Australian Government
Geoscience Australia

Methods of Mineral Potential Assessment: A Mineral Systems Approach

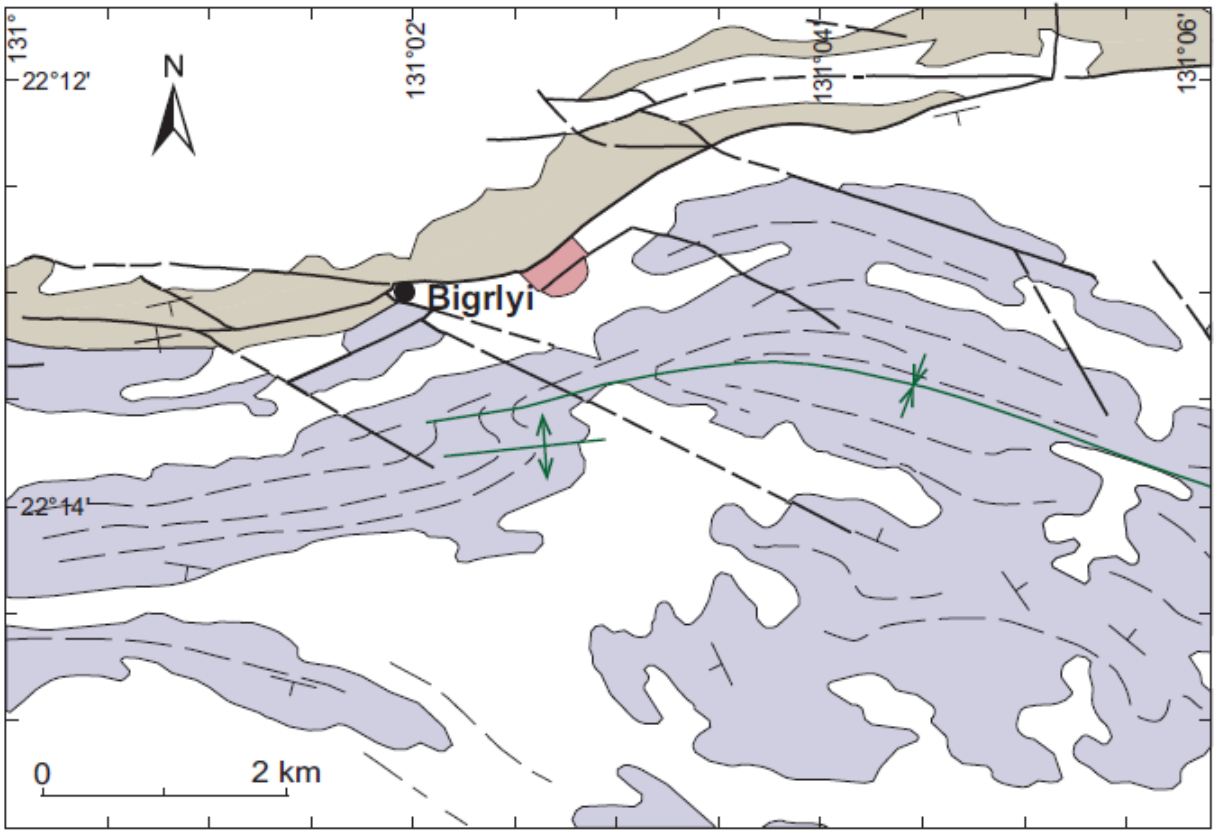
Outline

- Mineral potential assessment
  - Methods of assessment (mineral potential, prospectivity, and favourability maps)
- Mineral-systems approach
  - definition, advantages and disadvantages
- Lessons learnt and not learnt

Mineral potential

- Likelihood that an economic mineral deposits could have formed in the area
- Probabilistic approach to mineral deposits instead of deterministic
- Probabilities are conditional
  - on geological processes occurring in an area
  - on geological features indicative of those processes
- Probability of sandstone-hosted uranium deposits in an area
  - process: transport of U
  - geological features: leachable source of U; permeable sandstone; hydrogeological gradient

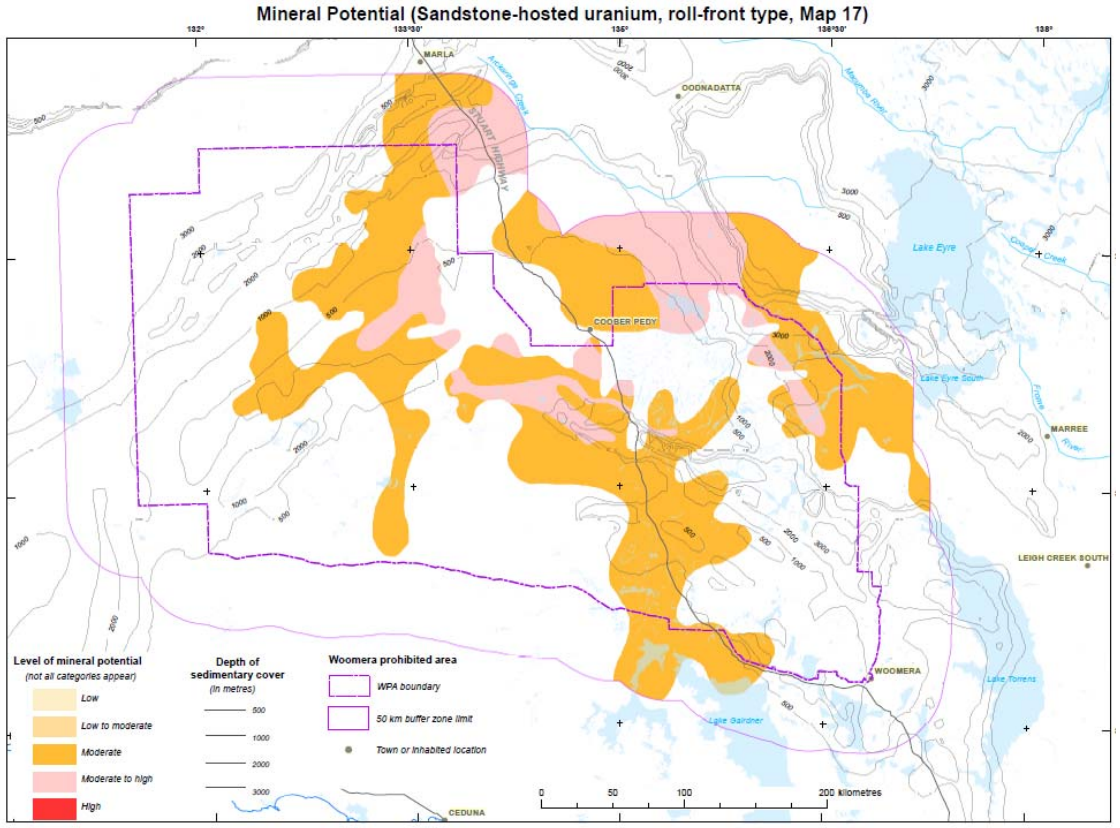
Methods of assessment (Quantitative)



