Australian Government
Geoscience Australia

Uranium mineral systems: How and where they form

Roger Skirrow

Section Leader, Mineral Exploration Promotion
Minerals and Natural Hazards Division
Geoscience Australia

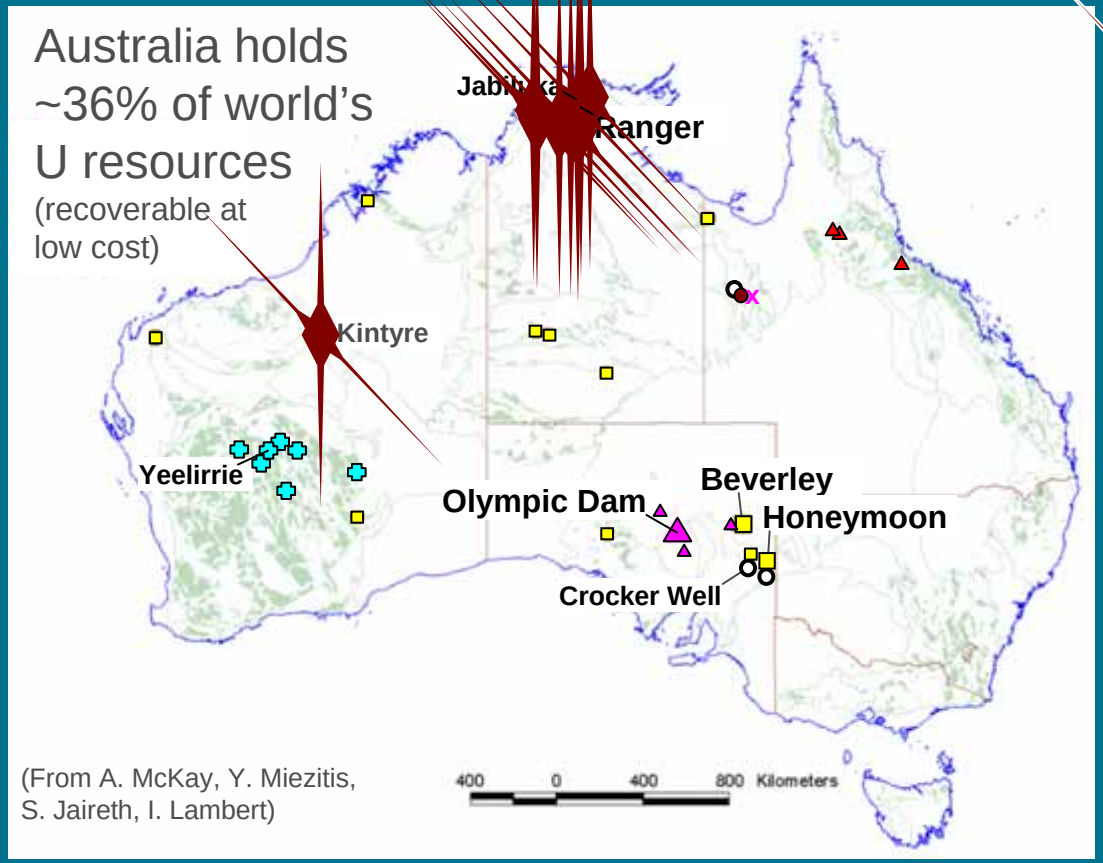
Outline

1. A mineral systems framework for U deposit classification and description
2. Fluids
3. Basin-related U mineral systems
4. Example: ‘sandstone’ U in the Frome region, SA

Summary

Uranium deposit classification

IAEA 'Red Book'



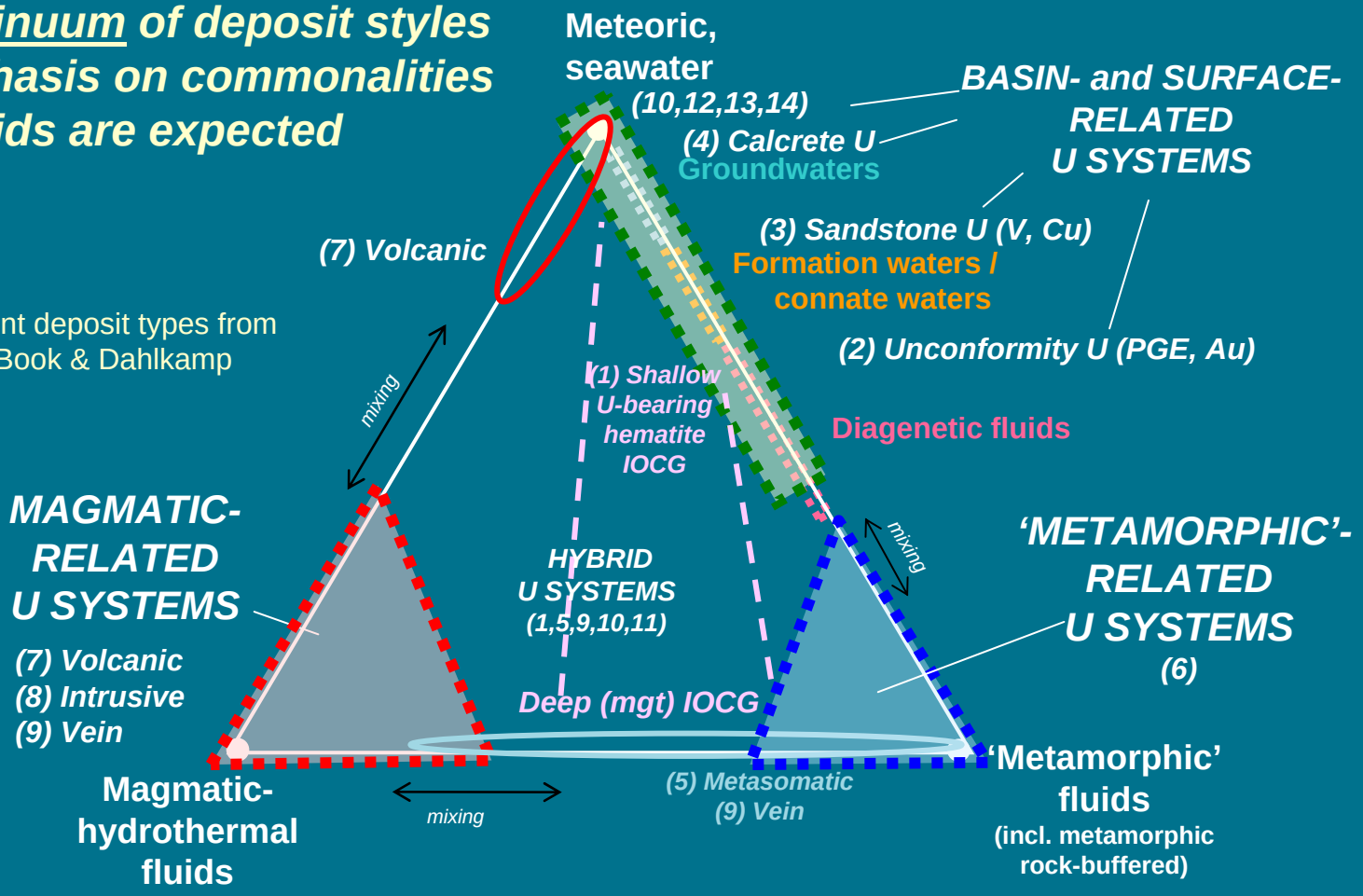
Deposit type (% of Australian resources)

1. Breccia complex (IOCG) 71%
2. Unconformity-related 19%
3. Sandstone 4%
4. Surficial ('calcrete') 3%
5. Metasomatite 2%
6. Metamorphic
7. Volcanic 1%
8. Intrusive
9. Vein
10. Quartz-pebble conglomerate
11. Collapse breccia pipe
12. Phosphorite
13. Lignite
14. Black shale

- ***Types based on host-rock or deposit morphology***
- ***Relationships between deposit types not clear***

