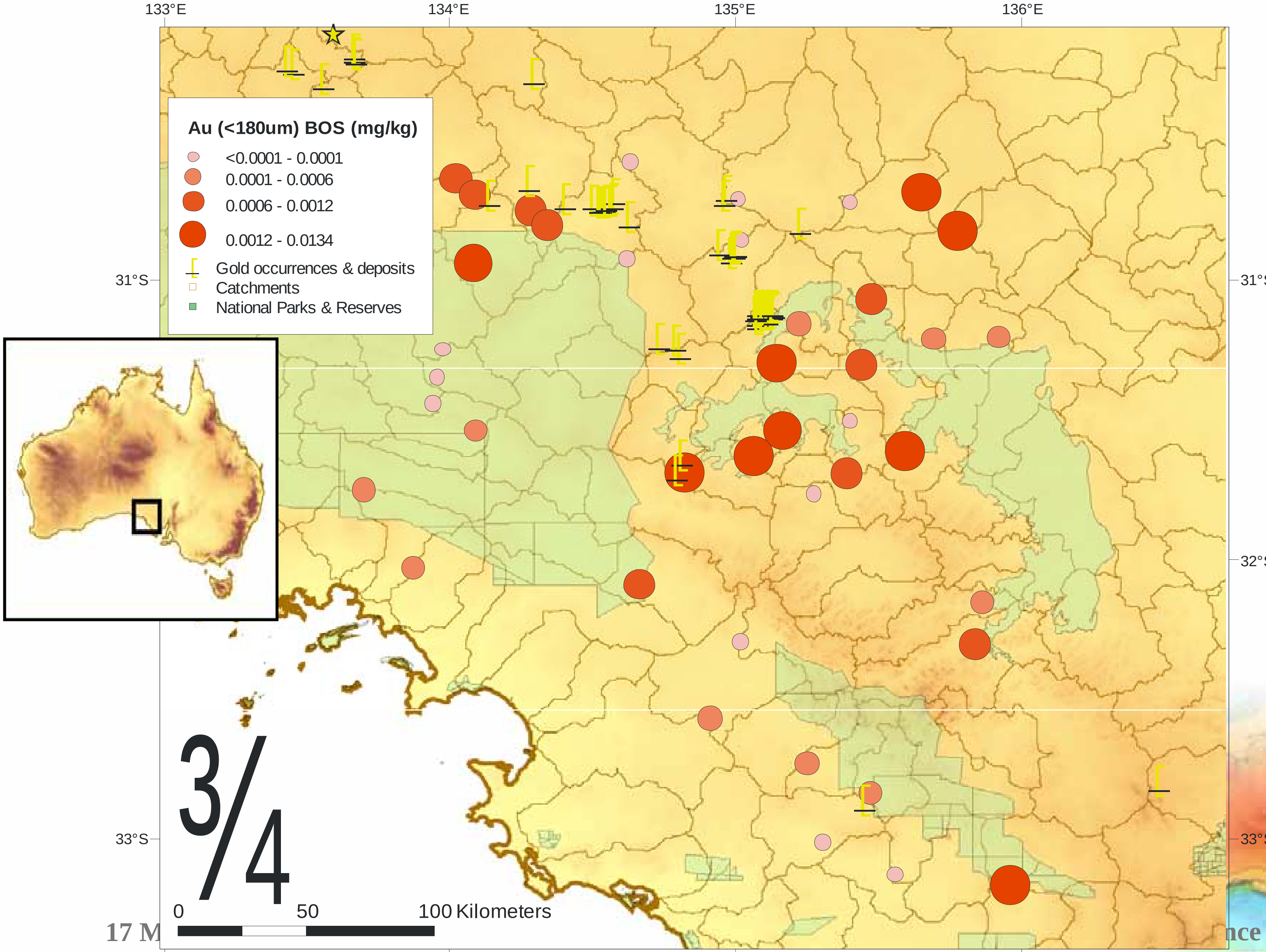
Selected Results from Pilot Projects

- **Significant Results — Gawler survey**
  - **I-type and A-type suites (Skirrow *et al*., 2006) are remarkably well mapped by the method**
  - **Any catchment with known Au deposit or occurrence shows elevated Au concentration in a least one of our 4 regolith samples/fractions**
  - **Central Gawler gold province is outlined, despite relatively low density**
  - **Ultramafic lithologies in the solid geology coverage are identified as anomalies in the regolith geochemistry, eg Cr**

