Australian Government
Geoscience Australia

Uranium deposit types: a systems perspective

Roger Skirrow

Onshore Energy & Minerals Division
roger.skirrow@ga.gov.au

Outline

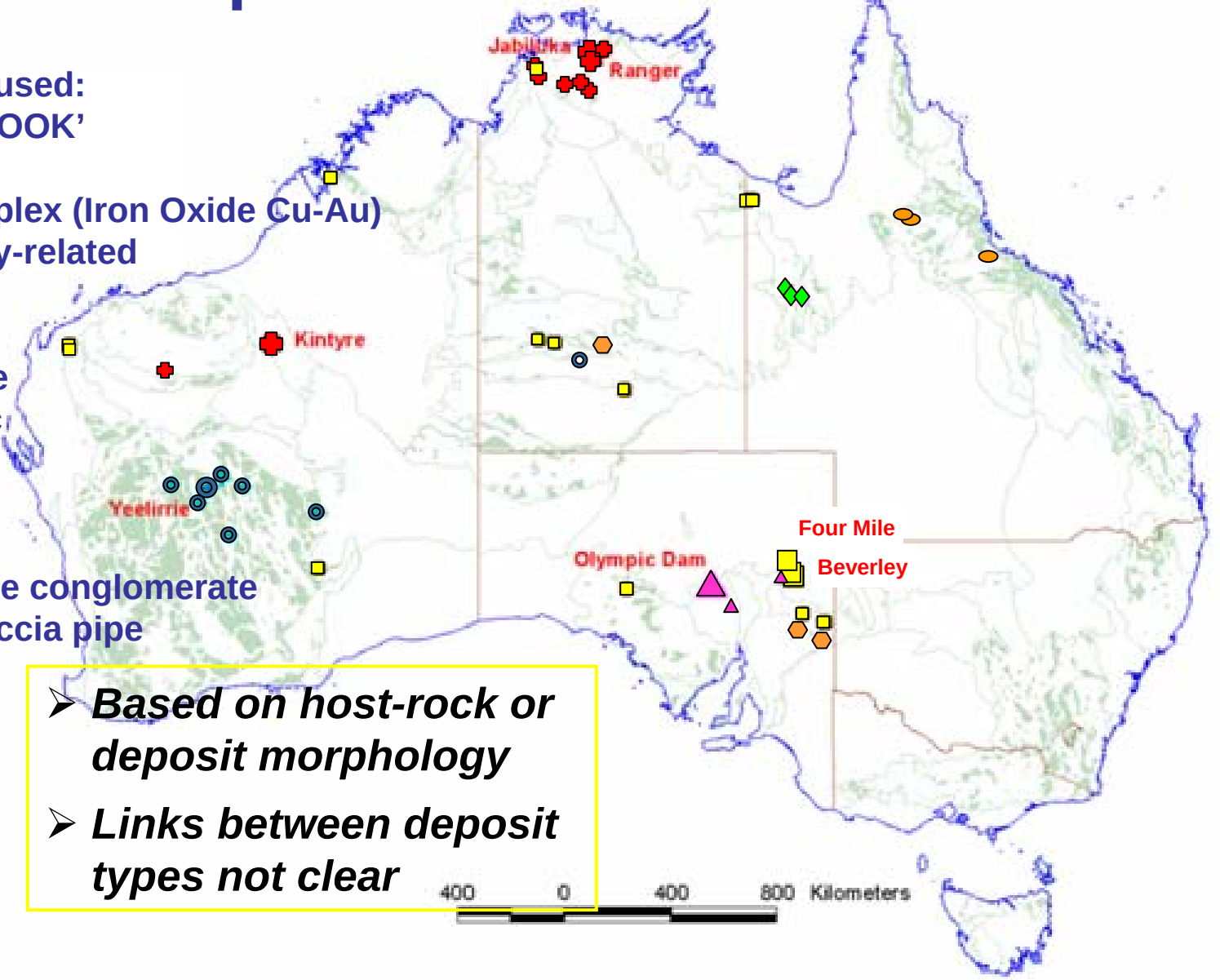
1. A new view of U deposit types: 3 families of mineral systems
2. Concepts and data for exploration targeting of uranium ore systems:
   - Magmatic-related U – we should have more!
   - Basin-related U – Australia's hidden potential

Results from Onshore Energy Security Program (OESP, 2006-2011)

Uranium deposit classification

Most widely used:
IAEA 'RED BOOK'

- Breccia complex (Iron Oxide Cu-Au)
- Unconformity-related
- Sandstone
- Surficial
- Metasomatite
- Metamorphic
- Volcanic
- Intrusive
- Vein
- Quartz-pebble conglomerate
- Collapse breccia pipe
- Phosphorite
- Lignite
- Black shale