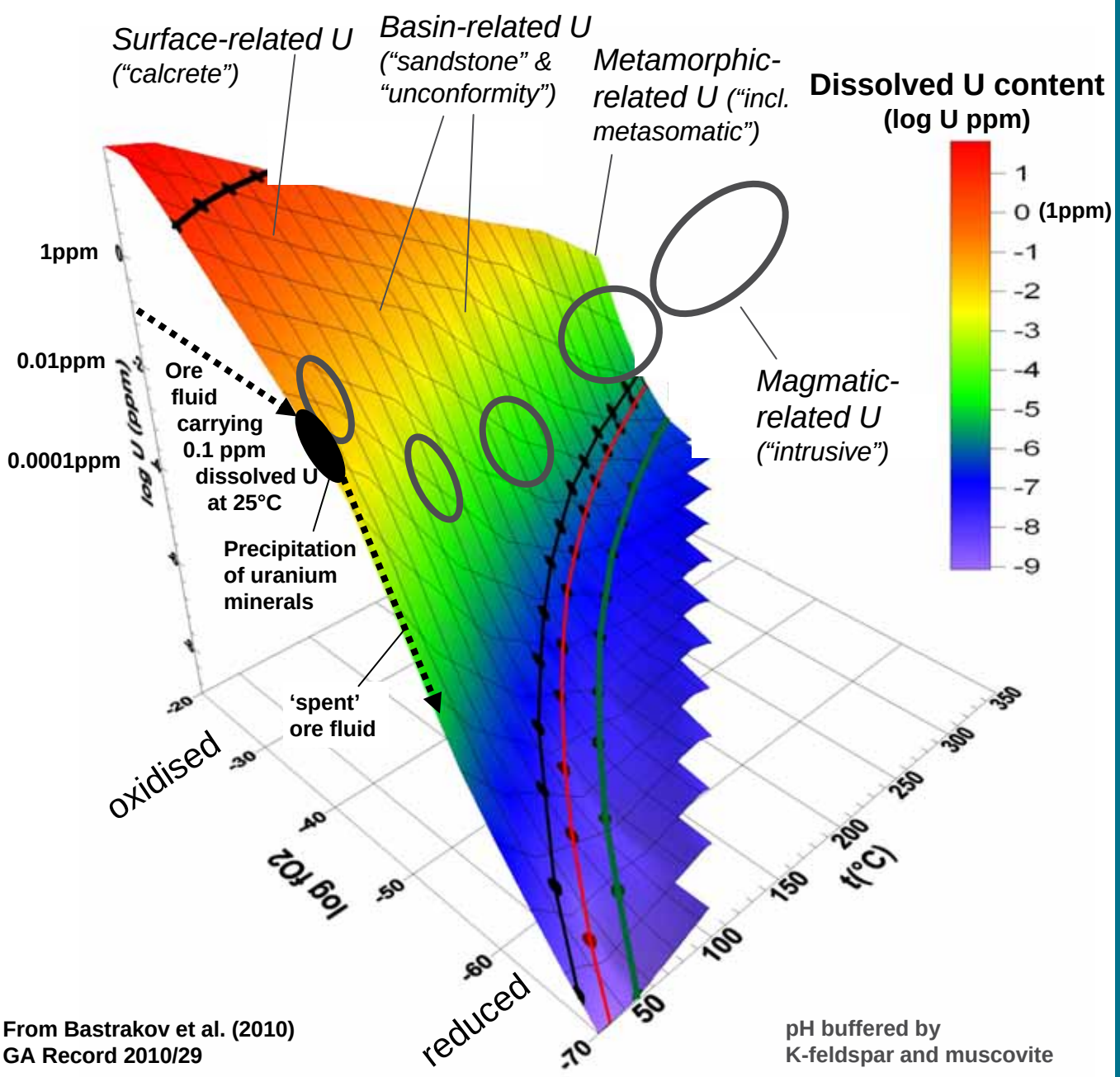
A mineral systems framework for U deposit types

- *Three end-member fluids*
- *<u>Continuum</u> of deposit styles*
- *Emphasis on commonalities*
- *Hybrids are expected*



(#) represent deposit types from IAEA Red Book & Dahlkamp (1990)

[From Skirrow et al. 2009, GA Record 2009/20]



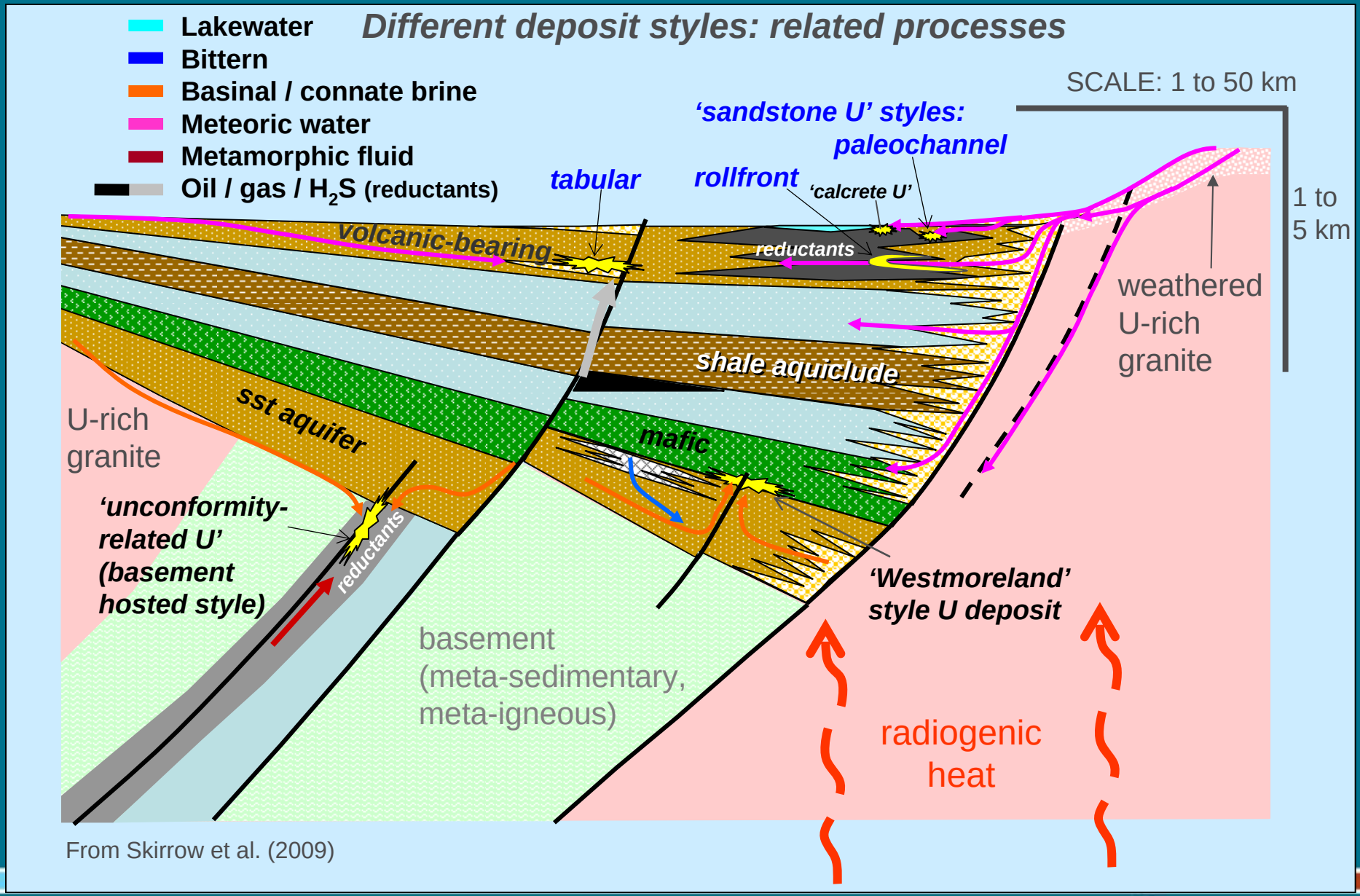
From Bastrakov et al. (2010)
GA Record 2010/29

pH buffered by
K-feldspar and muscovite

Fluids in uranium mineral systems:

a fundamental control on how and where they form

Basin- & surface-related uranium systems



From Skirrow et al. (2009)

Basin-related U systems

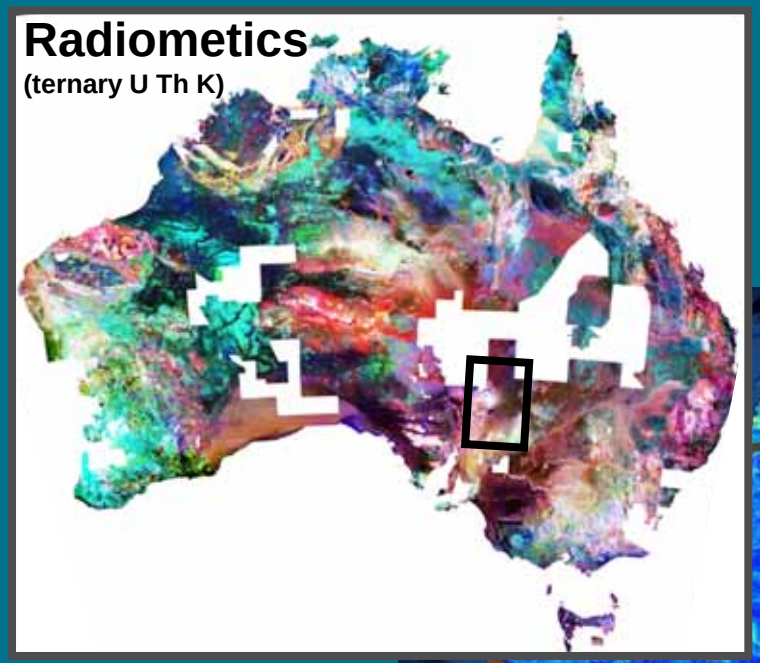
Example of ‘sandstone-hosted’ uranium systems, Frome region, SA