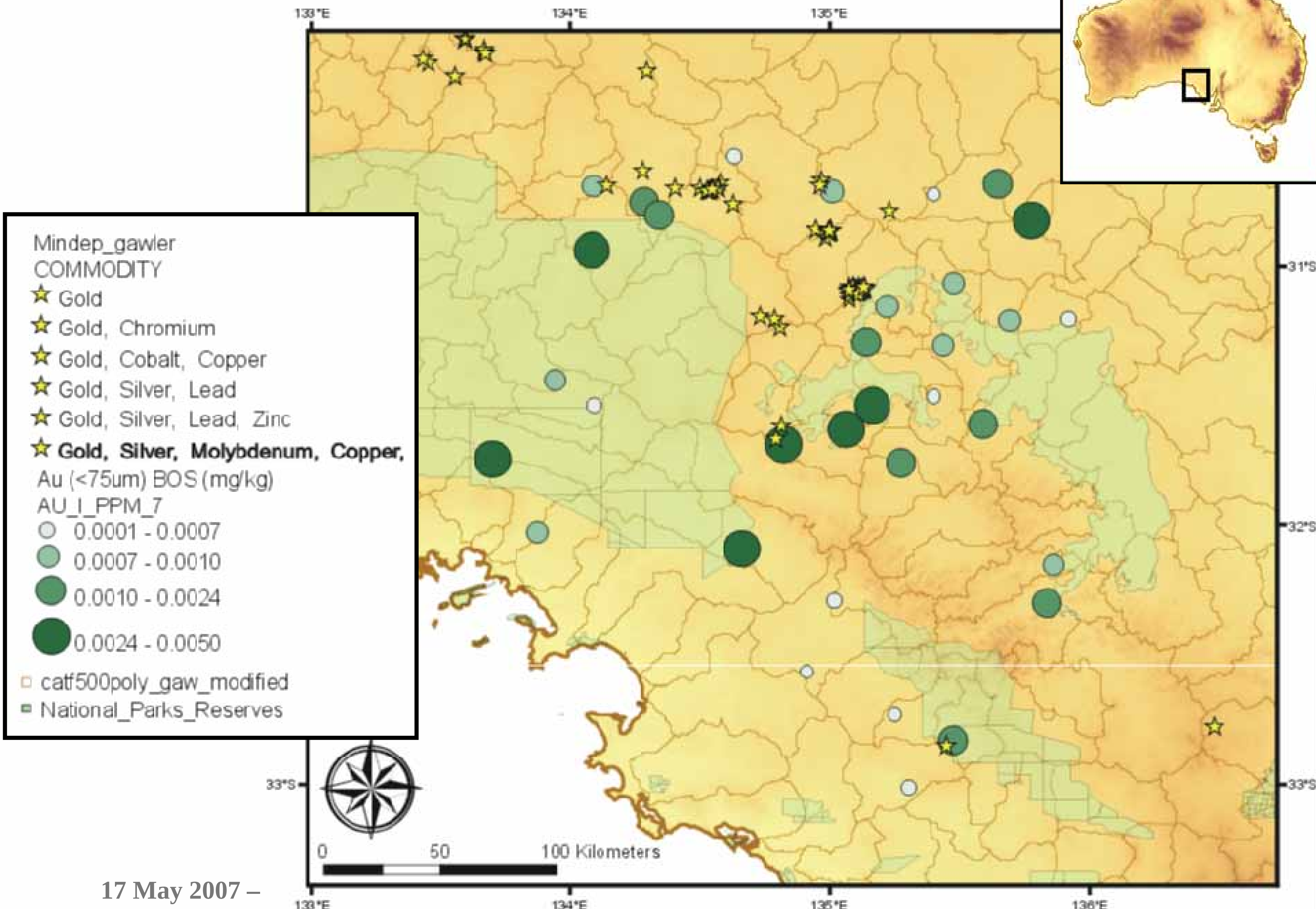
Gawler: Zn (ppm) in <180 um TOS



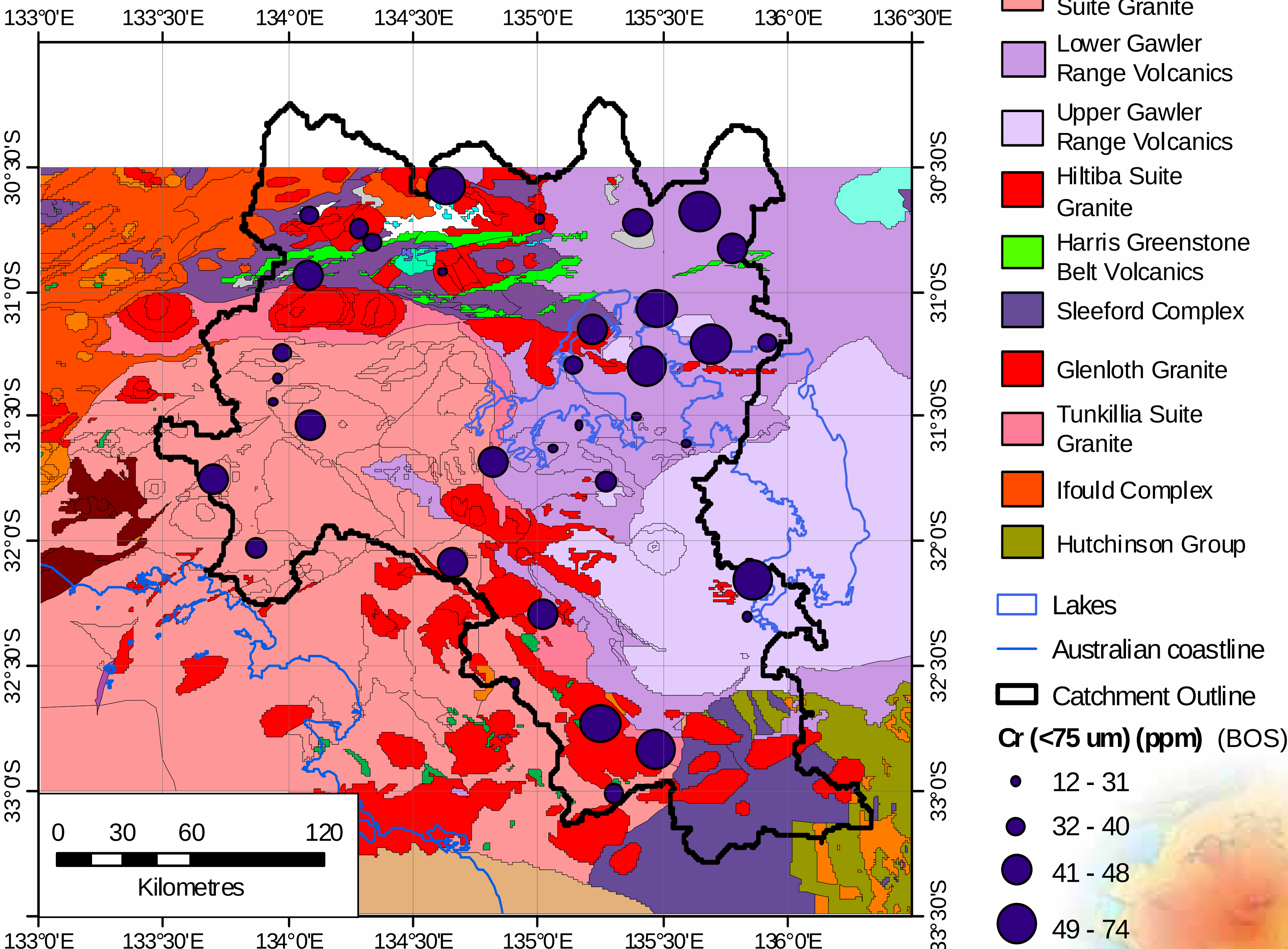
Gawler: Au (ppm) in <180 um BOS



Gawler: Au (ppm) in <75 um TOS



Gawler: Cr (ppm) in <75 um BOS



Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

What can NGSA deliver?

- Real U and Th concentration measurements that can be compared to airborne radiometric estimates (helps get a handle of radioactive decay chain disequilibrium processes)
- Only U and Th concentration measurements where airborne radiometric data are absent or substandard or where holes exist in other geochemical data coverages (OZCHEM, TerraSearch)

Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

What can NGSA deliver?

- **Concentration measurements for other elements useful in assessing U mineralisation styles:**
  - **Ca and V for uranium-in-calcrete deposits (Butt *et al.*, 1984; McKay *et al.*, 2001)**
  - **REEs and Au for quartz-pebble conglomerate uranium deposits (Dahlkamp, 1993)**
  - **Se for unconformity-contact and sandstone-type uranium deposits (Howard, 1977; Dahlkamp, 1993)**

Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

What can NGSA deliver?

- Concentration measurements for other elements useful in assessing the heat generation potential of granites:
  - High concentrations of F (Ashley, 1984)
  - High concentrations of incompatible elements, low K/Rb ratios and low total Sr concentrations (Simpson *et al.*, 1979)

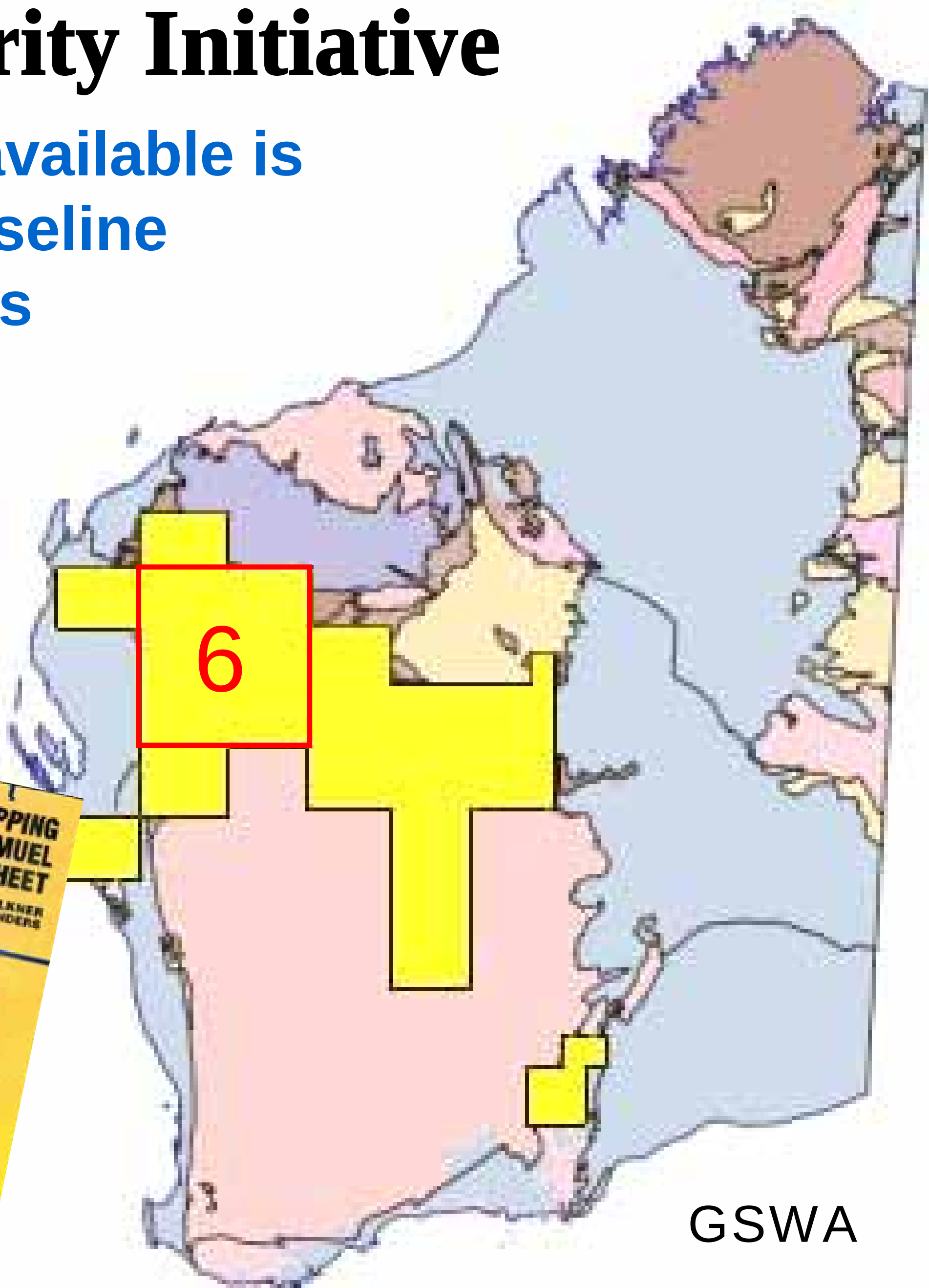
Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

Can we use existing datasets (from Government or industry)