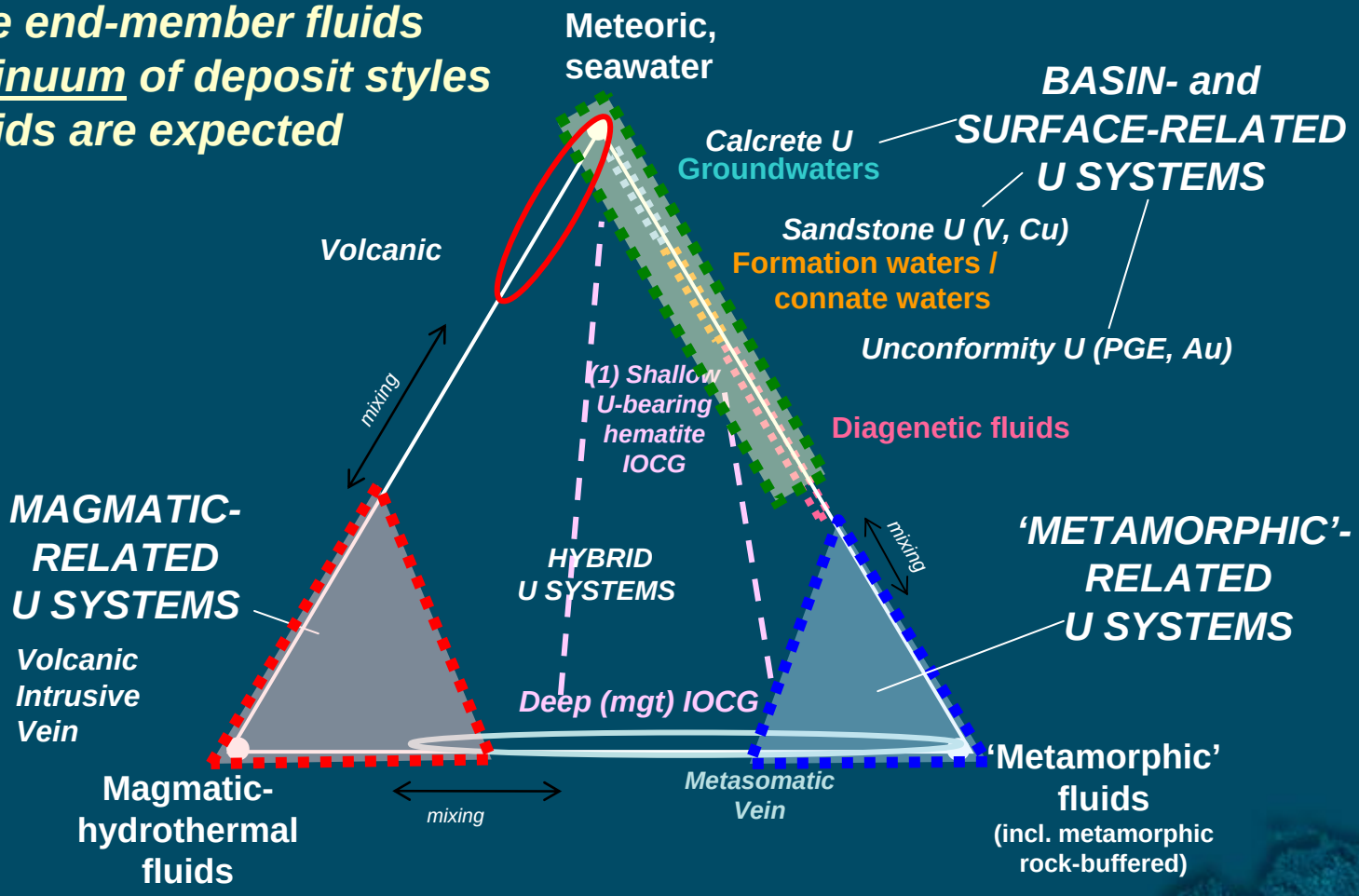


- ***Based on host-rock or deposit morphology***
- ***Links between deposit types not clear***

An alternative U deposit framework:

3 families of uranium mineral systems

- *Three end-member fluids*
- *Continuum of deposit styles*
- *Hybrids are expected*