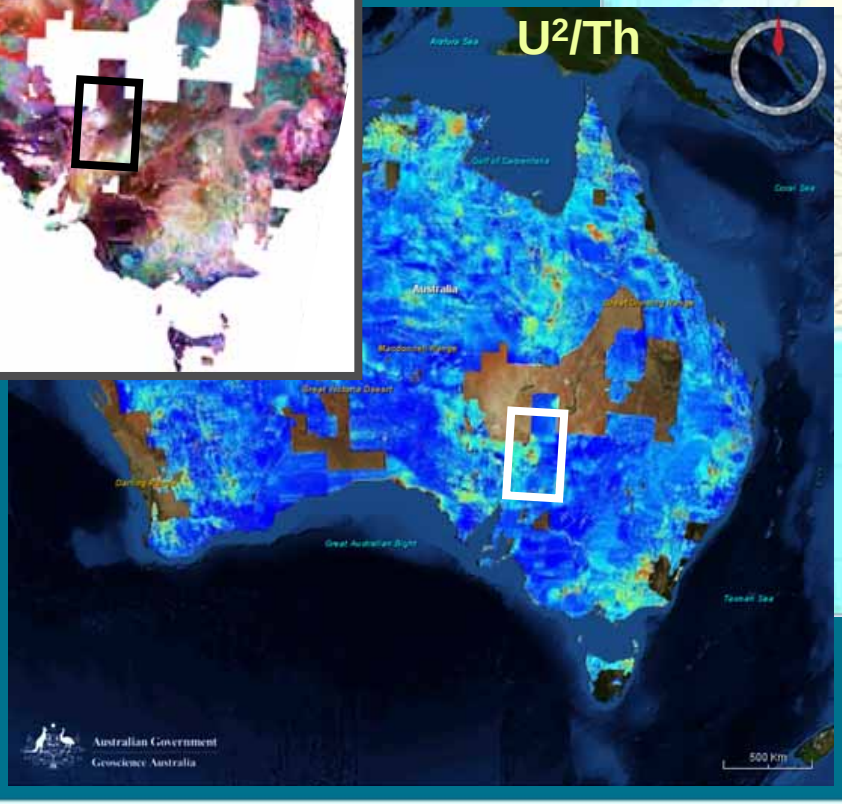
Mapping of mineral system components:

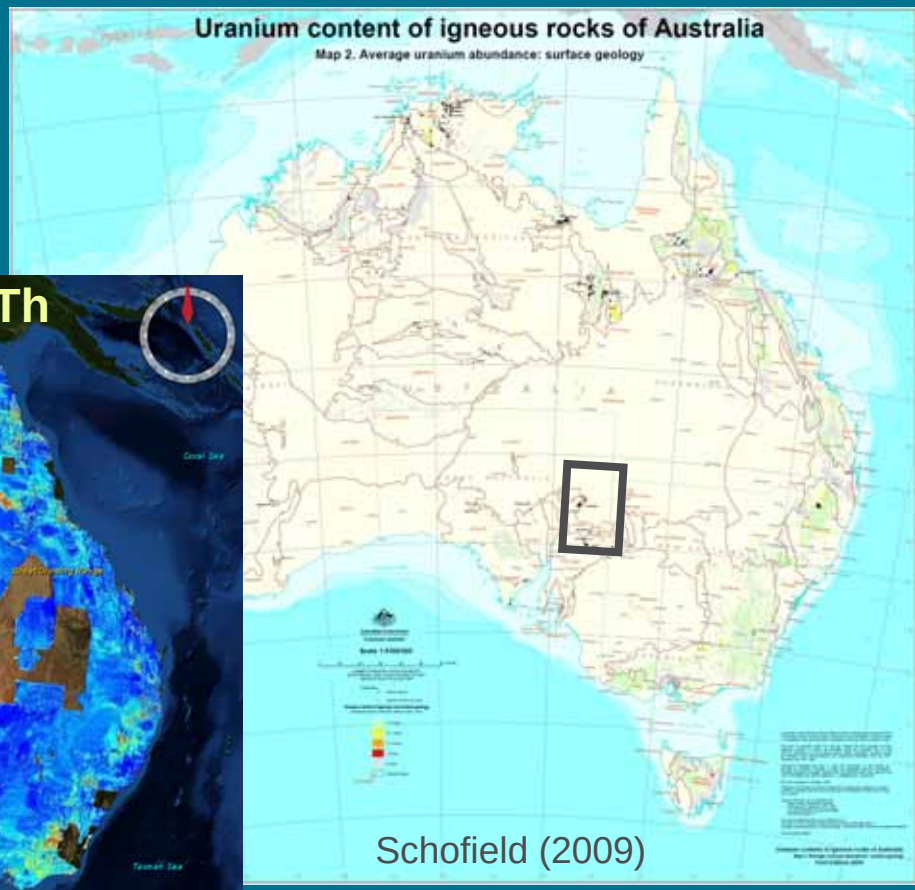
- **U sources**
- **‘Driver’ of fluid flow (energy source)**
- **Fluid pathways**
- **Ore depositional gradients**

Uranium sources for basin-related U systems:

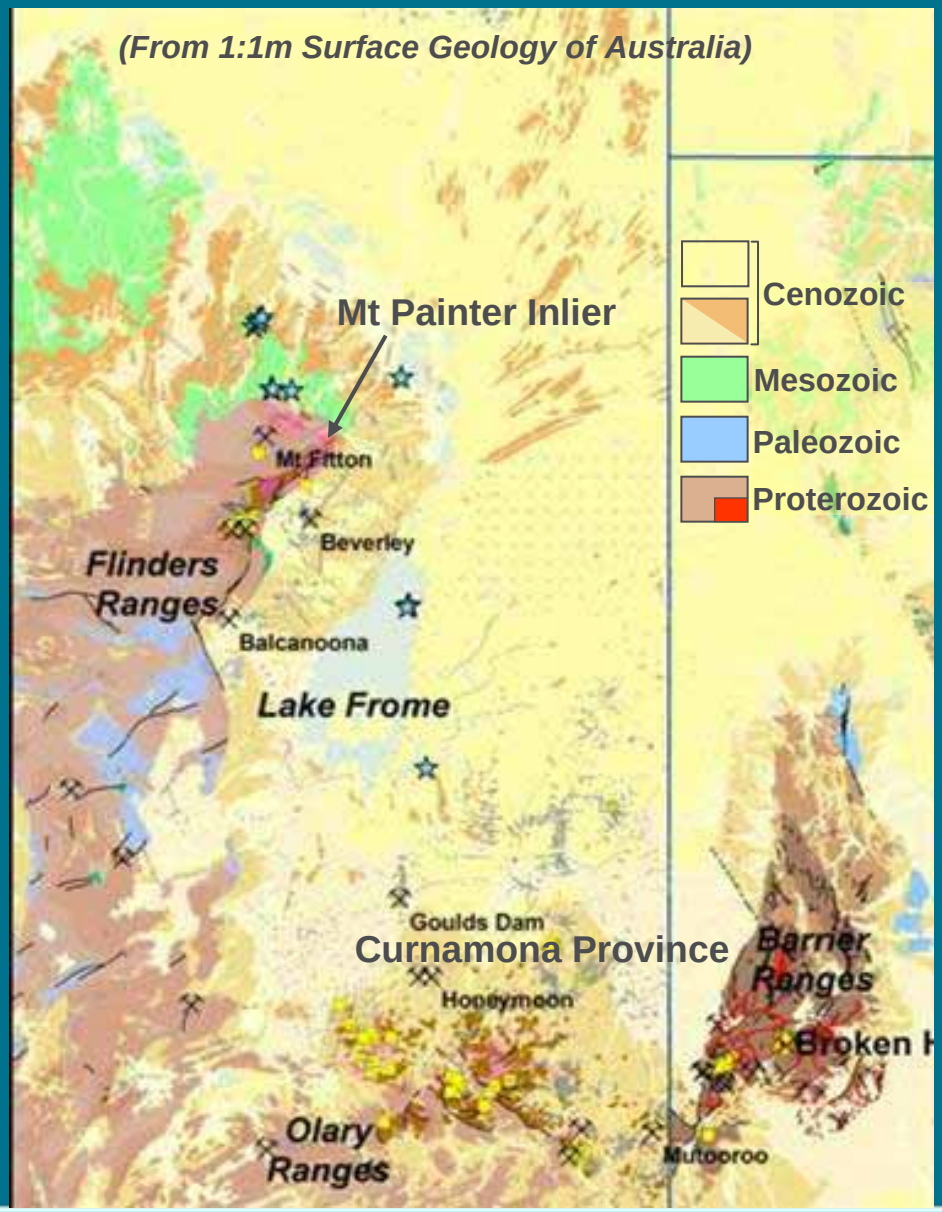
Identify using radiometrics and whole-rock geochemistry of igneous rocks (continental datasets from Geoscience Australia)