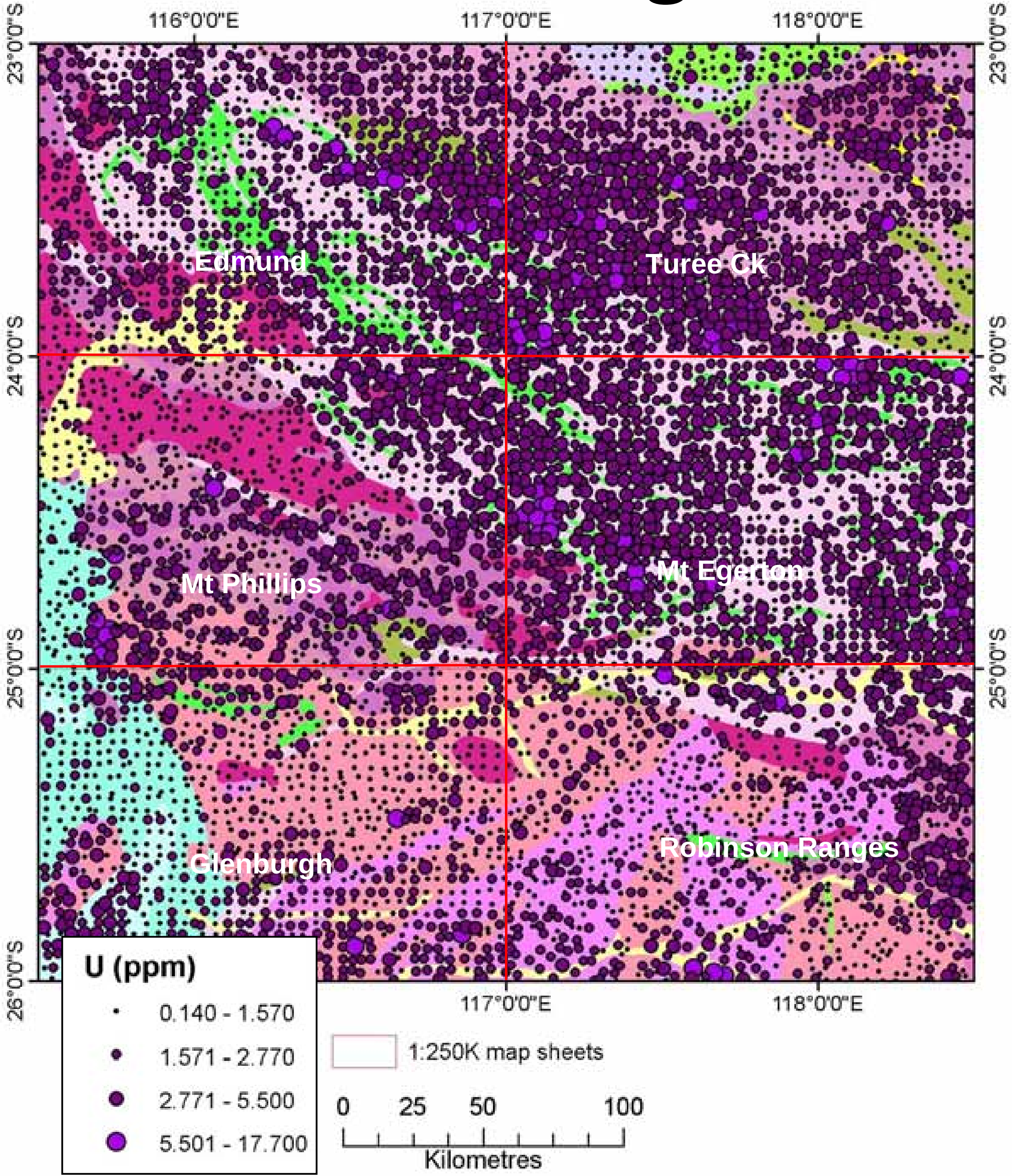
- **In general, they are *not* suitable because:**
  1. **Quality assessment/control data often lacking**
  2. **Extreme variation of sensitivity and instruments over the years/decades (‘edge effects’)**
  3. **Often only target & pathfinder elements (e.g., Au only or Au + Cu)**
  4. **Inhomogeneous sampling media (e.g., variable degrees of evolution, alteration, mineralisation and weathering; various rock types) precluding comparison**
  5. **If culling to be carried, requires good quality metadata to be available**
  6. **Geographic distribution often highly inhomogeneous**

Outline of a Proposal for Onshore Energy Security Initiative

- One of the best datasets available is the GSWA coverage of baseline regolith geochemical maps
- 21 x 1:250K map sheets
- 1 sample per 16 km^2
- Published 1994-2001



GSWA Regolith Geochemistry



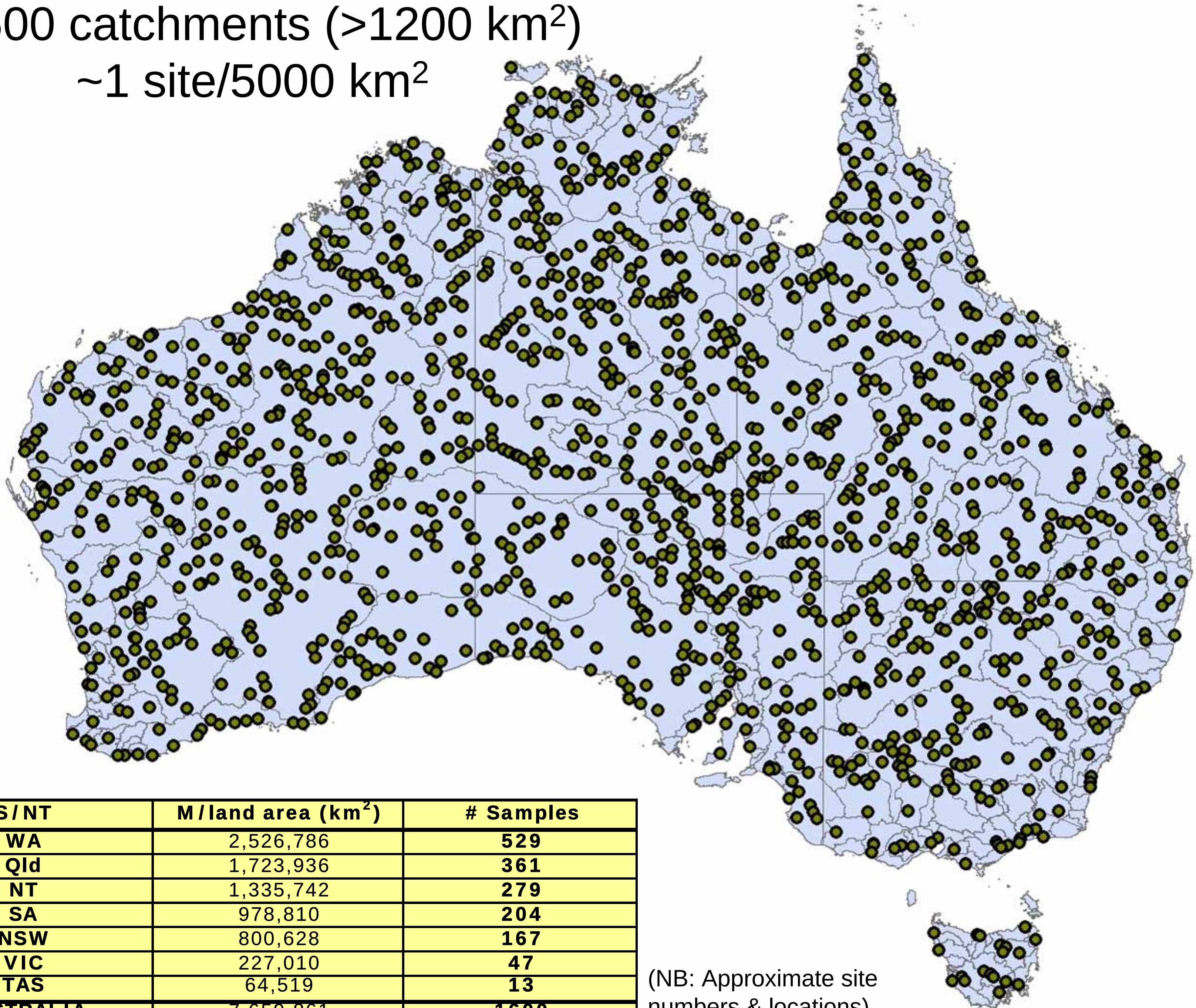
U (ppm) in all regolith materials

- Smooth geochemical patterns
- Clear relationship to lithology

Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

- Sampling density issue
- Can we reproduce major/continental patterns at a density that will be cost-effective at the national scale?