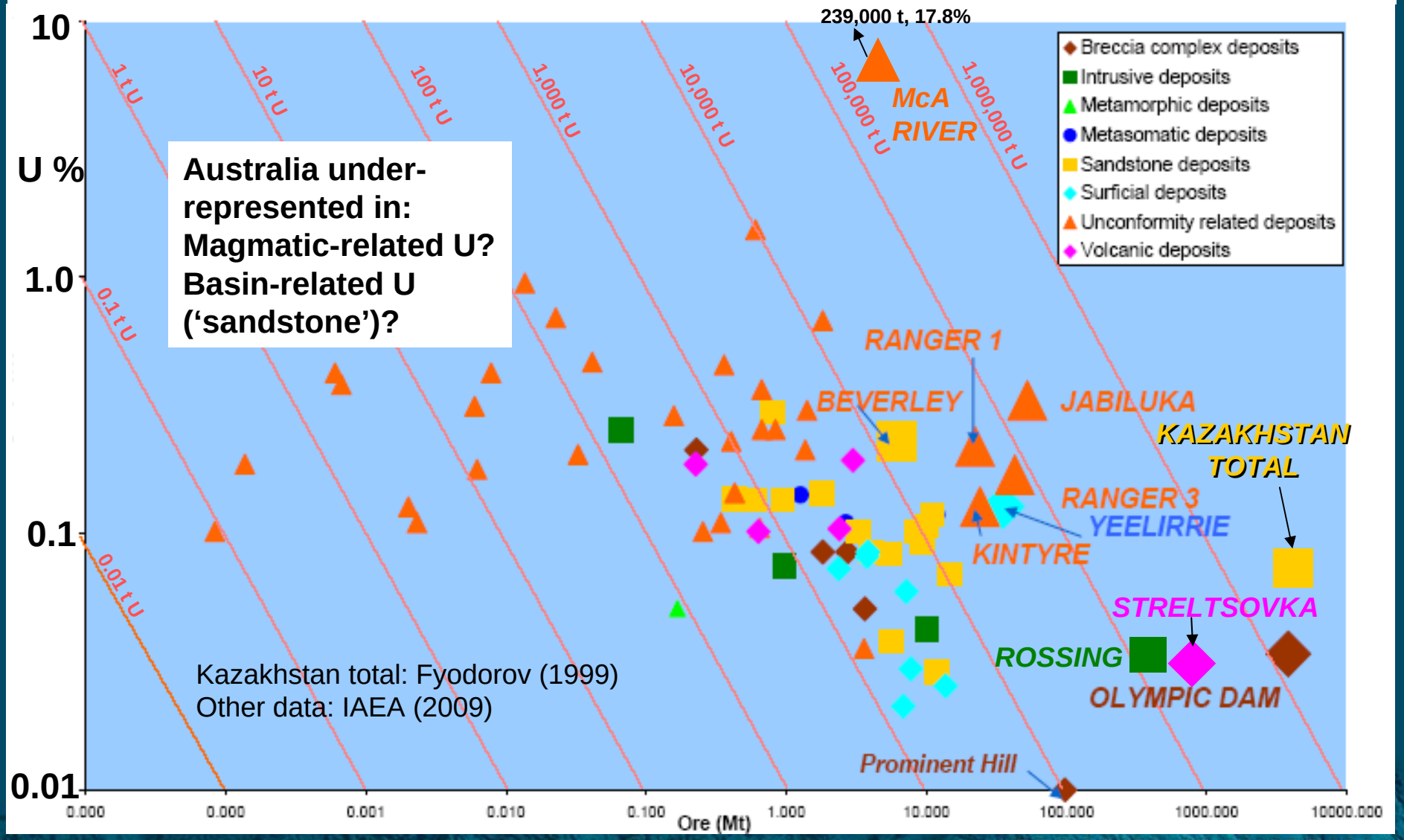
From Skirrow et al., 2009. Uranium mineral systems: Processes, exploration criteria, and a new deposit framework, Geoscience Australia Record 2009/20.

Why is this *systems* scheme important?

- Exploration for clones of ‘standard’ deposit types could overlook important variants/hybrids
- E.g. ‘Hematite breccia’ type was not a known U deposit type prior to 1975 discovery of OD
- E.g. Four Mile deposit is likely a hybrid of ‘sandstone U’ (and is higher grade than Beverley).

What and where is Aust's U potential?

Uranium grade / tonnage resources of Australian vs global deposits



Magmatic-related U systems: Key mappable criteria ('ingredients'):

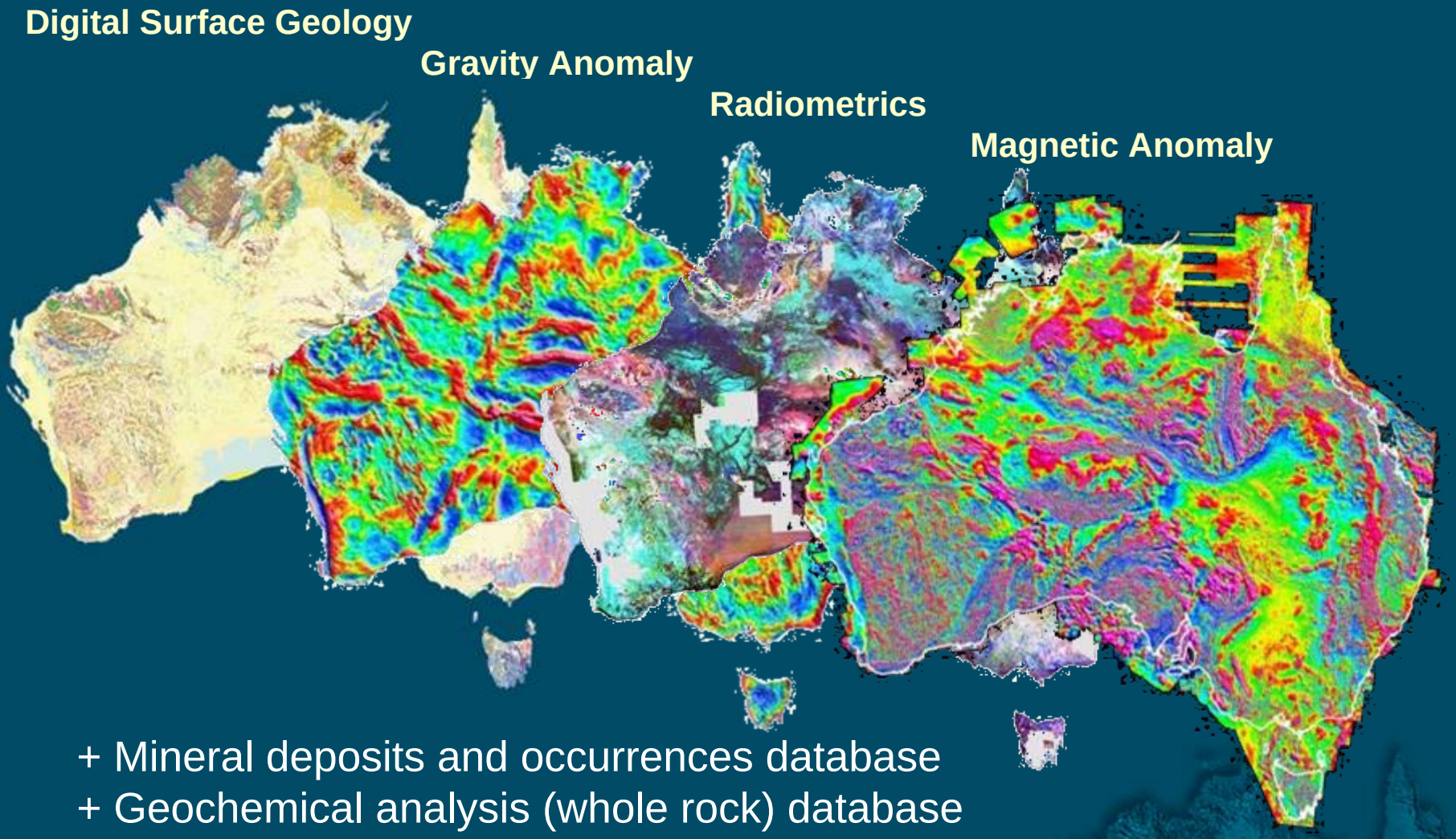
- Peralum, peralk, or A- and hi-T I-types
- Highly fractionated (Rb/Sr)
- High U solubility (peralkaline, Cl, F)
- Volcanic vs plutonic
- High U content
- Chem gradients for U deposition (pH etc)