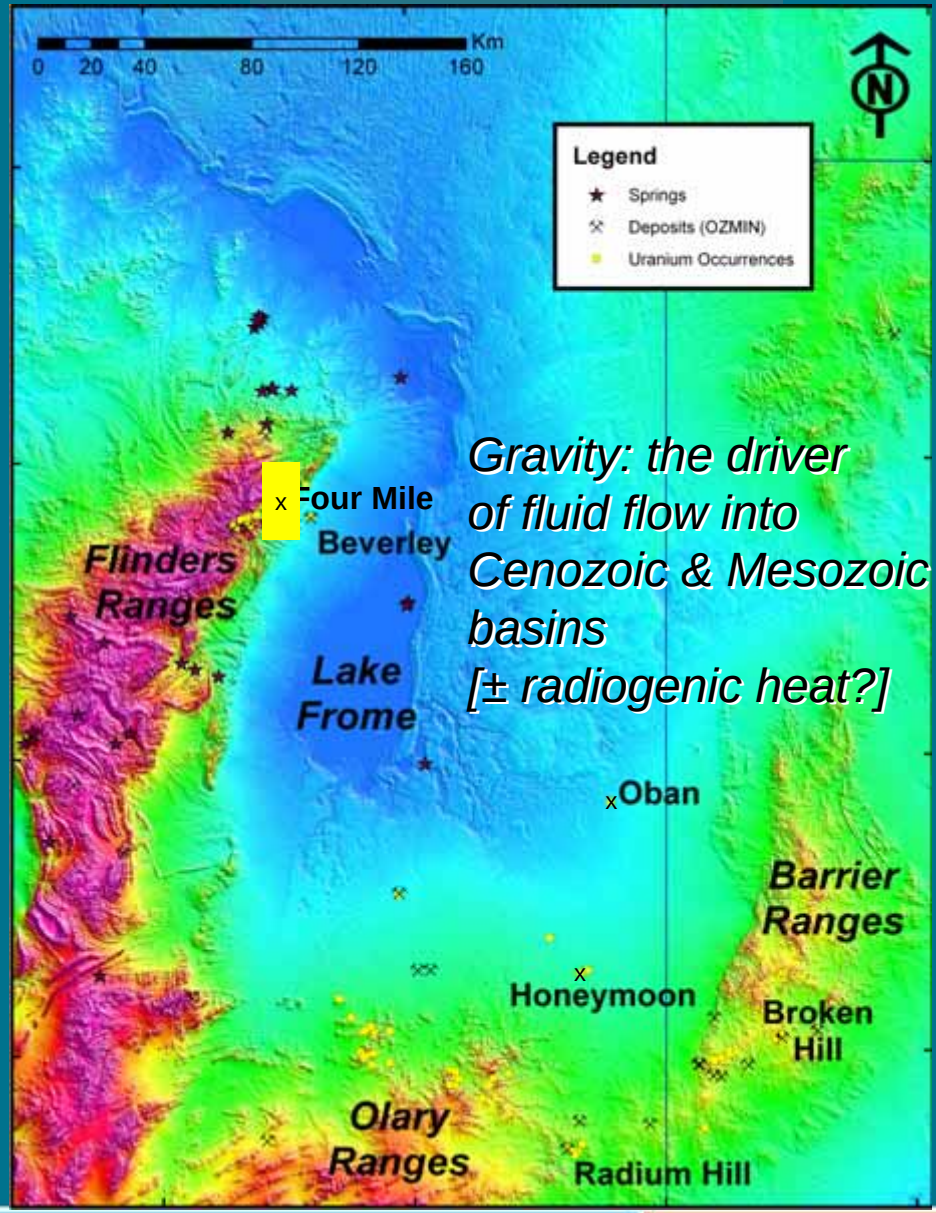




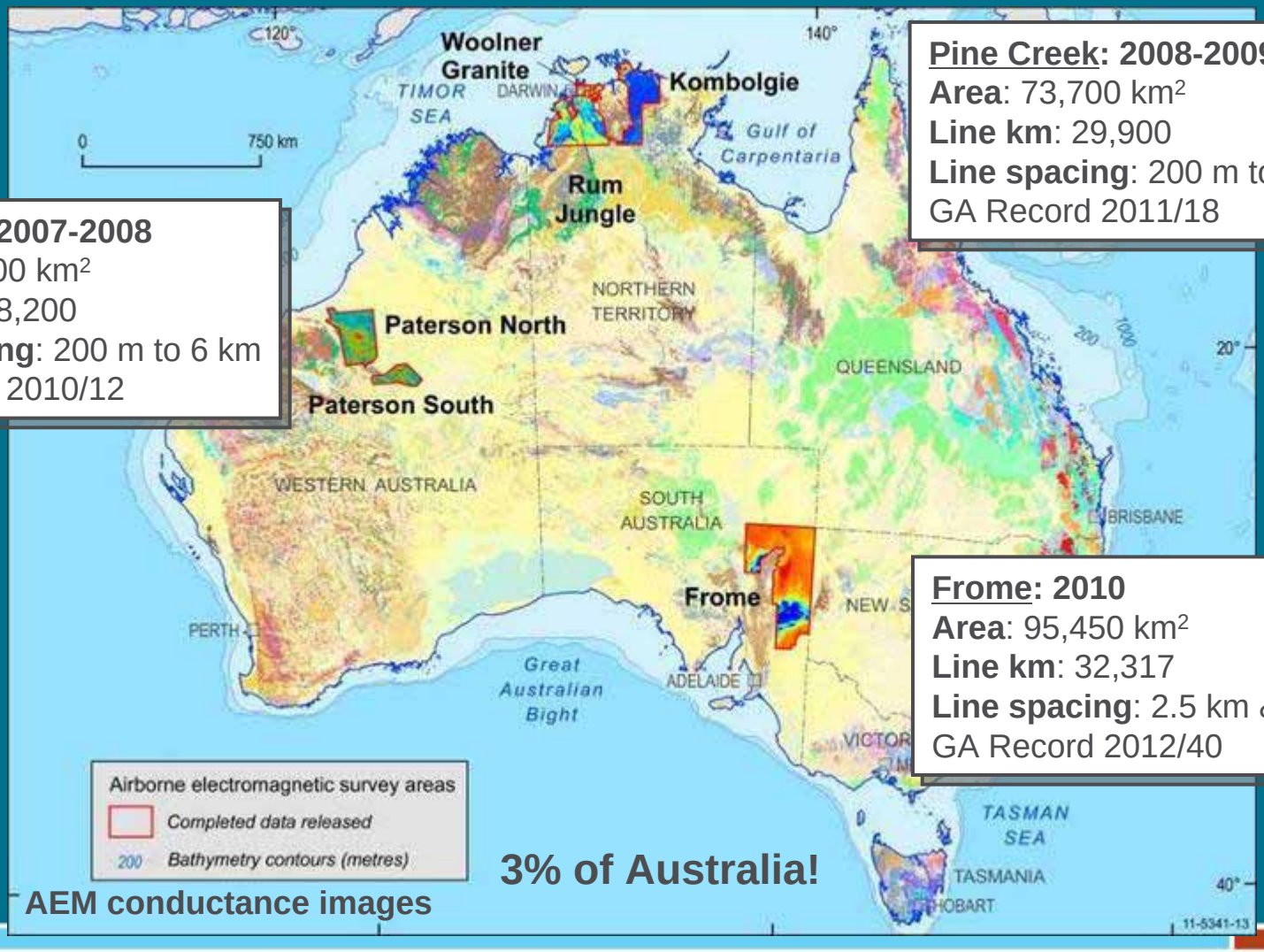
GEOLOGY



TOPOGRAPHY



Mapping *fluid flow pathways and U depositional settings* using airborne electromagnetic (AEM) data