probability	90%	50%	10%
Uranium (t)	xx	yy	zz

- Delineate areas permissive for a deposit
- Estimate number of deposits
- Estimate tonnage of metals at different probabilities
- Methods: NURE; 3-part USGS; Deposit density etc

Methods of assessment (Qualitative)



- Delineate areas permissive for a deposit
- Estimate and assign probabilities
  - Non-numerical (high, moderate, low)
  - Ordinal (numbers expressing ranking)
  - Cardinal (numbers expressing quantities); can be computed by probability equations

GIS methods of assessment

- Methods are not quantitative but the method of visualisation is quantitative
- Produce favourability or prospectivity maps by estimating probabilities
- Dominantly data-driven and 'objective'
- Techniques (see Bonham-Carter, 1994):
  - Boolean logic
  - Index overlay
  - Bayesian (Weights of evidence)
  - Fuzzy logic

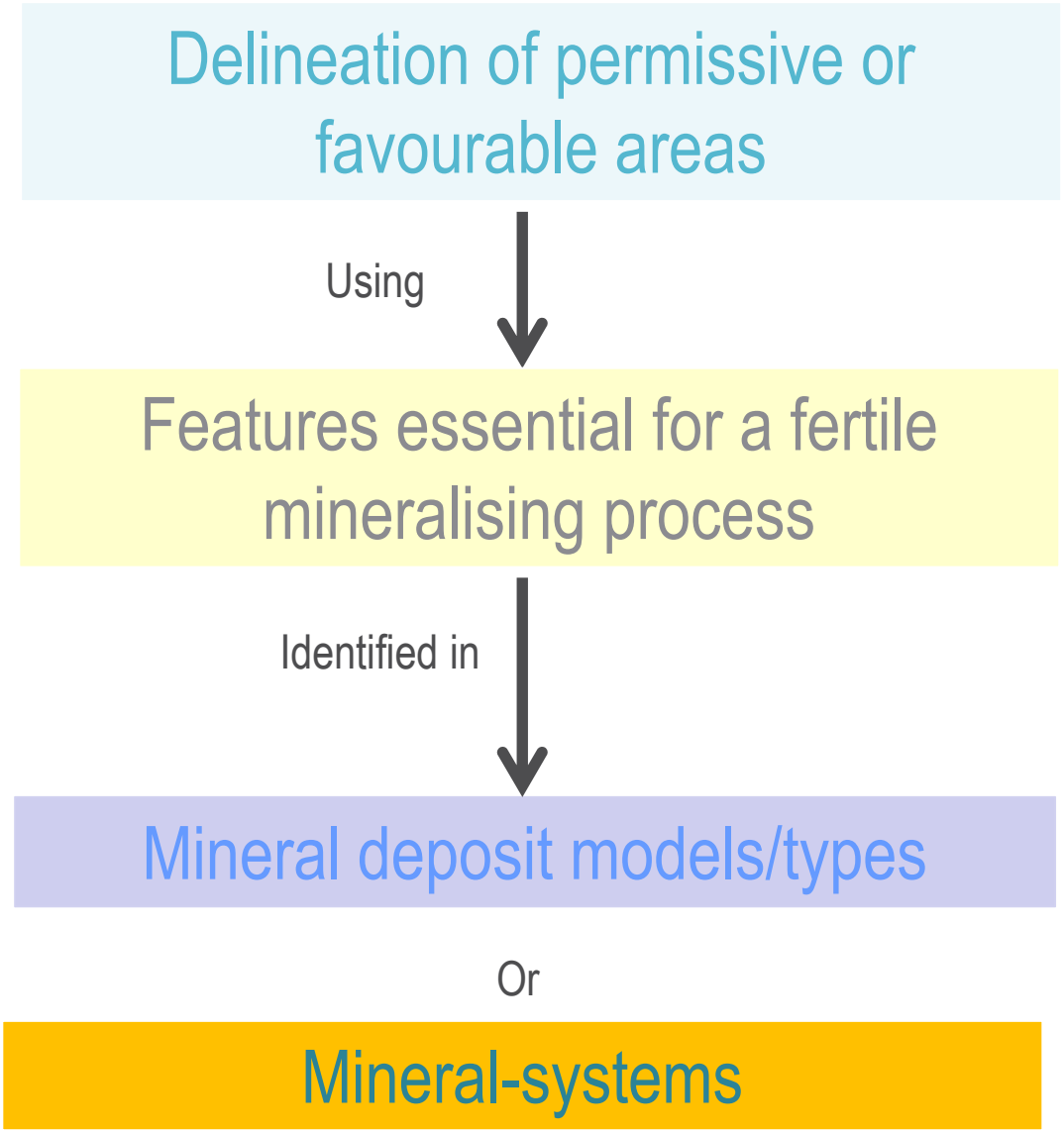
Which method and why

- Depends on the purpose/aim/objective
- For regional-scale exploration targeting
  - qualitative (GIS-based)
- For local-scale brown-fields exploration