→ 'Orthomagmatic' U systems

→ 'Magmatic-hydrothermal' U systems

→ 'Secondary' magmatic-related U systems

GA national datasets for exploration:
Magmatic U and other mineral systems



+ Mineral deposits and occurrences database
+ Geochemical analysis (whole rock) database
+ Geochronology database

Uranium content of igneous rocks of Australia

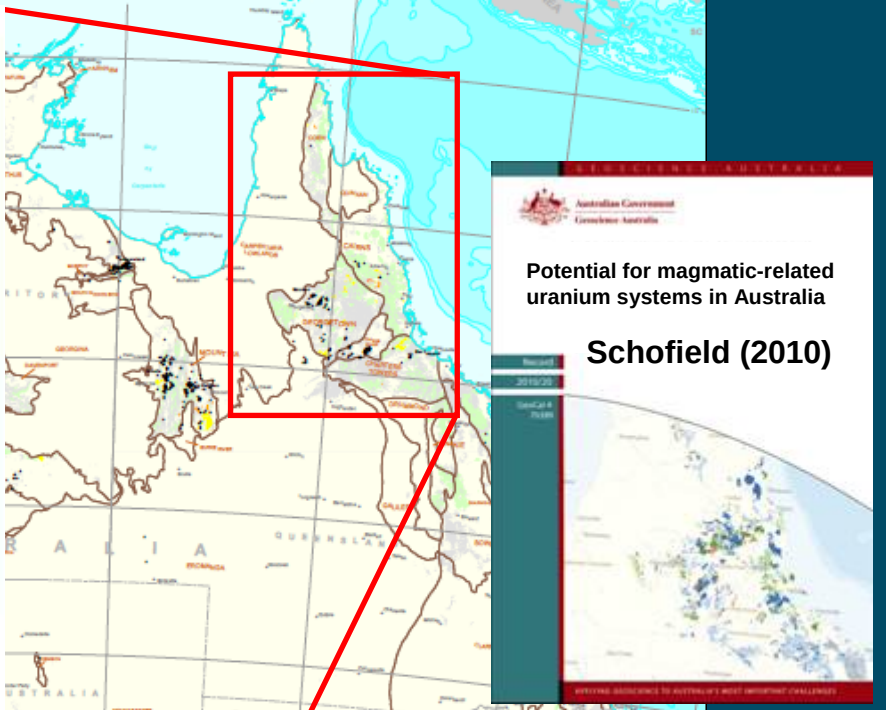
Map 2. Average uranium abundance: surface geology