Pine Creek: 2008-2009
Area: 73,700 km²
Line km: 29,900
Line spacing: 200 m to 5 km
GA Record 2011/18

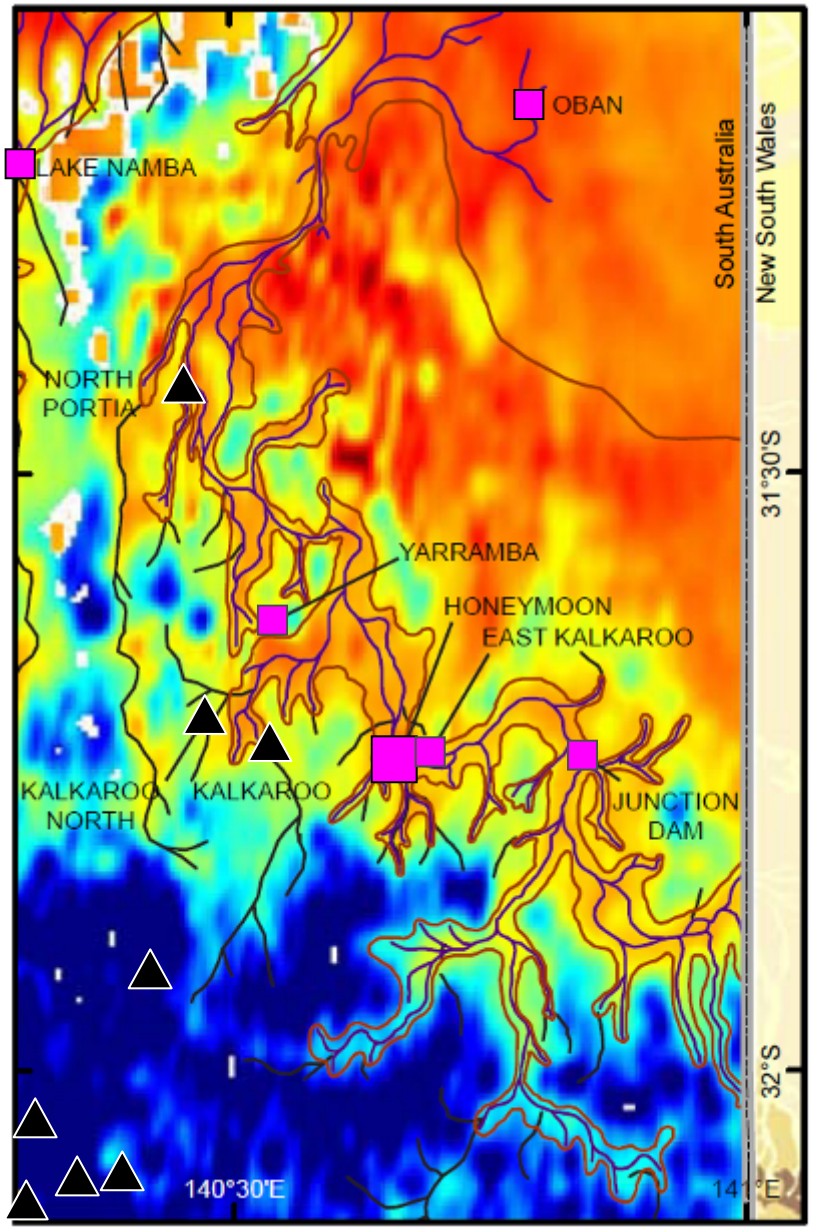
Paterson: 2007-2008
Area: 47,600 km²
Line km: 28,200
Line spacing: 200 m to 6 km
GA Record 2010/12

Frome: 2010
Area: 95,450 km²
Line km: 32,317
Line spacing: 2.5 km & 5 km
GA Record 2012/40

3% of Australia!

AEM conductance images

Mapping fluid pathways (paleovalleys) using regional AEM



Sandstone-hosted uranium occurrence

Magmatic-hydrothermal uranium occurrence

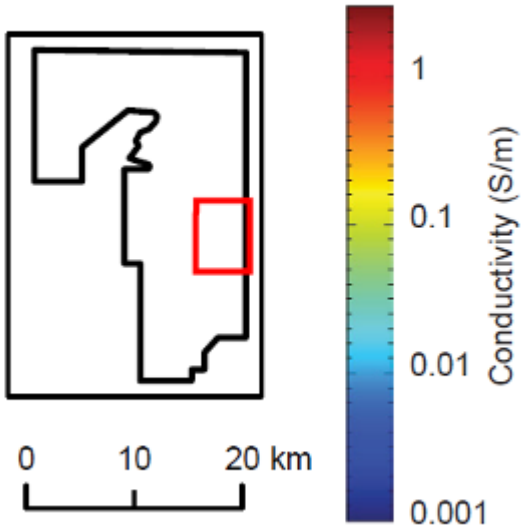
New Eyre Formation-involved palaeovalley boundary interpretation

New Eyre Formation-involved palaeovalley thalweg interpretation

New Namba Formation/Quaternary-involved palaeovalley thalweg interpretation

State border

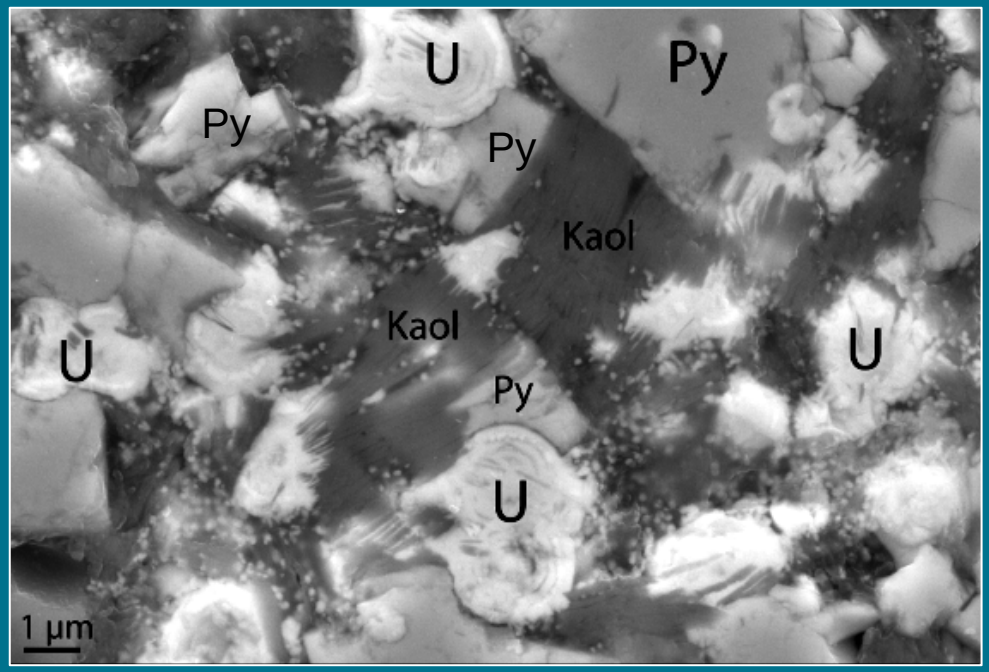
Conductivity depth slice (80-100m)



From Roach (2012), GA Record 2012/40

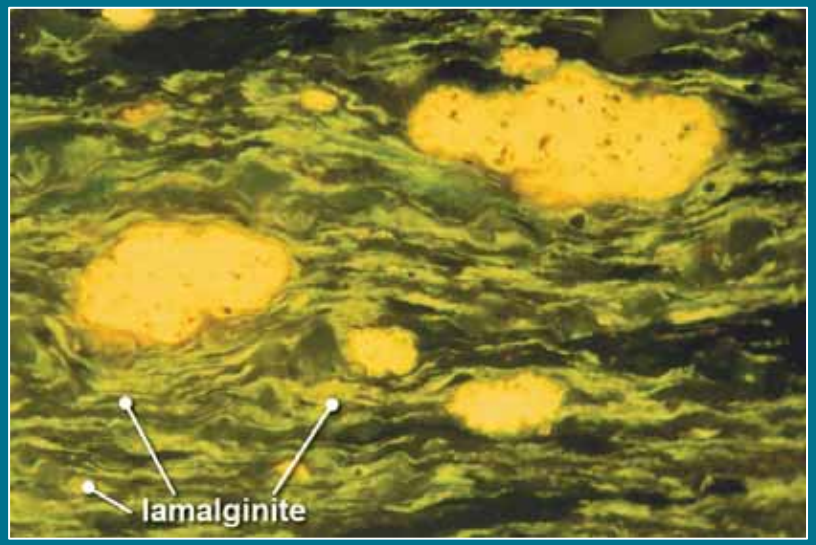
U depositional gradients: oxidation-reduction fronts
(organic- and/or sulfide-rich sediments)