~1600 catchments (>1200 km^2)
~1 site/5000 km^2



S/NT	M/land area (km^2)	# Samples
WA	2,526,786	**529**
Qld	1,723,936	**361**
NT	1,335,742	**279**
SA	978,810	**204**
NSW	800,628	**167**
VIC	227,010	**47**
TAS	64,519	**13**
AUSTRALIA	7,659,861	**1600**

(NB: Approximate site numbers & locations)

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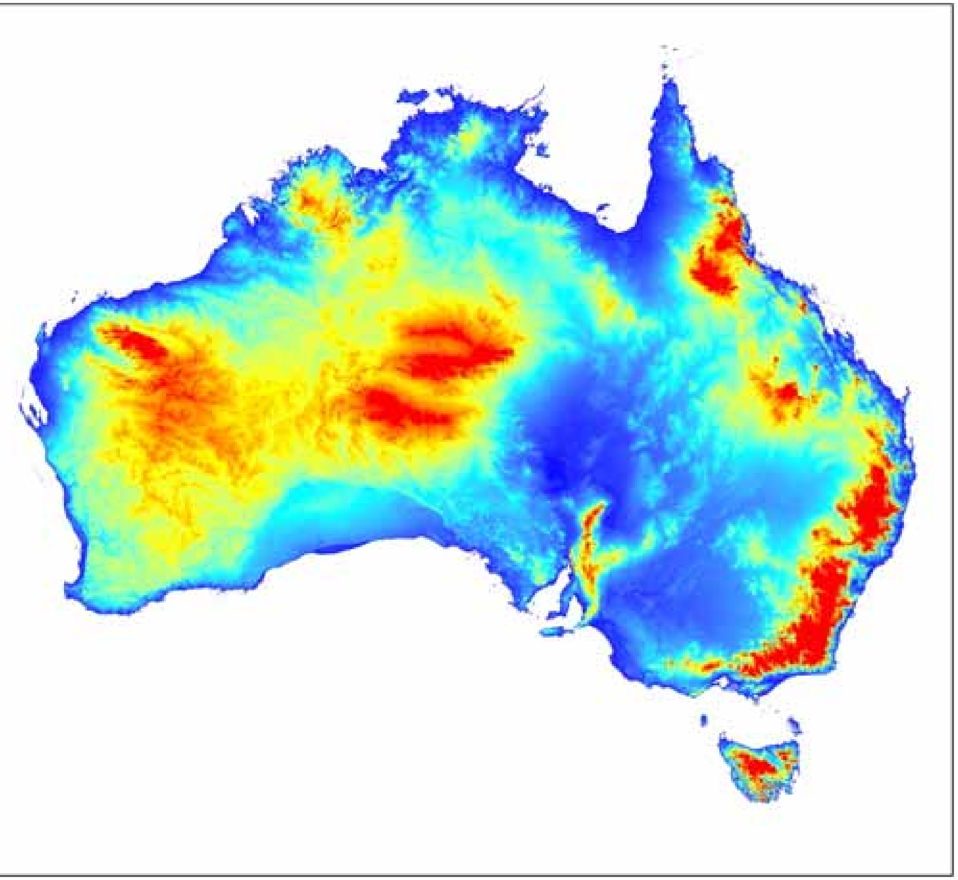
How Can Ultra-Low Density Ever Work?

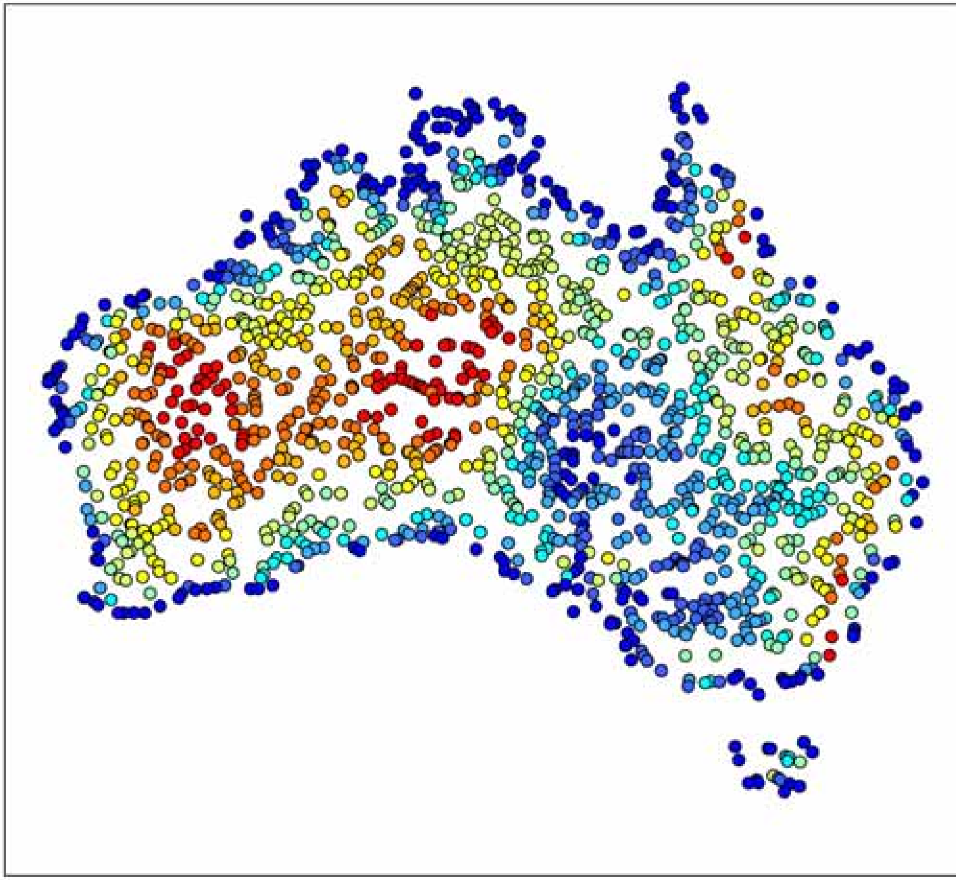
- **Large-scale variation is (much) greater than local-scale variation**
- **The “fractal nature of geochemical landscapes” (Bølviken *et al.*, 1992): geochemical patterns are similar from microscopic to global scales**
- **Analogy between geochemical landscapes and topography**
- **Finally, the proof is in the patterns: they are coherent and they make sense!**

How Can Ultra-Low Density Ever Work?

- 9” DEM (120 M cells)