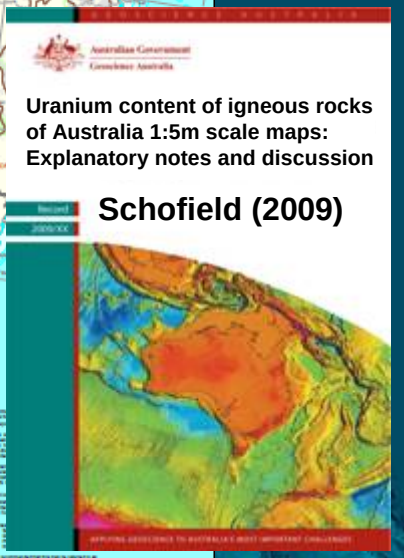
Magmatic-related uranium

Prospectivity

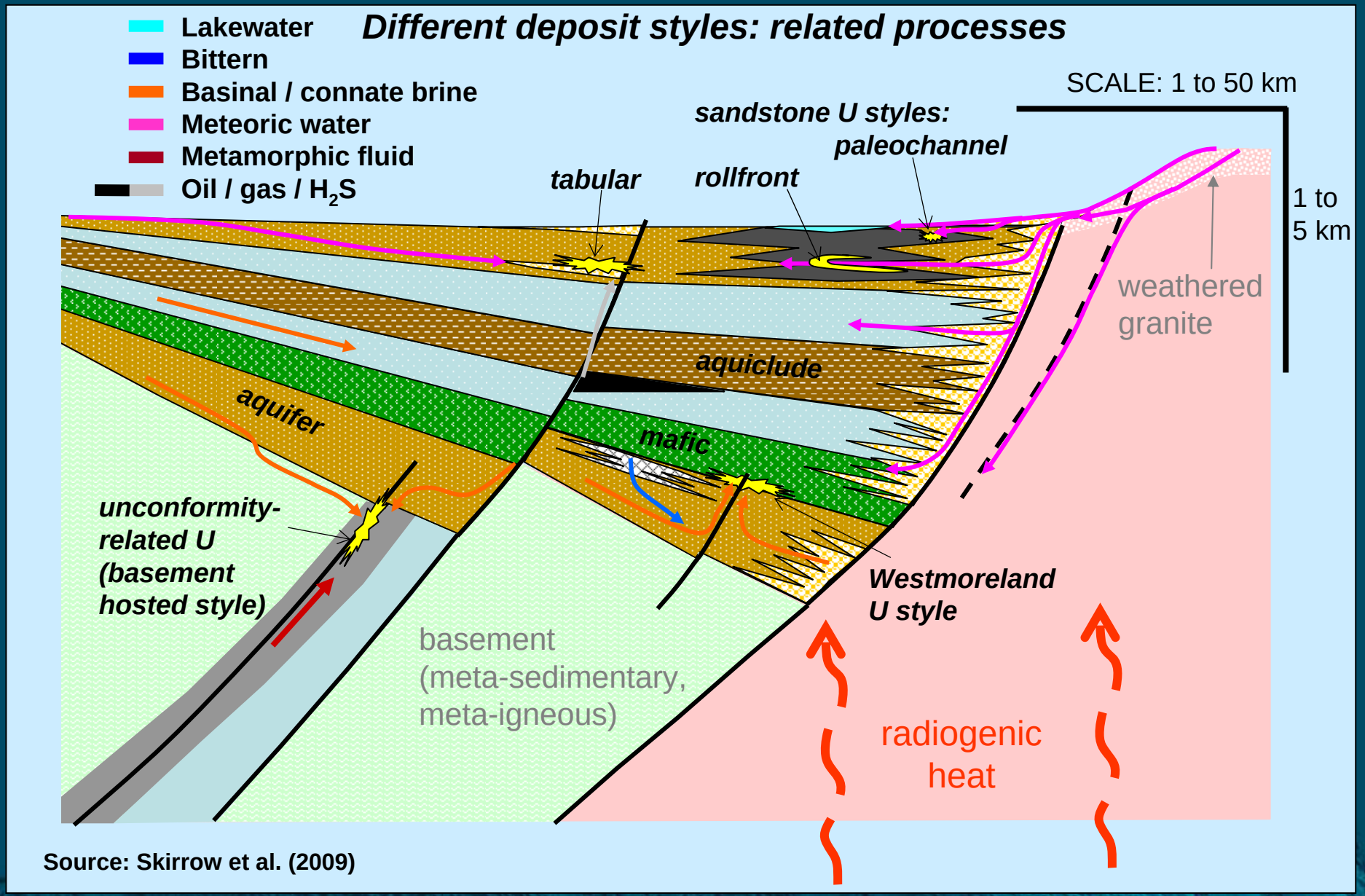
- <0.5
- 0.5 - 0.6
- 0.6 - 0.7
- 0.7 - 0.8
- 0.8 - 0.9
- 0.9 - 1.0
- non-felsic
- No data

Weipa
COEN
Kowanyama
QUINKAN
Cooktown
Mossman
CAIRNS
Cairns
Atherton
Georgetown
GEORGETOWN
CLARKE RIVER
Townsville
CHARTERS TOWERS
Julia Creek