Four Mile East uranium mineralisation: biogenic pyrite as a reductant for U



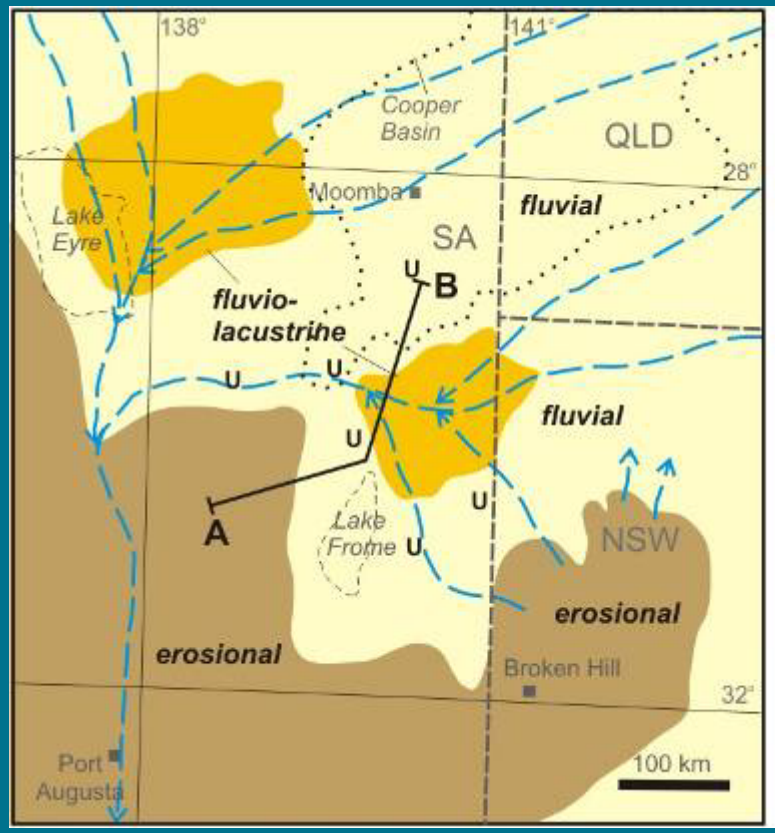
[Field emission SEM micrographs, Schofield et al., 2009, GA Record 2009/40]

Organic matter as U reductant: Namba facies 1

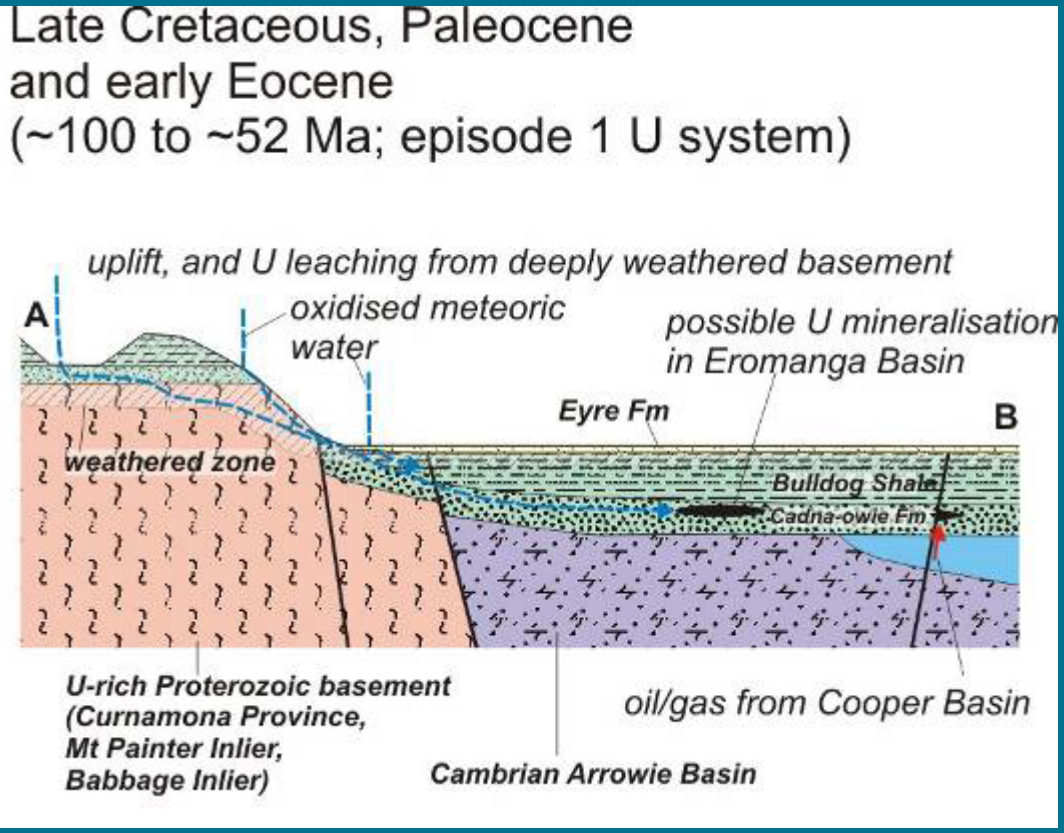


[Fluorescence micrograph from Michaelsen & Fabris, 2012, Organic facies of the Frome Embayment and Callabonna Sub-basin: What are the U reductants? *Geological Survey of South Australia]*

FROME URANIUM PROVINCE EVOLUTION

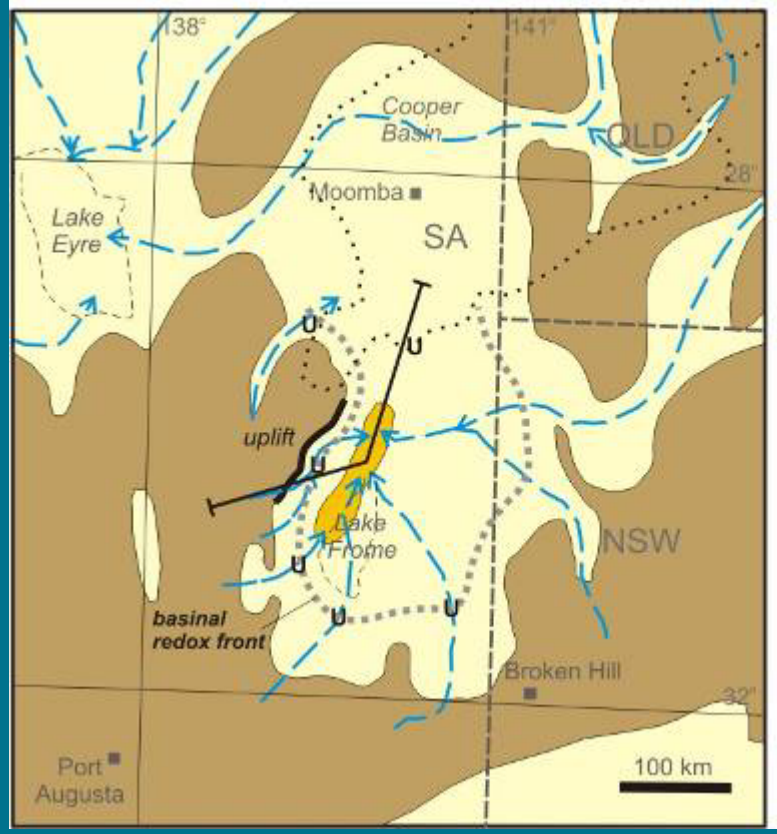


Paleogeographic reconstruction from Langford et al. (1995)

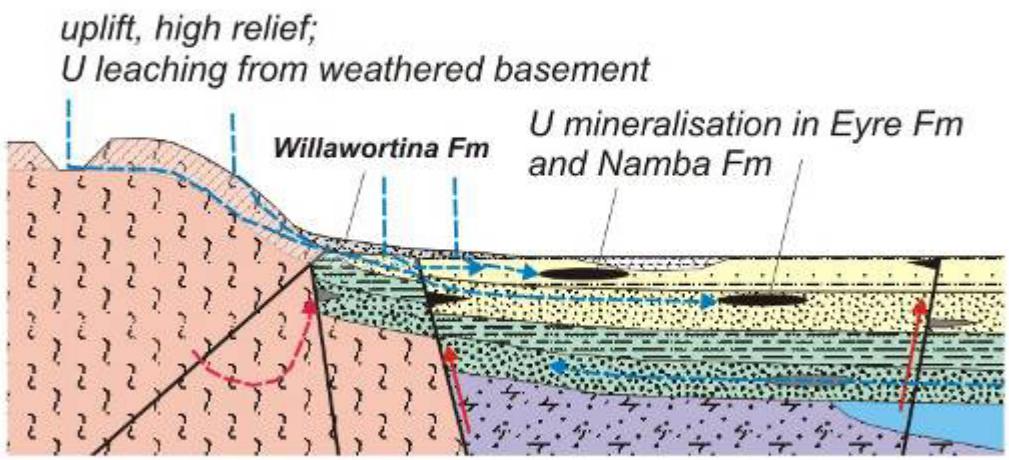


[From Skirrow (ed.) 2009, GA Record 2009/40]