  - qualitative (GIS-based)
- Competing land-use decisions
  - quantitative
  - qualitative
- For mineral endowment and inventory
  - quantitative

Prospectivity map
Favourability map

Mineral potential map

Essential for qualitative and quantitative methods



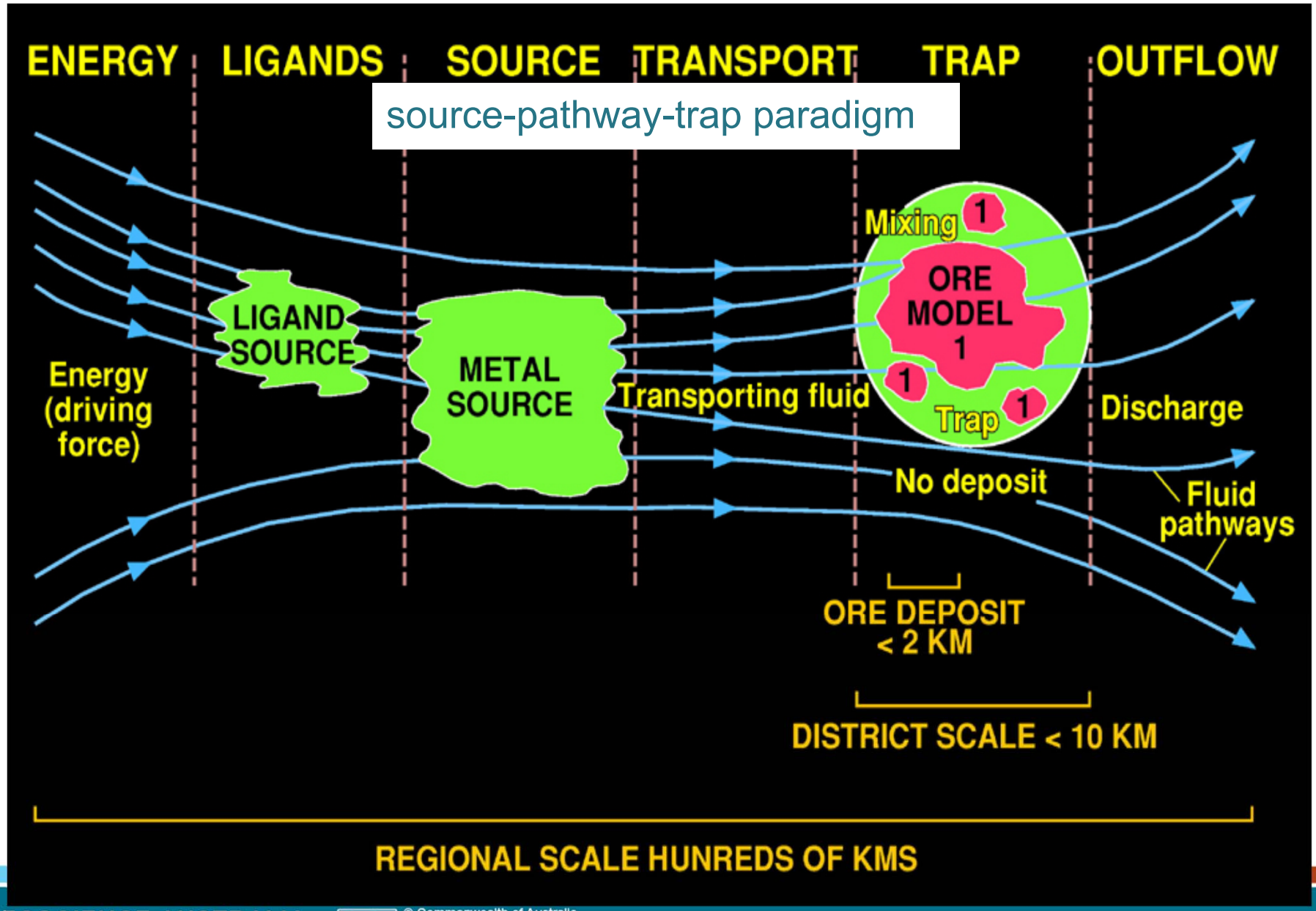
Mineral system: initial concept

- Wyborn et al (1994)
- Australian Proterozoic mineral system: essential ingredients and mappable criteria
- "All geological factors that control generation and preservation of mineral deposits …"
- Stress on "Processes"
- Analogous to Petroleum Systems
- Emergence of Relational Databases and GISs

Seven important geological factors

1. Source of fluids and ligands
2. Source of metals and other components
3. Migration pathways (inflow and outflow zones)
4. Thermal gradients
5. Source of energy to transport fluid and metals
6. Mechanical and structural focusing mechanism at the trap site
7. Chemical and/or physical cause for precipitation at the trap site

Mineral system (Knox-Robinson & Wyborn, 1997)