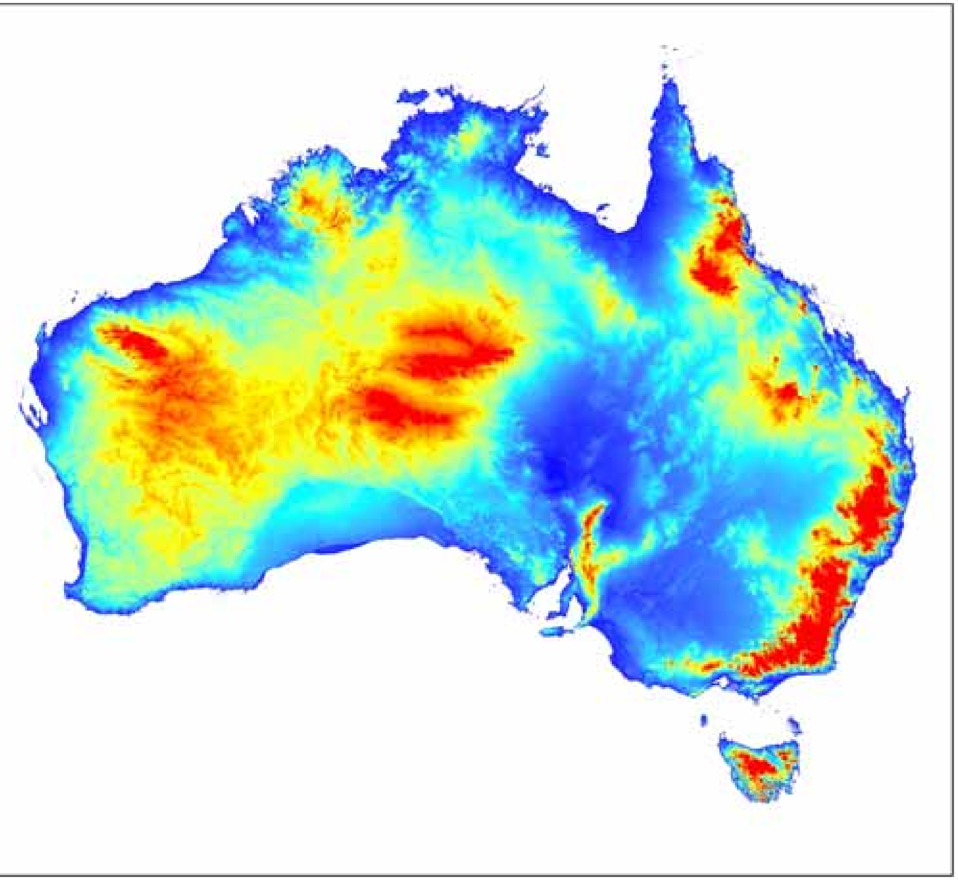


- 1618 outlet sites

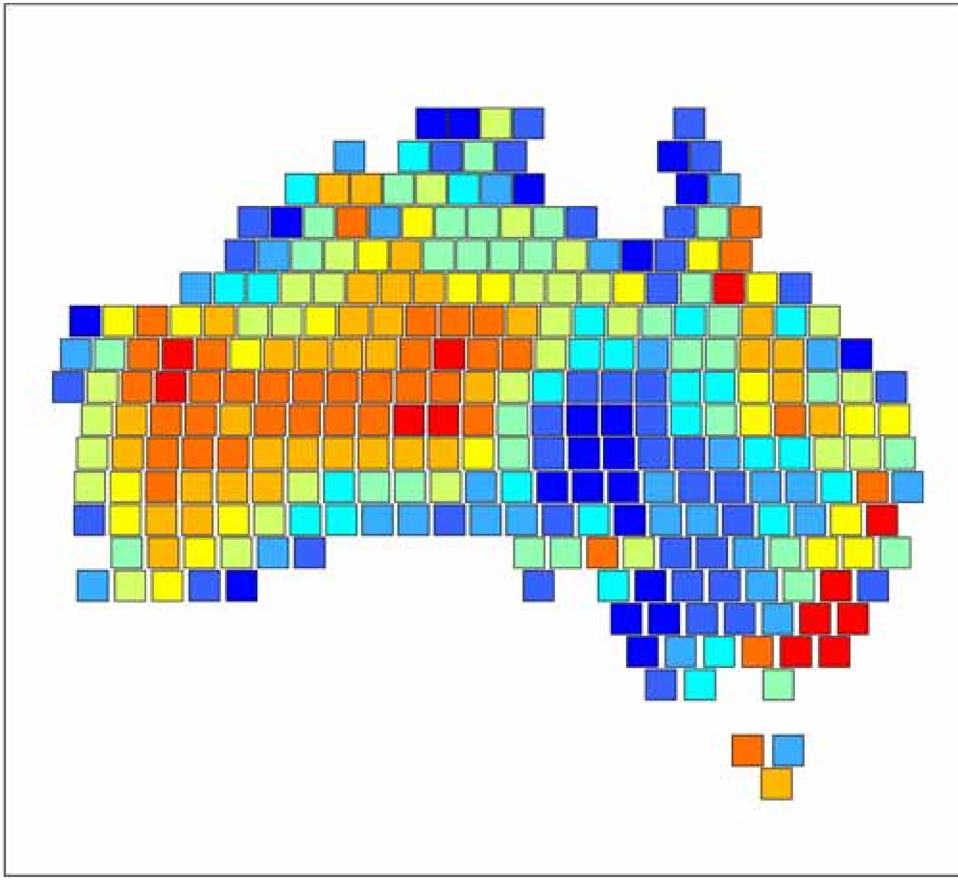


How Can Ultra-Low Density Ever Work?

- 9” DEM



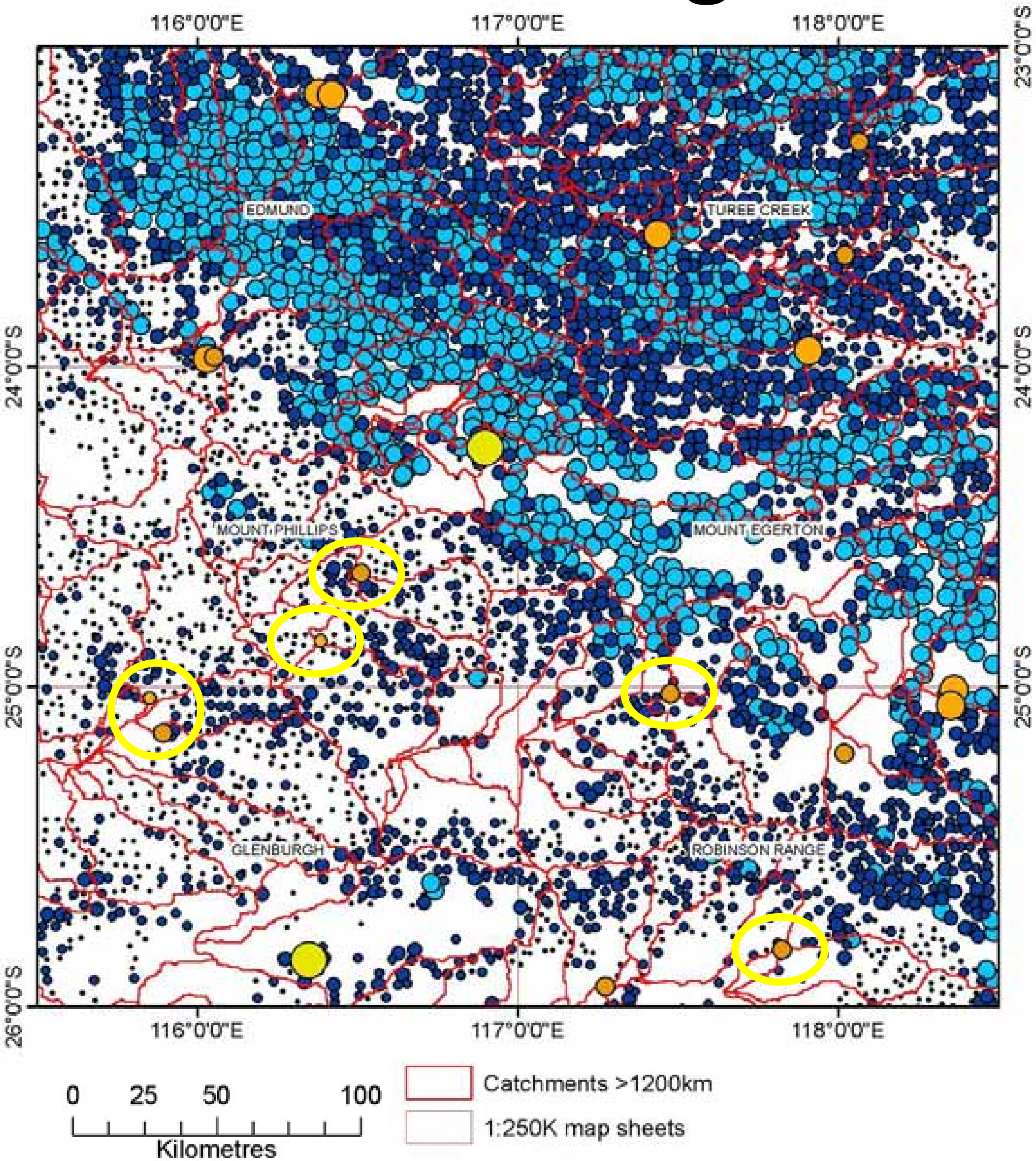
- 293 grid readings



Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

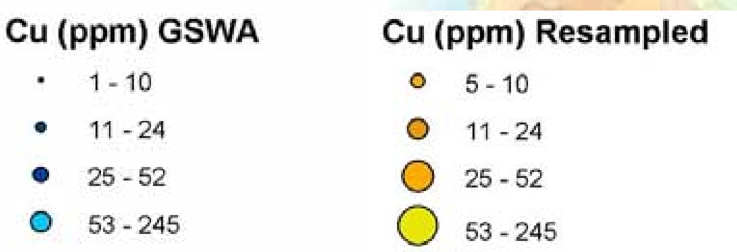
- Sampling density issue
- Can we reproduce major geochemical patterns at a density that will be cost-effective at the national scale?
- Test: Where useable datasets exist, we can lower the sampling density of this survey and use that data
- Results suggest that dominant geochemical patterns are still visible at the low-density suggested