FROME URANIUM PROVINCE EVOLUTION

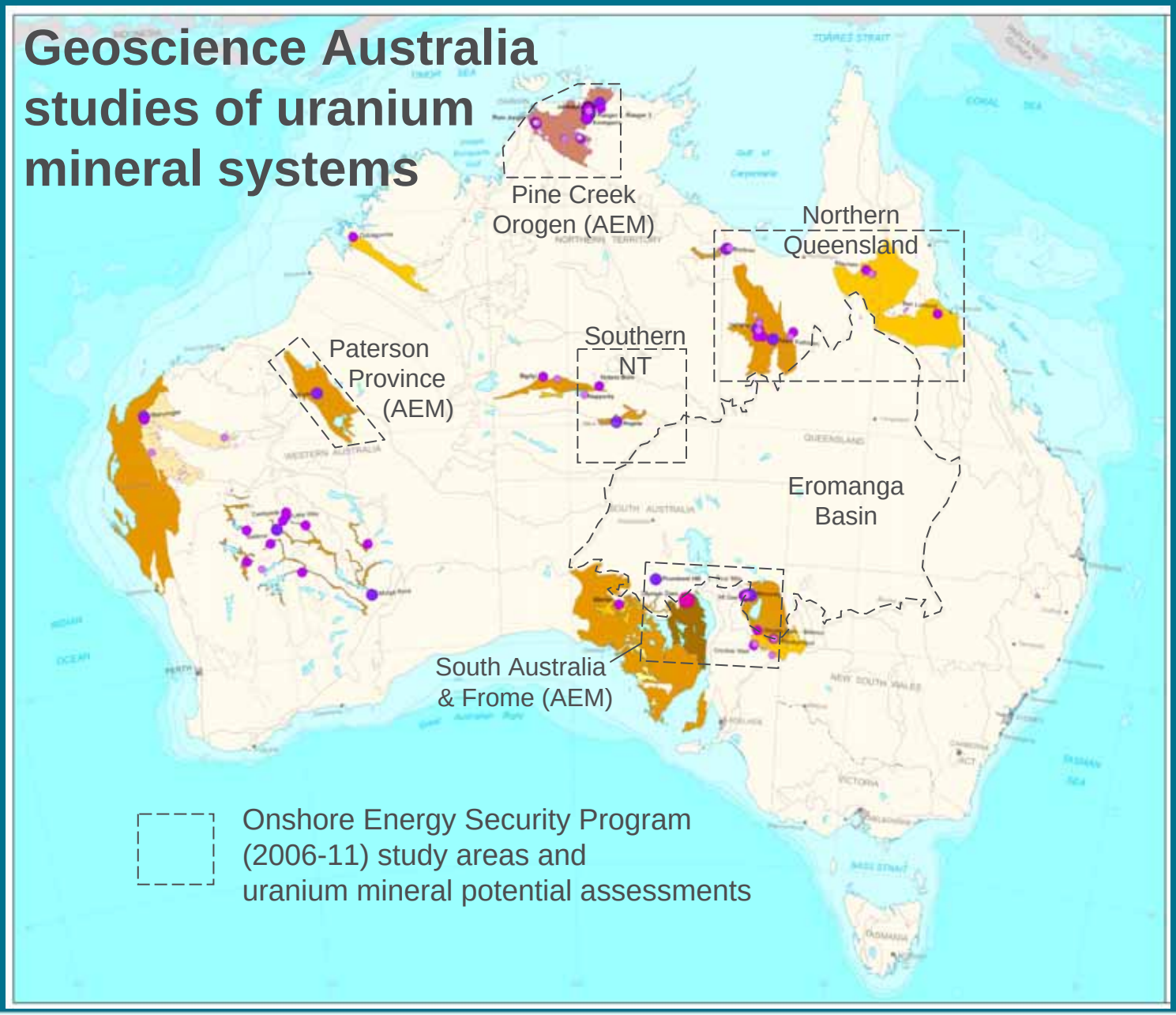


Pliocene and Pleistocene
(~5.3 to ~0.01 Ma; episode 3 U system)



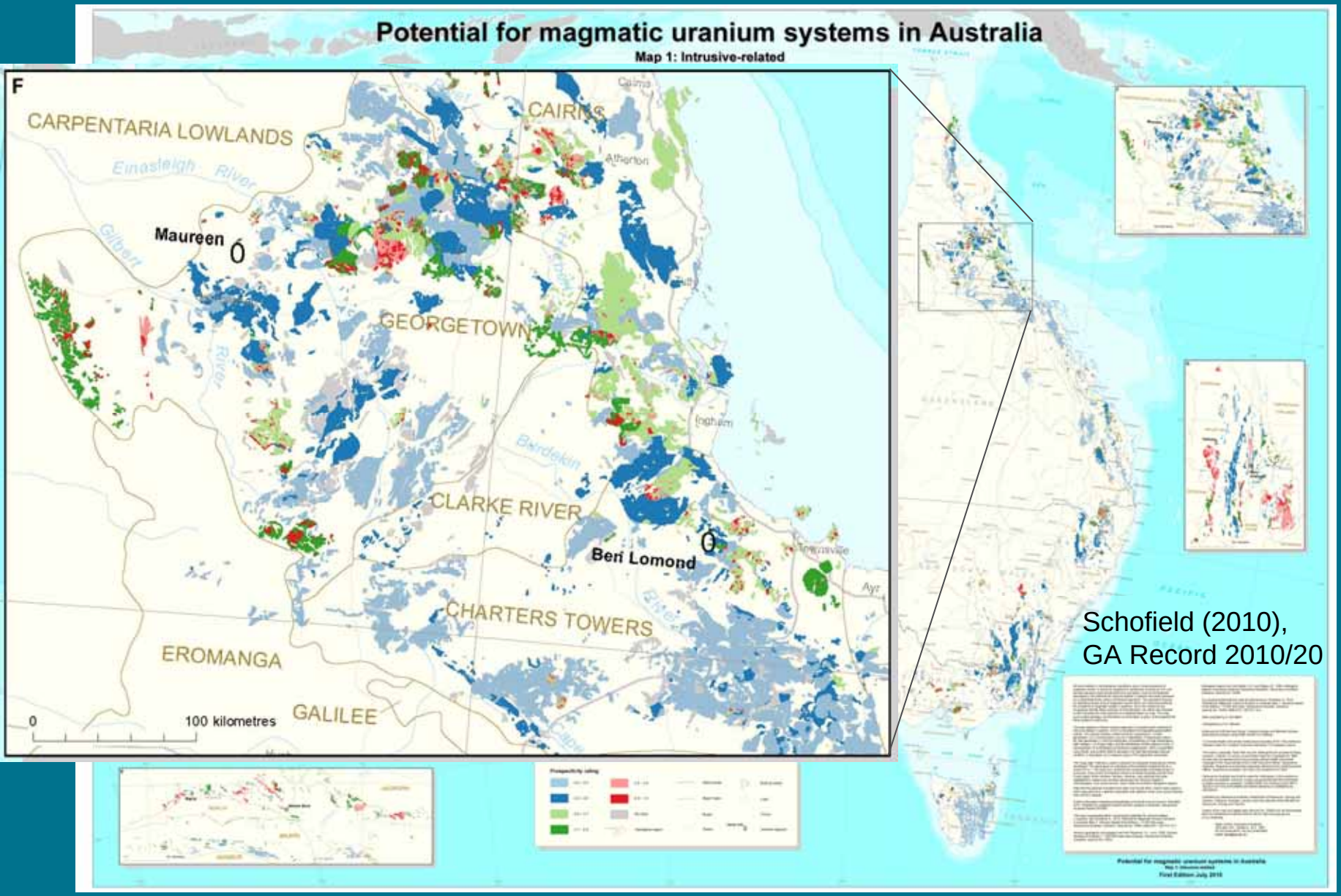
[From Skirrow (ed.) 2009, GA Record 2009/40]