Mineral potential assessment method

Features Of Mineral System

- Setting
- Source
  - Metal
  - Ligand
  - Energy
- Pathway
- Trap:
  - Mechanical
  - Chemical
- Timing
- Preservation

combining 2 approaches

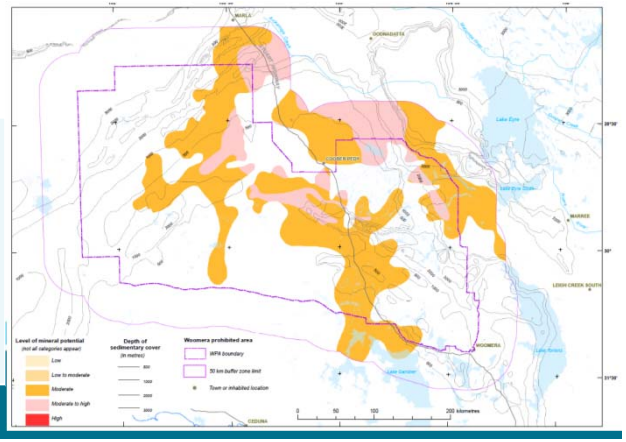
Mineral System + Probabilistic

Identify mappable geological features

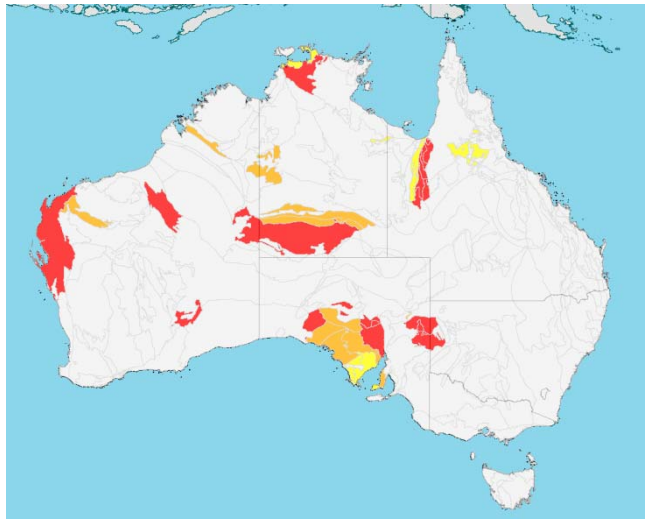
Assign probabilities to mappable features

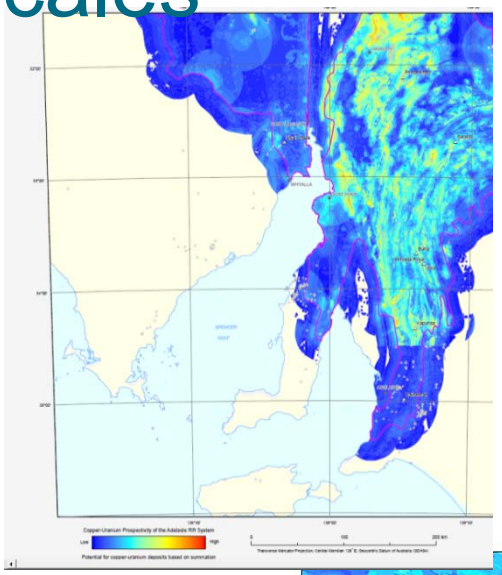
Assess mineral potential (by computing probabilities)