GSWA Regolith Geochemistry



Cu (ppm) in stream sediments

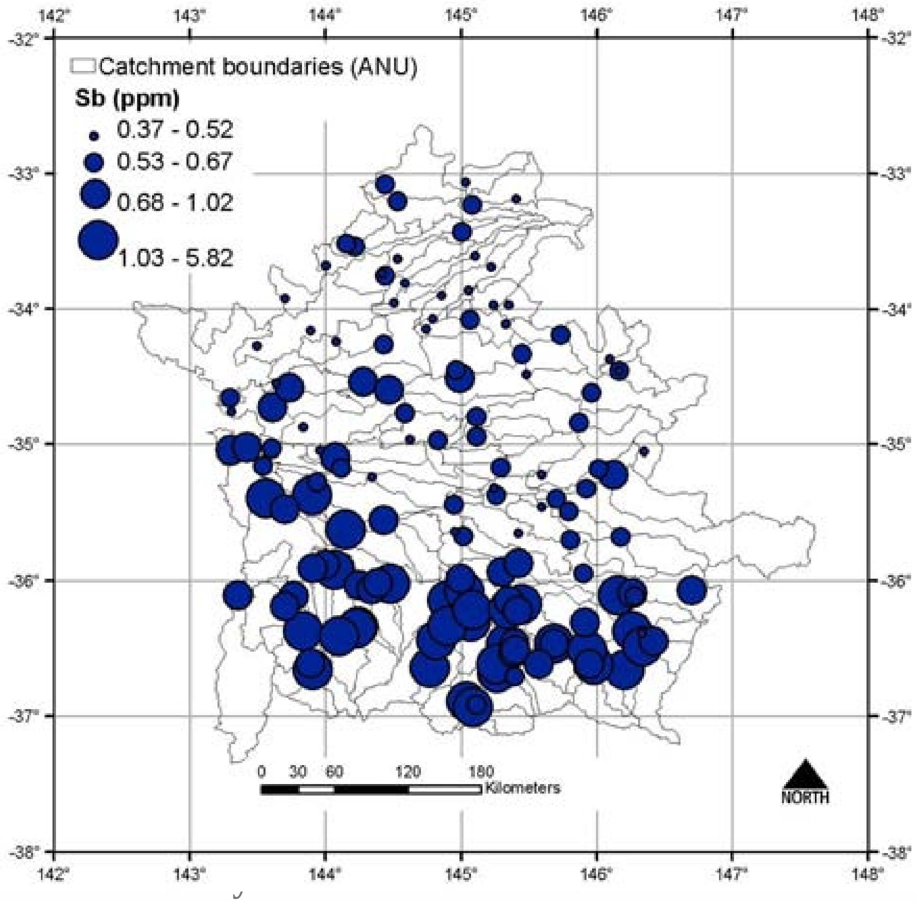
- Resample original density of 1/16 km^2 to 1/5000 km^2
- Catchments >1200 km^2 targeted
- Took the closest GSWA point to where our catchment modelling indicates lowest point
- Broad geochemical trends still evident

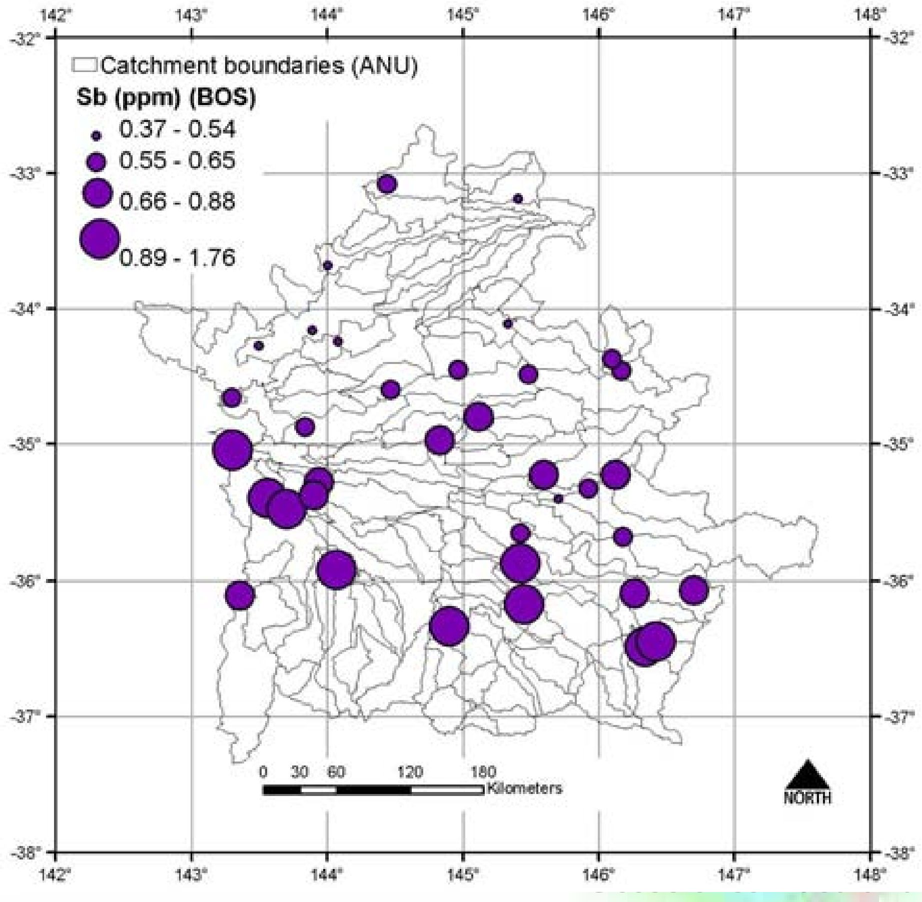


Riverina Regolith Geochemistry

Sb (ppm) in bottom outlet sediment

- Resample catchments >1200 km^2
- ~1 sample/5000 km^2





Outline of a Proposal for a National Geochemical Survey of Australia (NGSA)

- **Apply the tested methodology and roll-out a national survey in collaboration with the State/Territory (esp. fieldwork component)**
- **Deliver a national-scale geochemical database and (web-delivered) maps, as well as reports & papers**
- **Apply cost-effective ultra-low-density (~1 site/5,000 km^2)**
- **Size ~ 8 M km^2, hence about 1600 sampling sites based on catchments**

Conclusions

- Geochemical surveys are a proven mineral exploration strategy
- A geochemical survey has not been applied nationally before because
  - It was not clear that ultra-low sampling density would work here
  - Cost of a high-density survey was prohibitive
  - Choice of sampling media was an unresolved issue

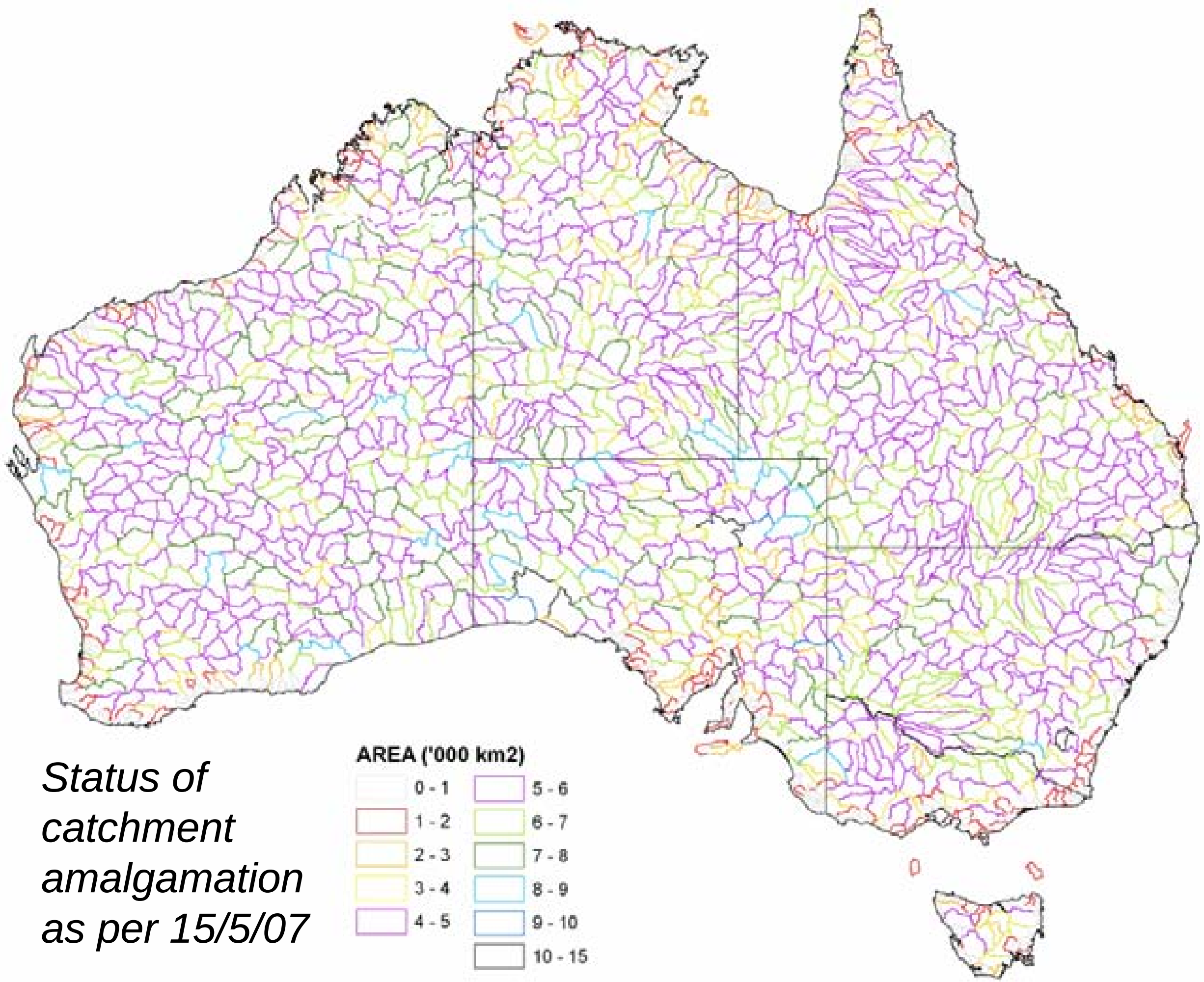
Conclusions

- We have now developed and field-tested a methodology in various Australian landscape and climate settings
- The methodology delivers geochemical maps that show clear relationships to basement lithology
- Even through thick, transported cover
- We have shown that ultra-low density will work in Australian conditions
- Therefore, we have put forward a proposal for a National Geochemical Survey of Australia, which will be funded under the OESI