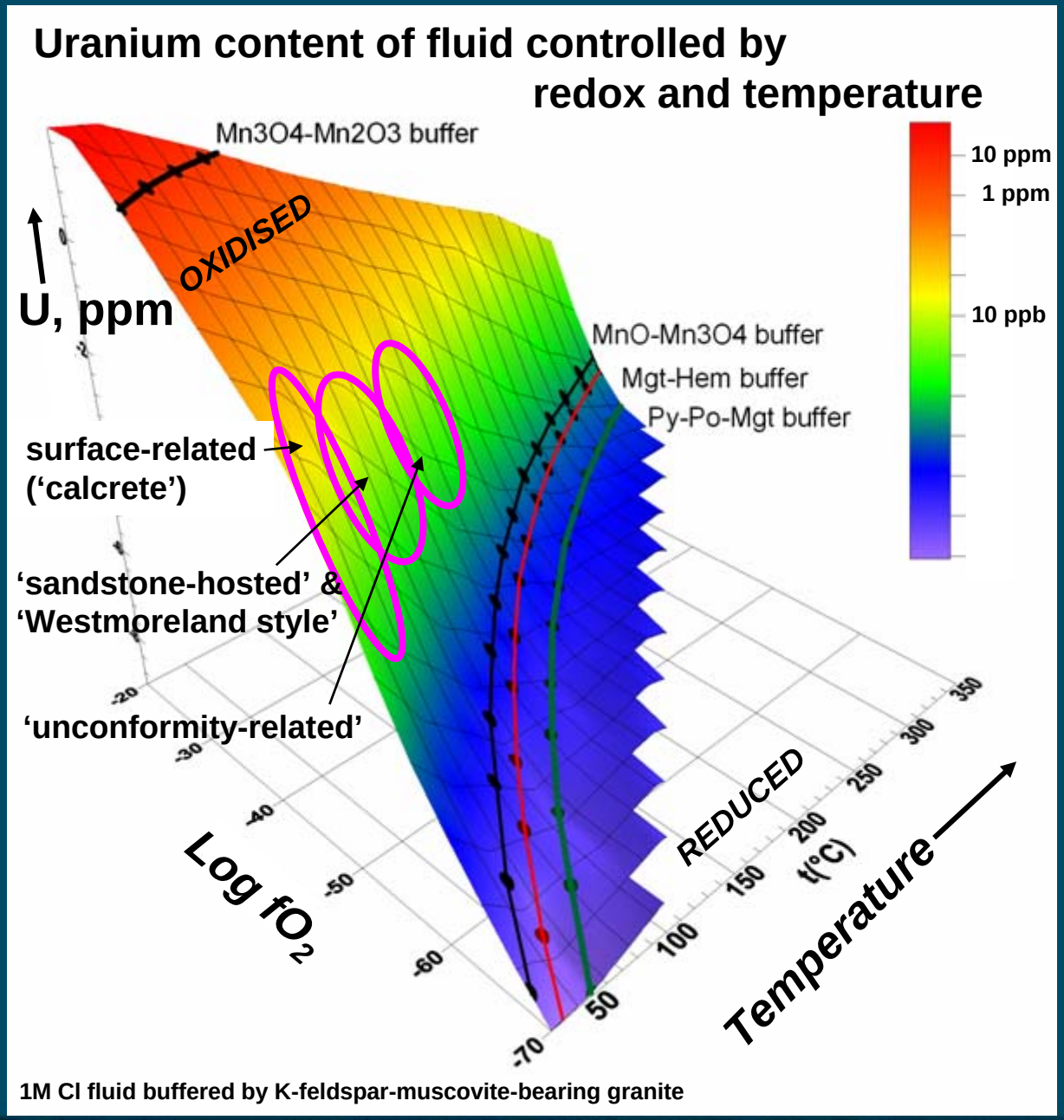




Basin-related uranium systems



Source: Skirrow et al. (2009)