Map: prospectivity, favourability, mineral potential

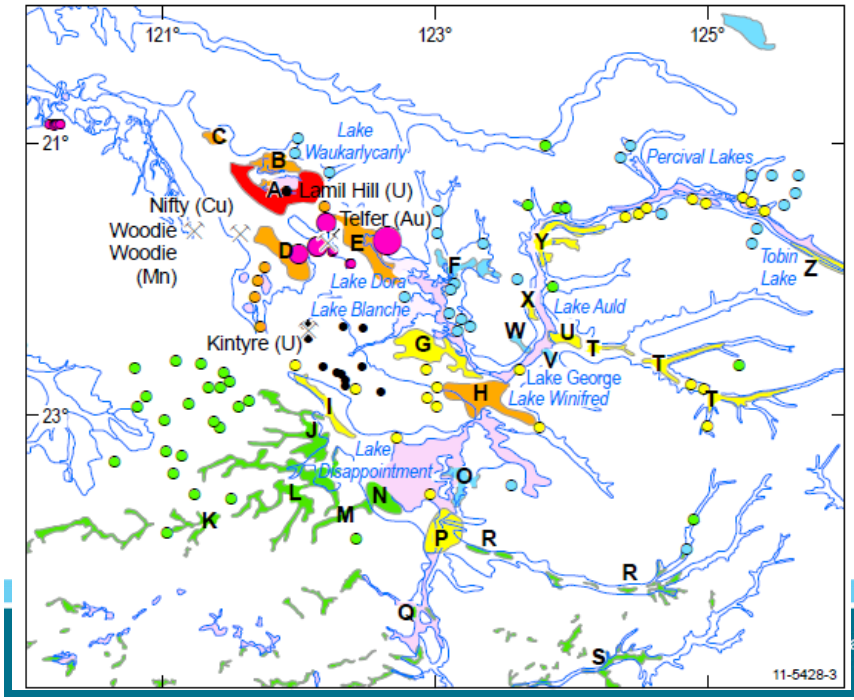


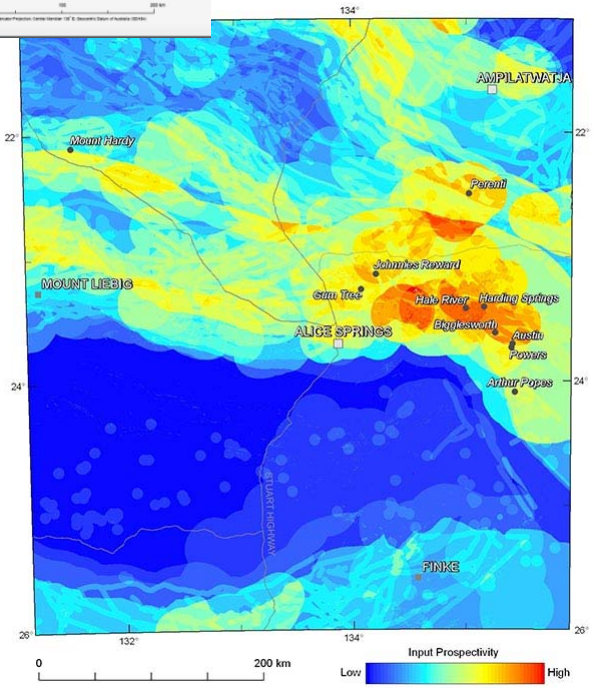
Assessments at various scales





http://www.ga.gov.au/minerals/projects/concluded-projects/mineral-potential.html



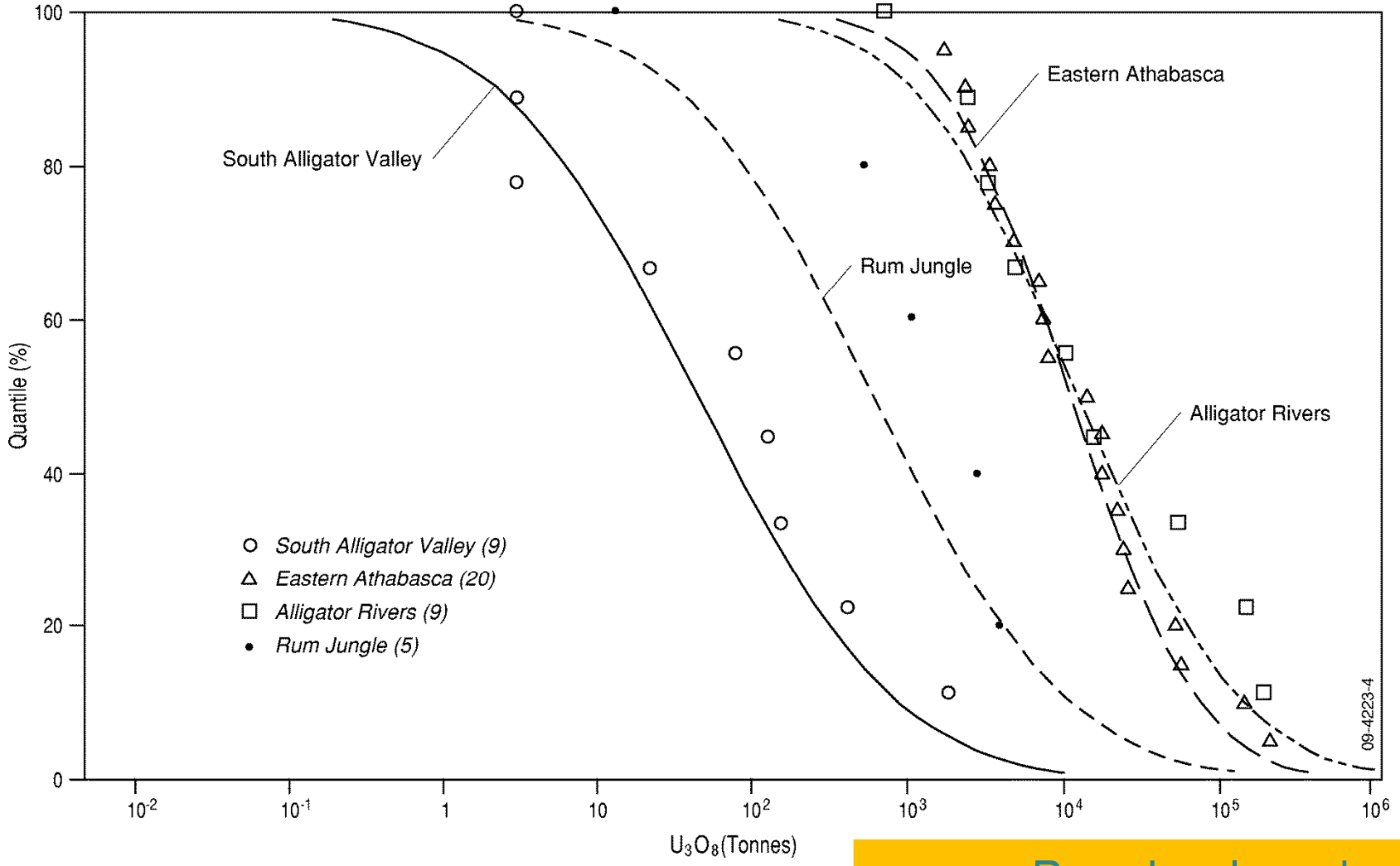


http://www.ga.gov.au/minerals/projects/concluded-projects/uranium-systems.html

Limitations of mineral-systems approach

- Preservation considered important but listed factors do not include features critical for preservation
- Age, duration and relative timing of events in a mineral system do not receive adequate attention
- Requires change to focus on ‘giant’ instead of average-size deposits
- Requires rethinking to take in take into account clustering of deposits