Conclusions

- The National Geochemical Survey of Australia will
  1. Provide data where there are gaps in Ozchem and airborne radiometrics coverages in a cost-effective way
  2. Address mother-daughter disequilibrium in decay chains, thereby strengthening and complementing radiometric surveys & interpretations
  3. Allow multi-element ranking of radiometrics anomalies (e.g., differentiate signatures of U from various deposit types or from ‘hot’ granites, black shales or palaeochannels)
  4. Complement other OESI projects, in particular AWAGS and Geothermal Energy
  5. Be internally consistent dataset with state-of-the-art detection limits
  6. Have spin-off outcomes in mineral exploration for other commodities and in natural resource management

National Geochemical Survey of Australia (NGSA)



Status of catchment amalgamation as per 15/5/07

- **Sample transported regolith at outlets of ~1600 catchments over mainland Australia**
- **Average density ~1 site/5000 km^2 (*similar to Foregs European Atlas*)**
- **Sample at 2 depths (surface and ~80 cm depth)**
- **Total analyses for 60+ elements on 2 size fractions**

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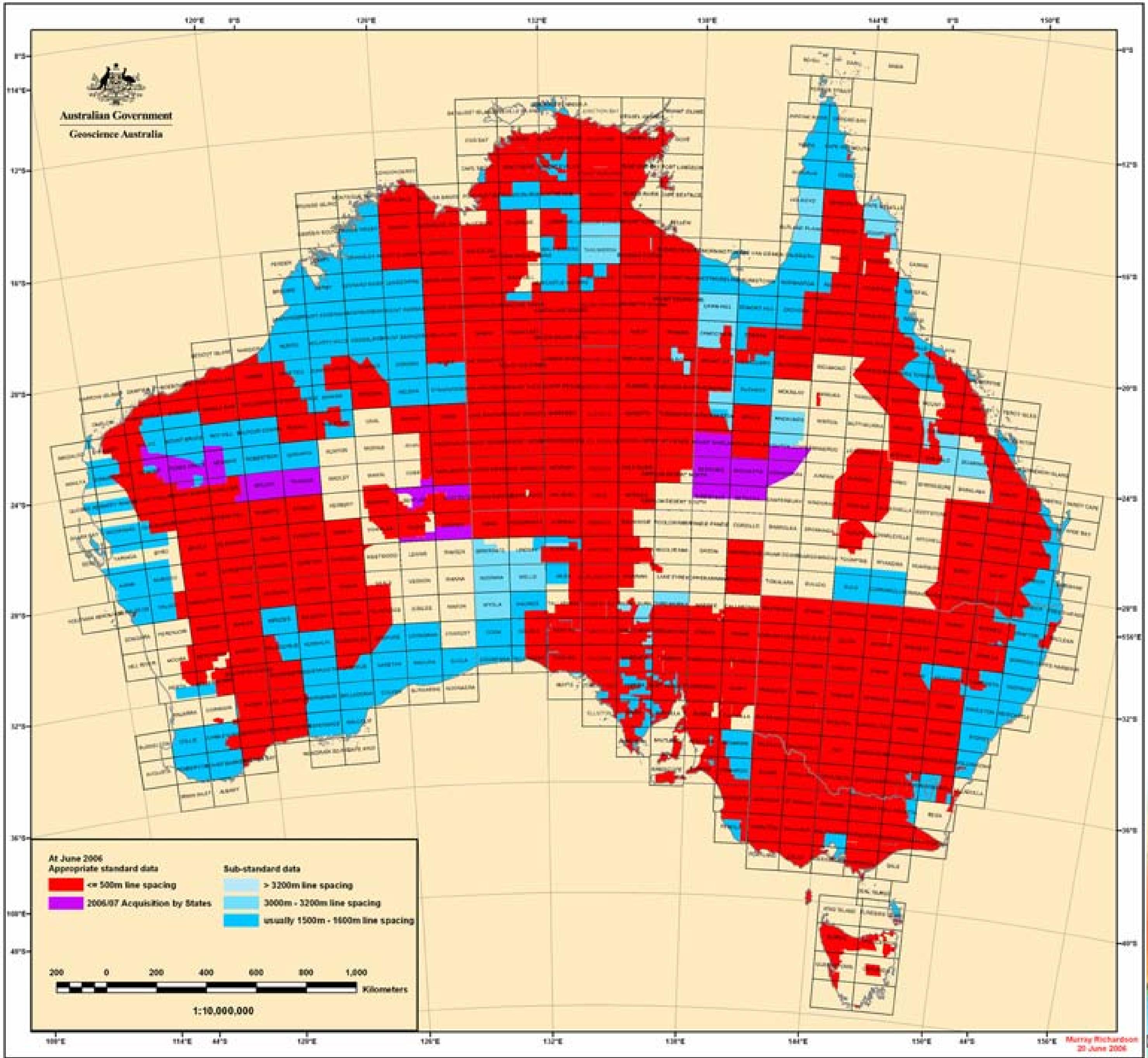