Geoscience Australia studies of uranium mineral systems

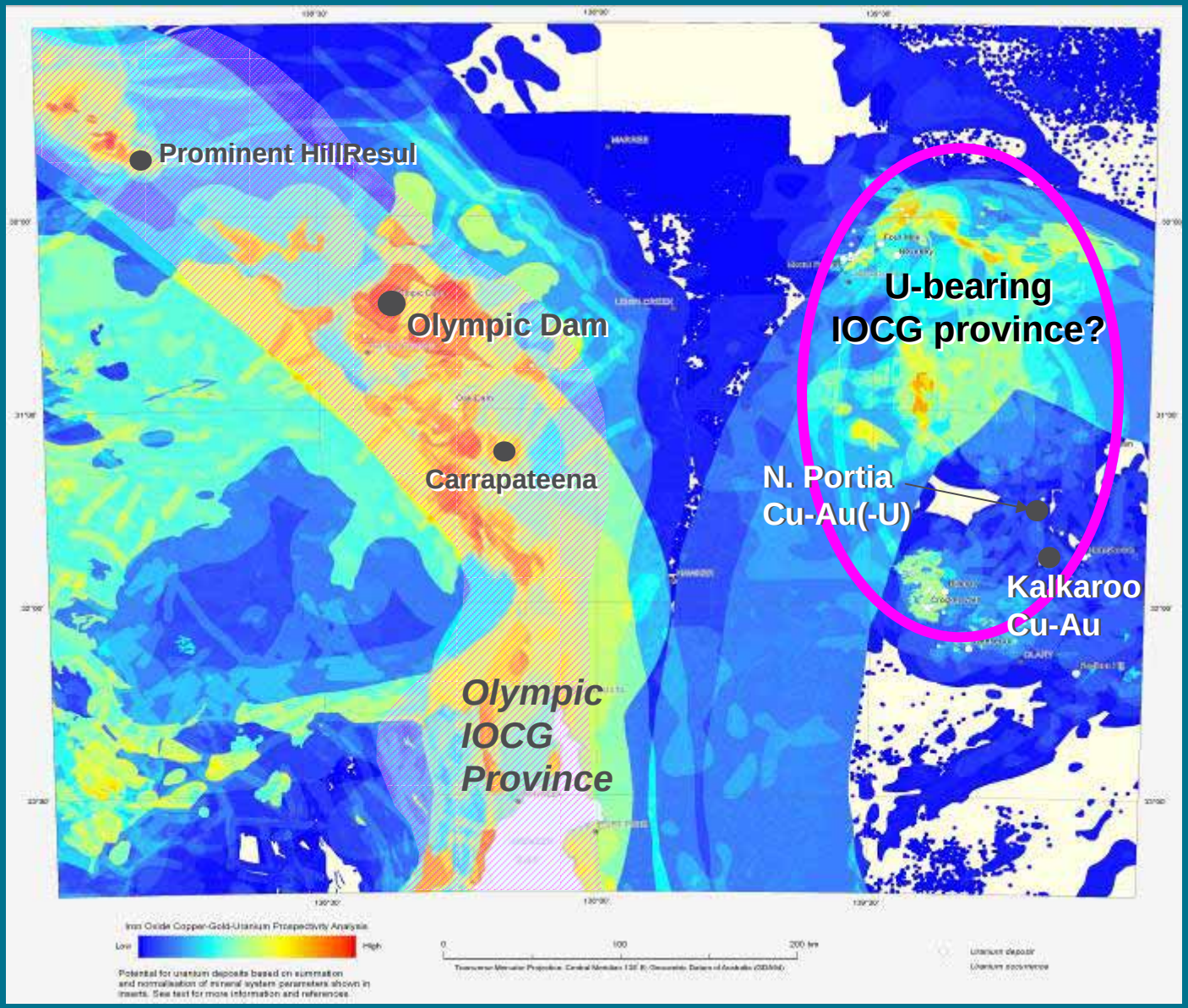


U deposits, by size

Known U resources, by tonnes in region



U-bearing IOCG prospectivity map of Gawler-Curnamona region

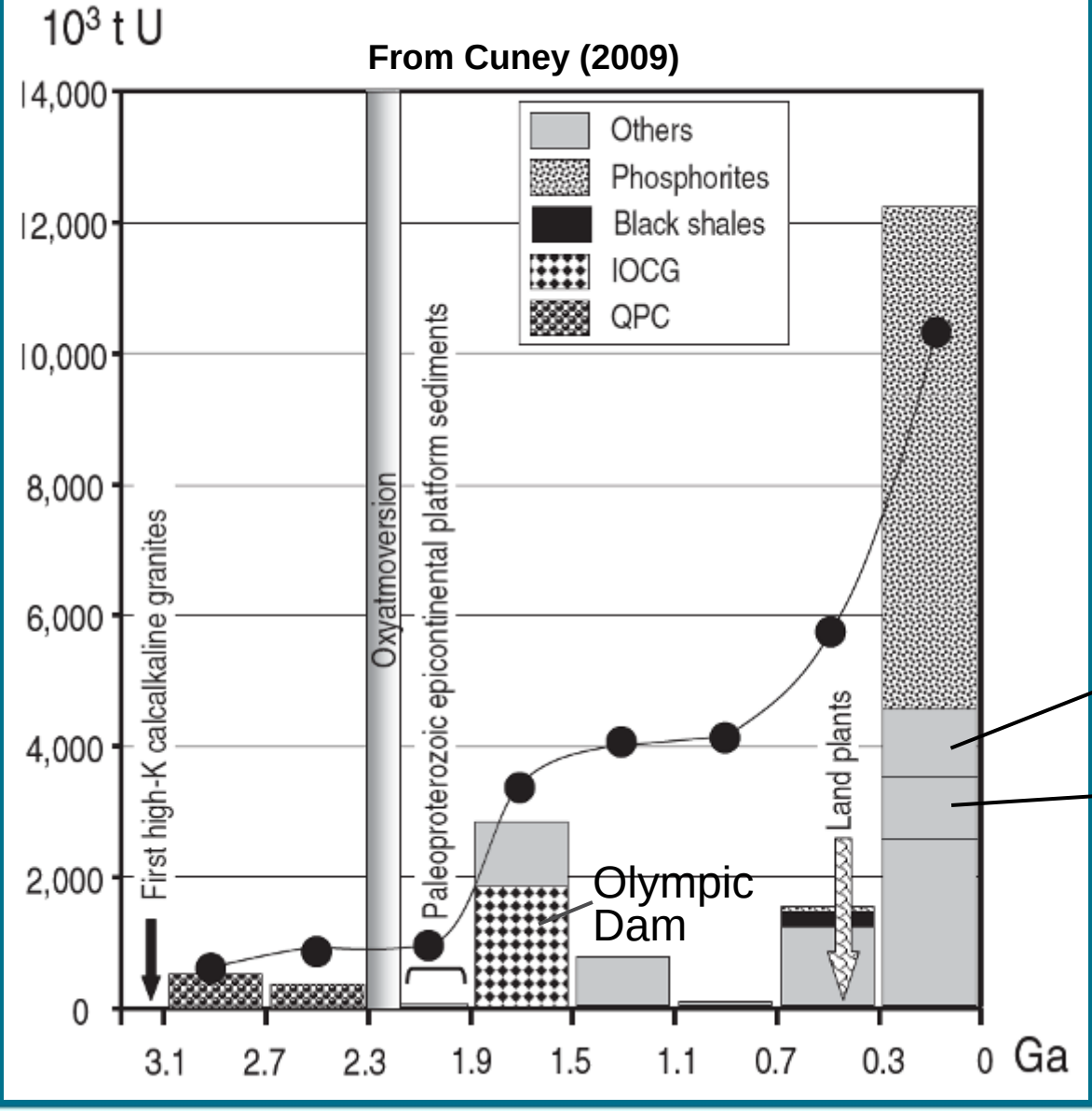


From:
An assessment of the uranium prospectivity of east central South Australia
(Huston (ed.) 2011, GA Record 2011/34)

SUMMARY

- New mineral system scheme places known deposit types into a framework based on three end-member fluids
- Shows (genetic) relationships between deposit types, and allows for ‘hybrid’ types involving more than one fluid
- Fundamental control is fluid chemistry: U is mobilised in oxidised fluids and deposited via reduction and/or pH incr.
- Australia has world’s largest resources of U, yet still has potential for discovery of giant ‘sandstone-U’, magmatic-related U, IOCG-U, and unconformity-related U

Uranium deposits through time



Does Australia host giant 'sandstone-U' and magmatic-related U deposits?

Kazakhstan 'sandstone-U'

Rössing & Streltsovka magmatic-related-U