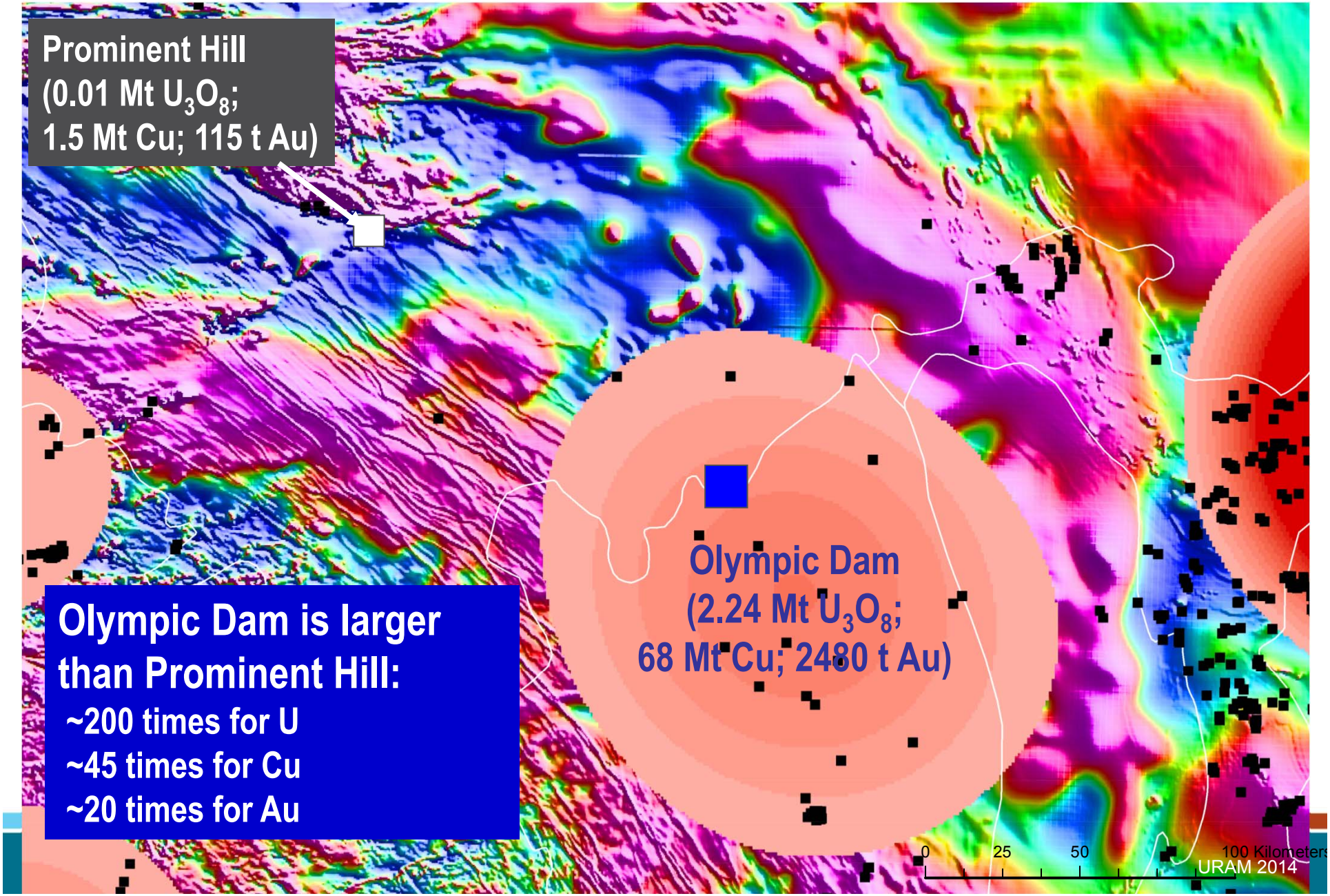
4 regions with unconformity-related uranium