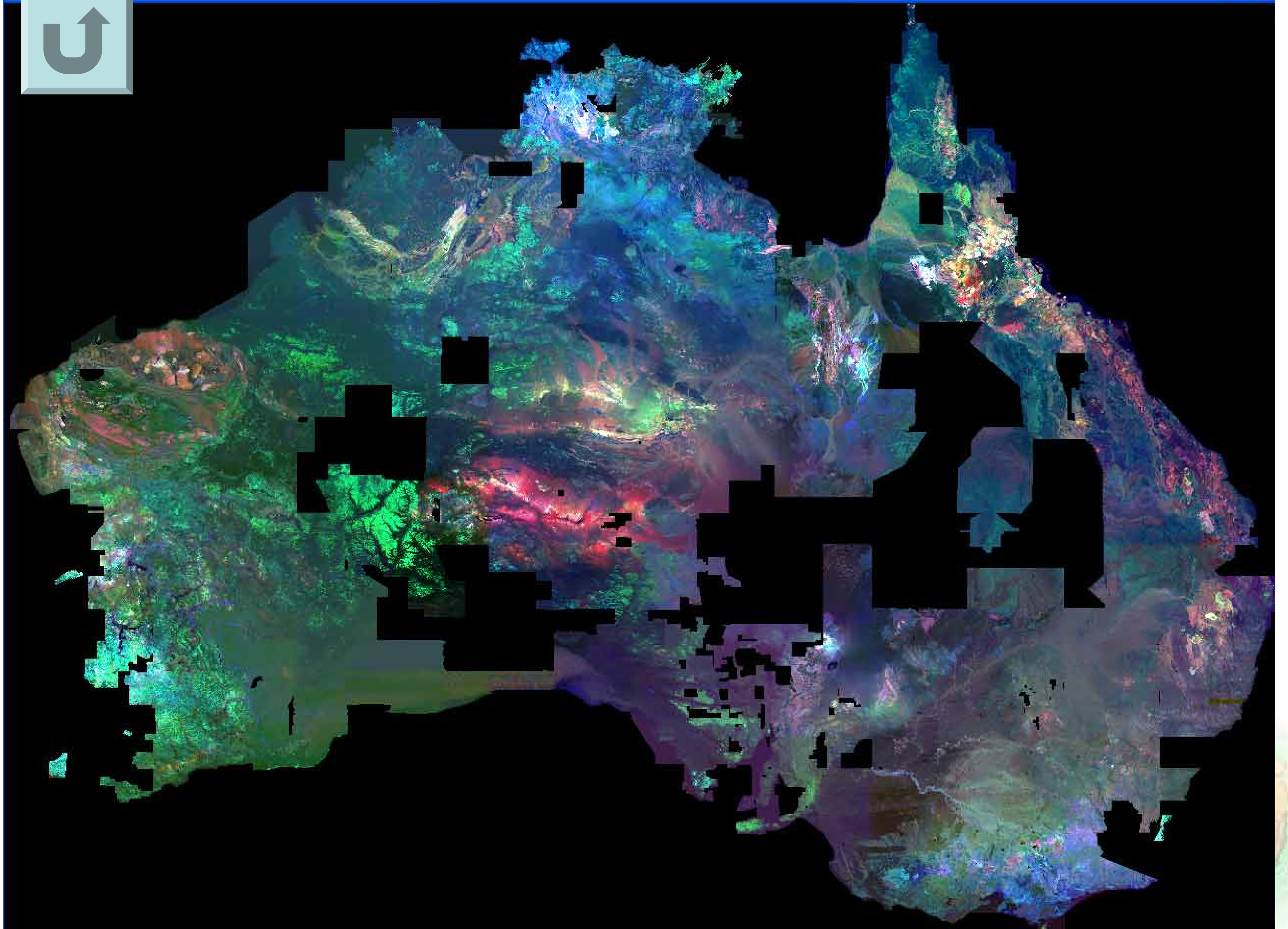

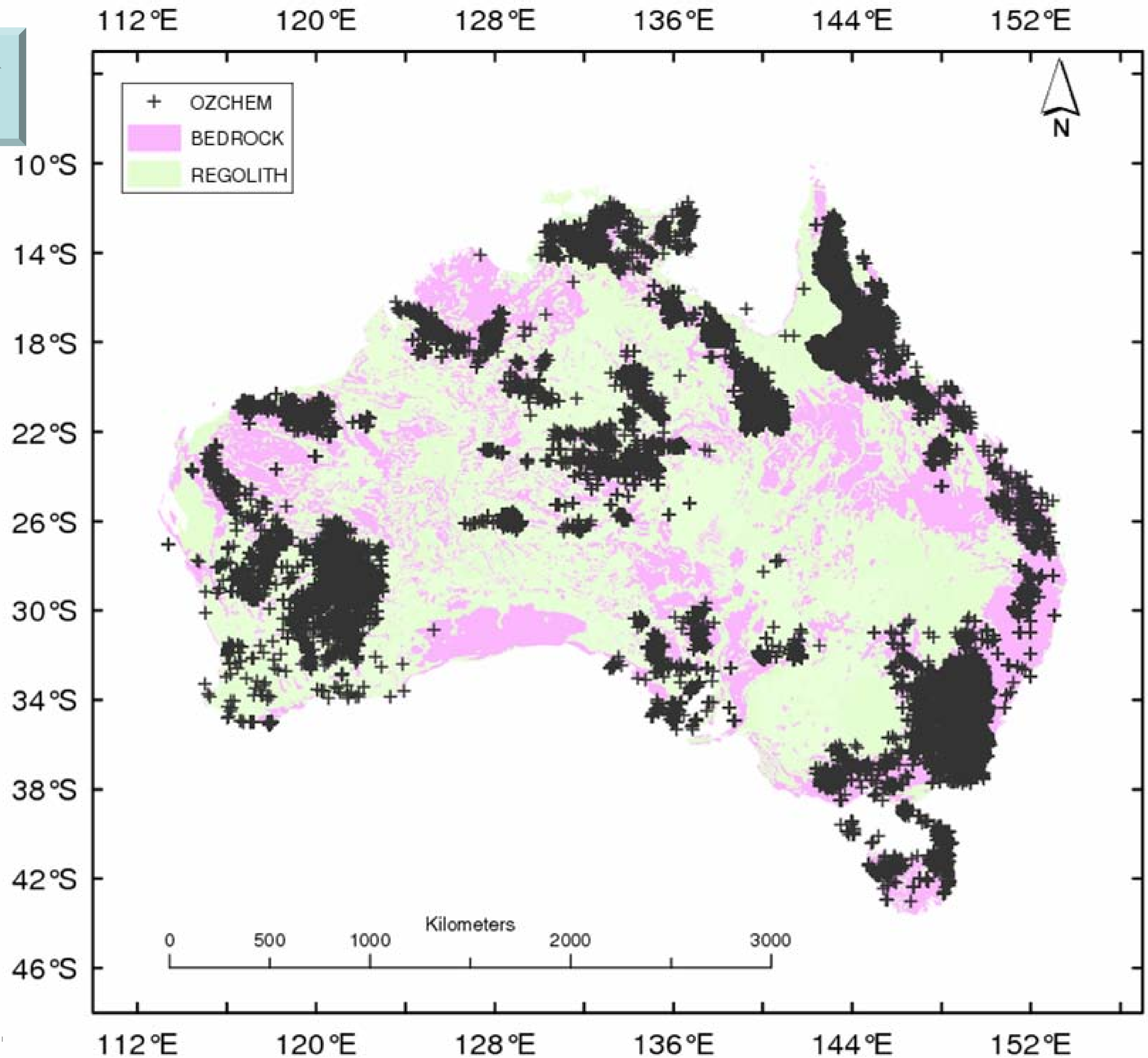
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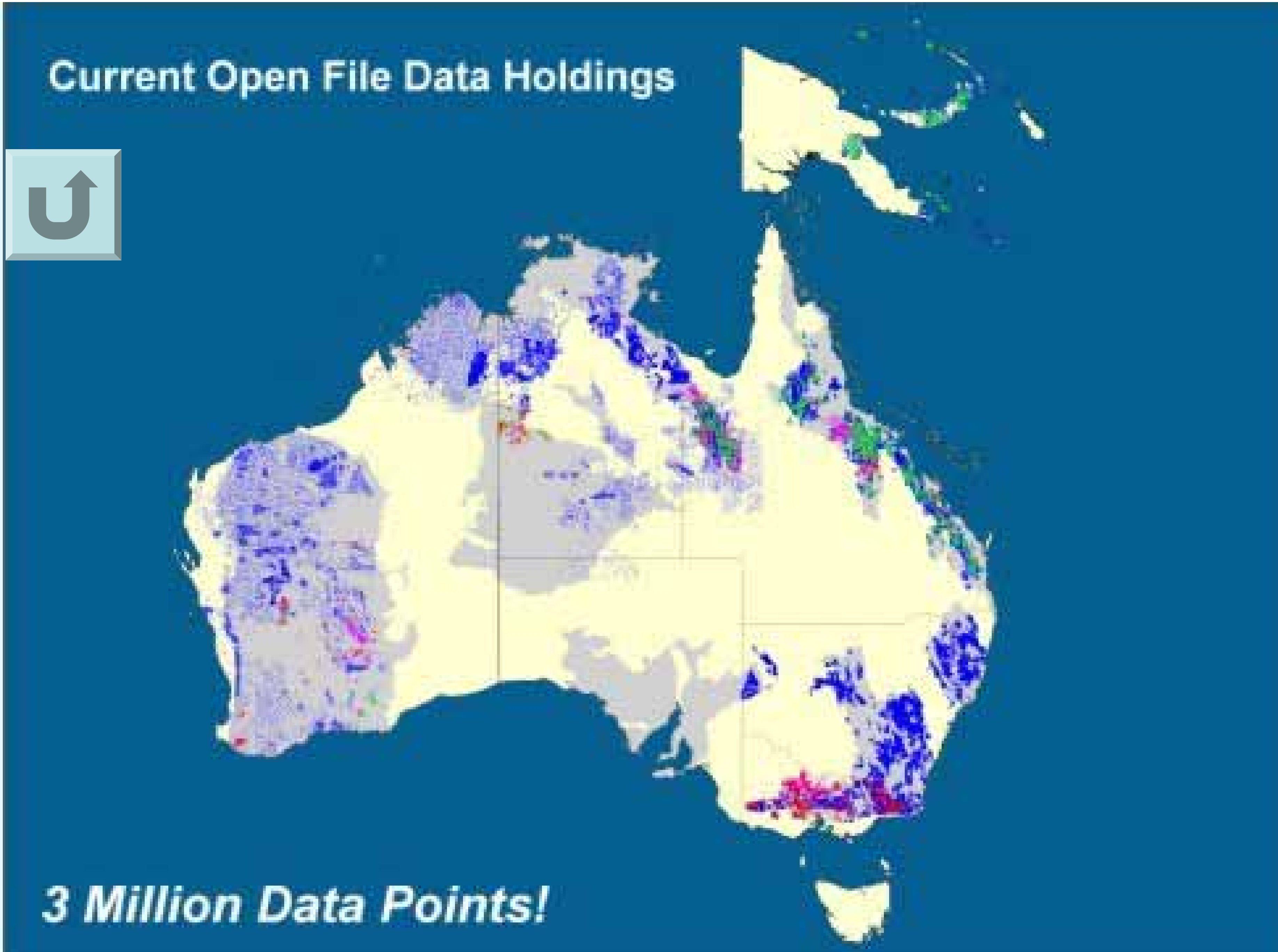
Current Open File Data Holdings
3 Million Data Points!