Alligator Rivers and Eastern Athabasca similar

Rum Jungle and S Alligator Valley different

Supergiant (Bull Elephant): Olympic Dam



Reliability or robustness of assessment

Depends on

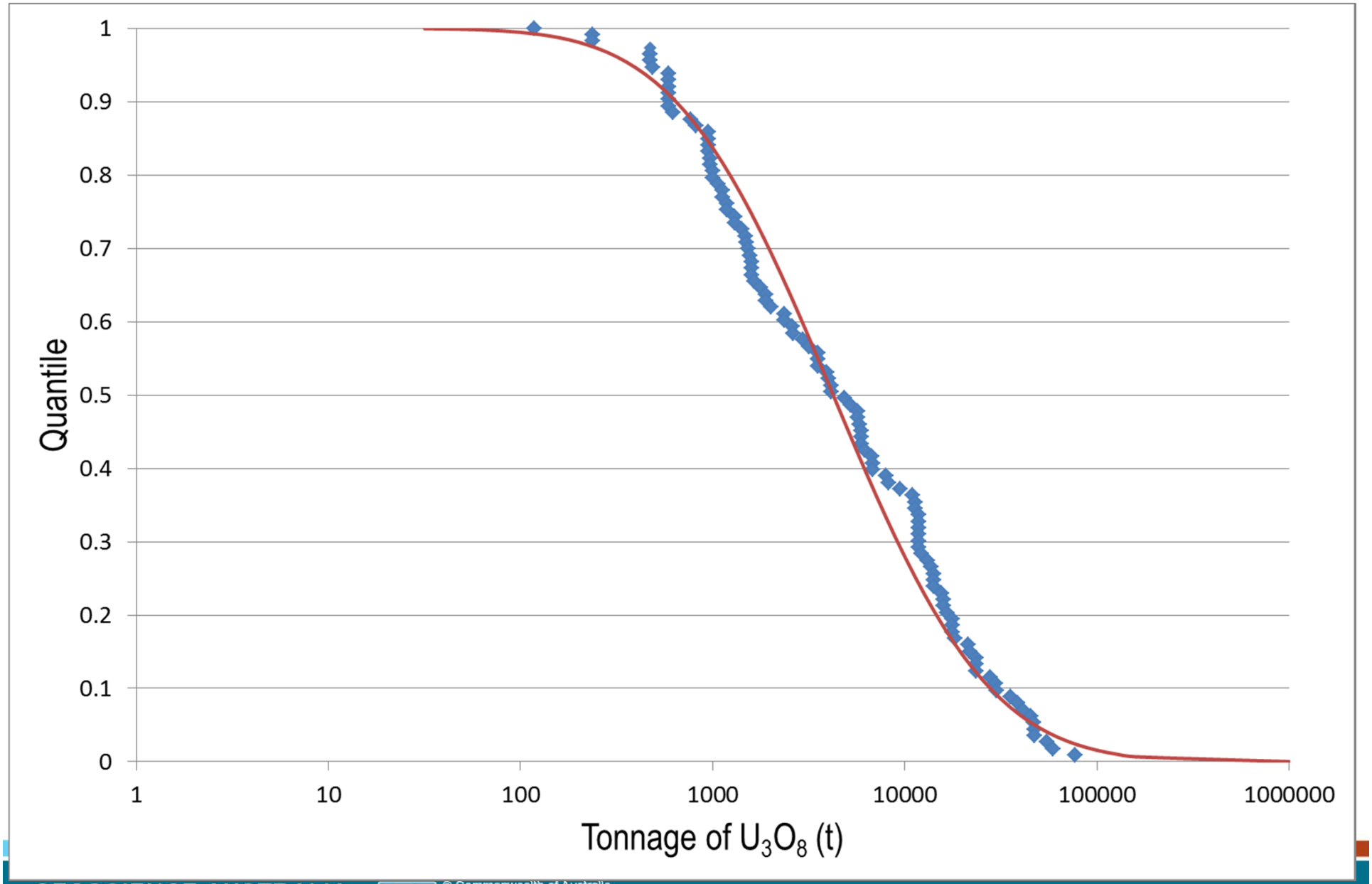
- Knowledge of mineral systems/deposit styles (their critical features)
- Identification of mappable signatures in datasets which correspond to critical features of mineral systems
- Extent and quality of datasets

Conclusions

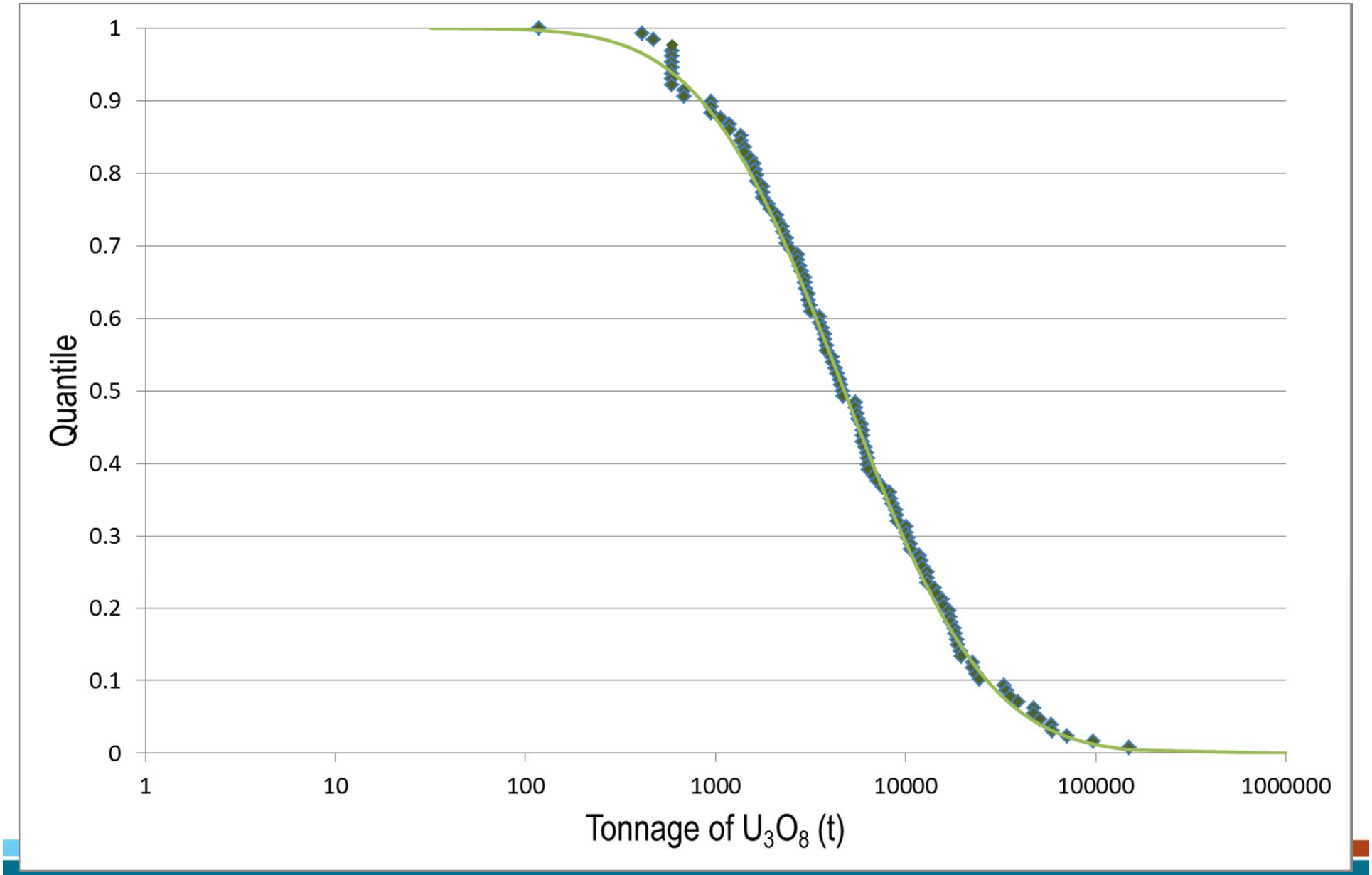
- Choice of methods depends on the objective
- Basics:
  - Know your mineral system (deposit-type): SCIENCE
  - Create useful datasets: A MUST
- Mineral system approach can be rewarding. For successful examples visit GA's website:

  http://www.ga.gov.au/minerals/projects/concluded-projects/mineral-potential.html; and
  http://www.ga.gov.au/minerals/projects/concluded-projects/uranium-systems.html
- Don't overdo or oversell it (only detailed exploration such as drilling can find a deposit)

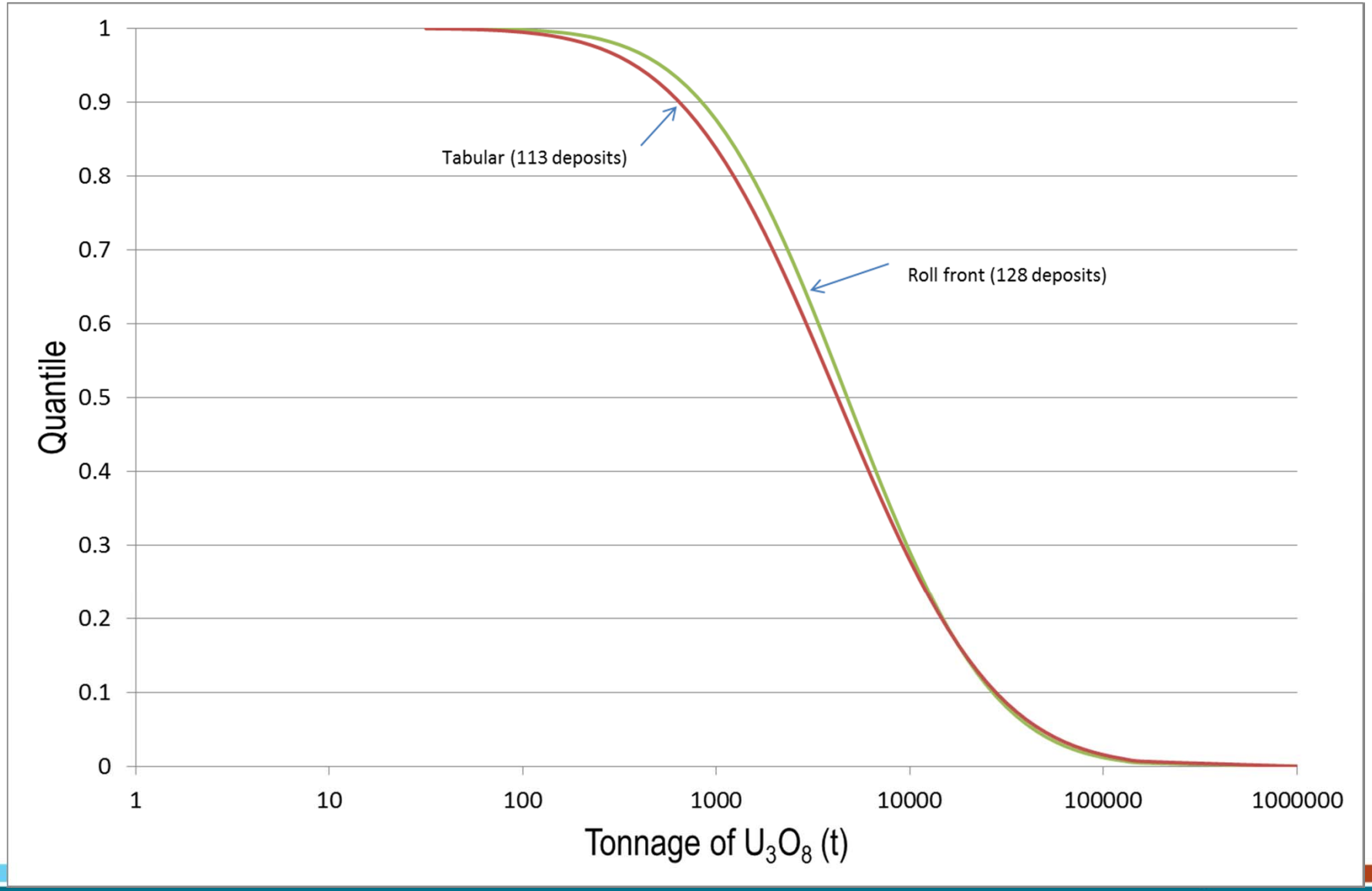
Tonnage data for tabular deposits (113 deposits)



Tonnage data for roll front deposits (128 deposits)



Tabular and roll front deposits (comparison)



Deposit density (Singer et al., 2001)

Low-sulphide gold-quartz veins

Region	Density (deposit/1000km^2)
Sierra Nevada, California	4.6
Meguma Group, Canada	5.4
Bendigo, Australia	5.0
Klamath Mountains, California	4.3

Volcanic-associated massive sulphide

Region	Density (deposit/1000km^2)
Snow Lake, Manitoba, Canada	30
Hokuruku, Japan	8.8-13
Western Tasmania, Australia	3.3