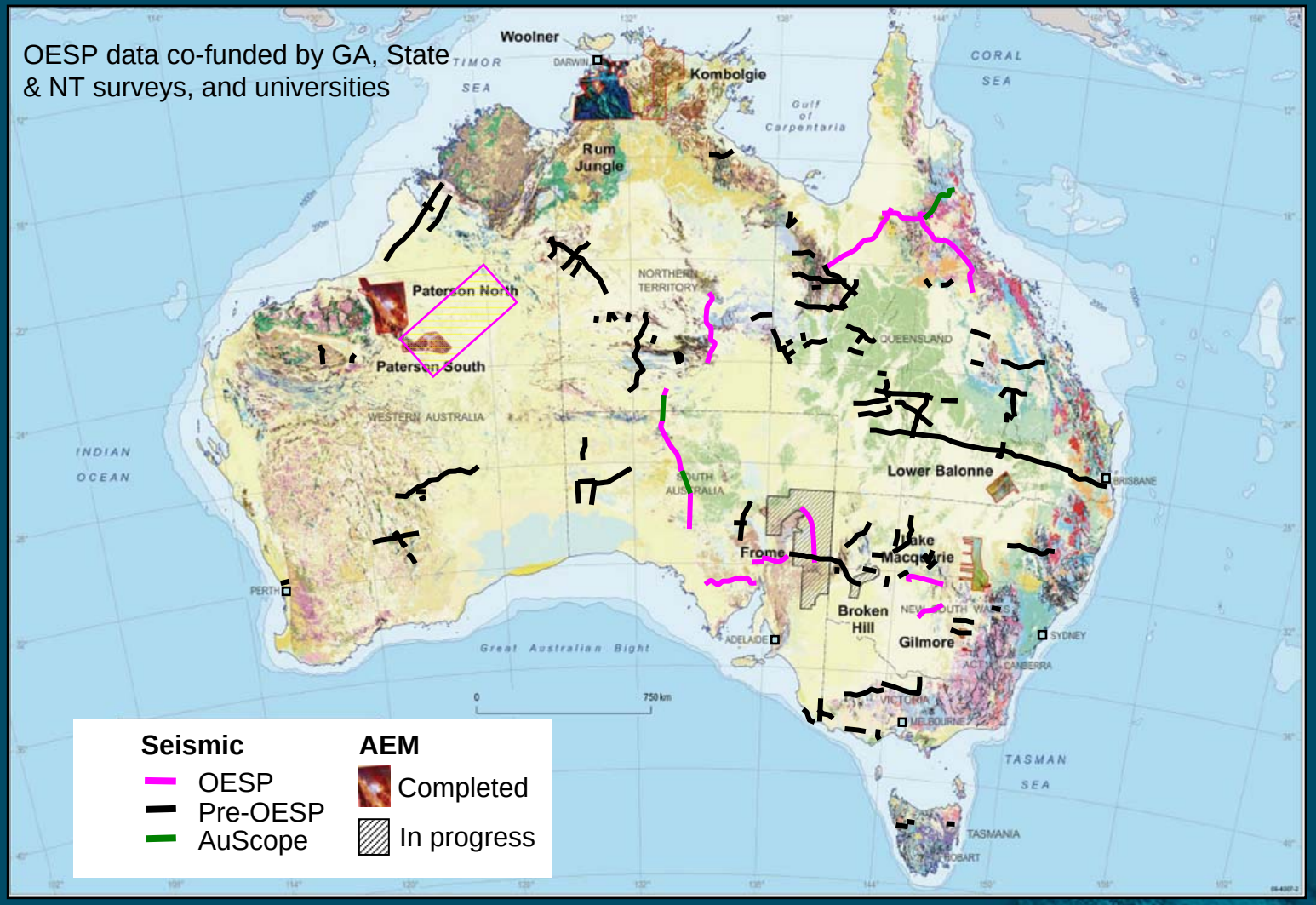
BASIN- AND SURFACE-RELATED U SYSTEMS

- Continuum of fluid characteristics
- All involve highly oxidised fluids
- U depositional conditions differ but reduction is key in most systems

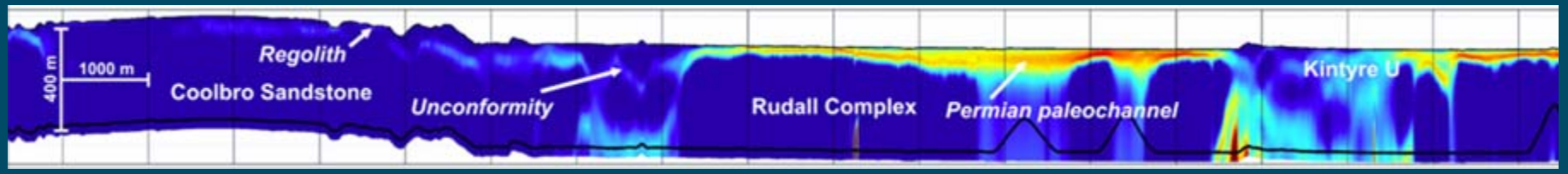
Source: Bastrakov et al. (in press) and Skirrow et al. (2009)

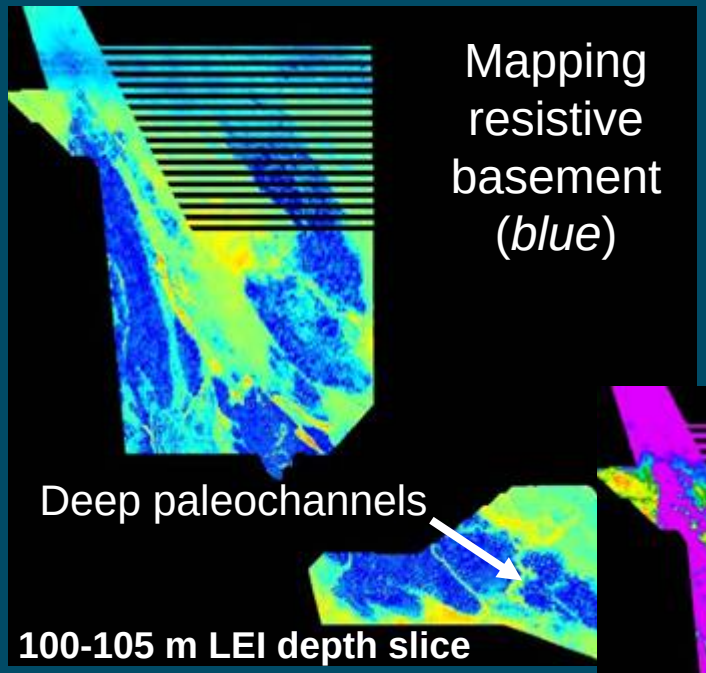
GA datasets for basin-related U exploration:

National datasets + regional seismic, AEM & 3D data



Examples from Paterson AEM survey, WA



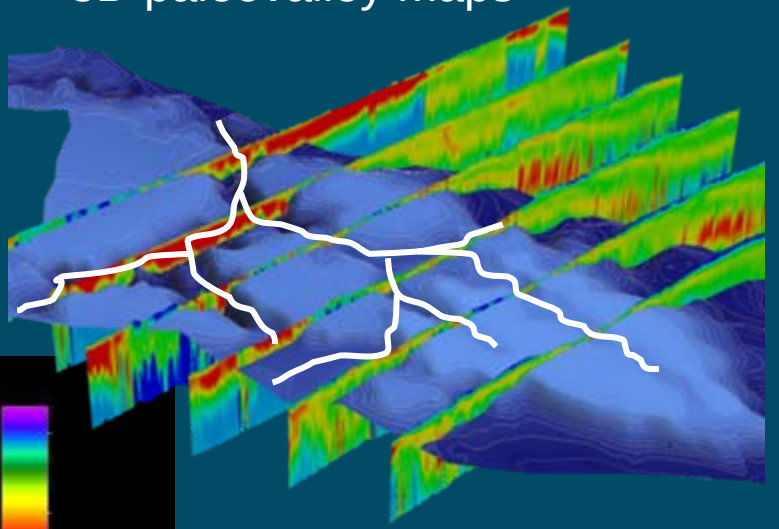


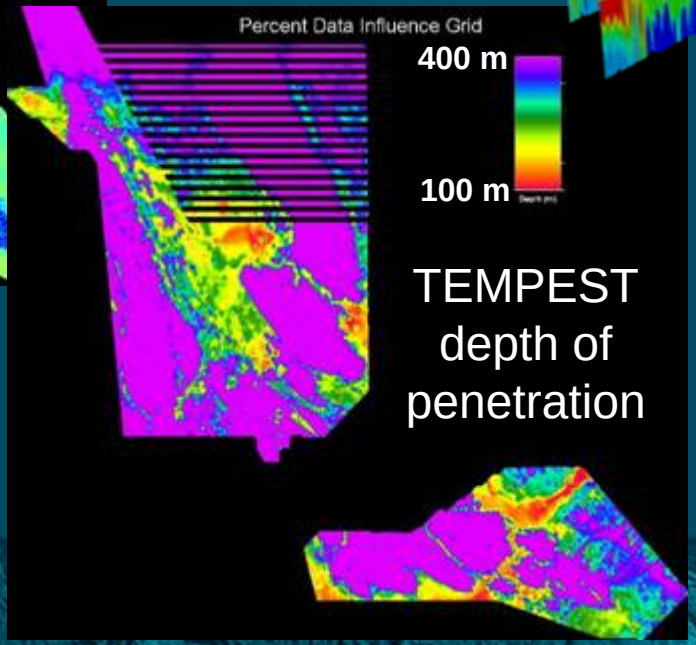
Mapping resistive basement (*blue*)

Deep paleochannels

100-105 m LEI depth slice

3D paleovalley maps



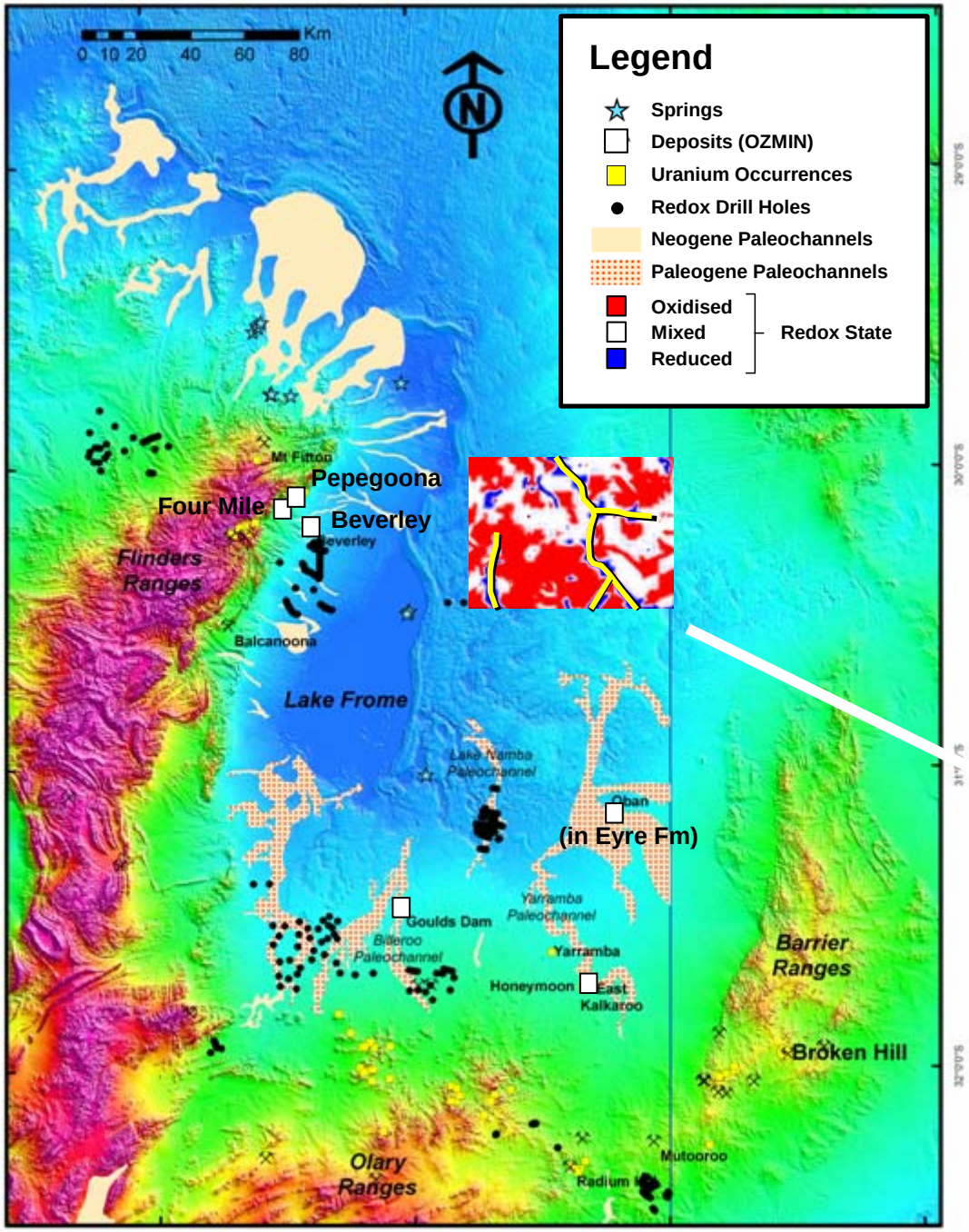


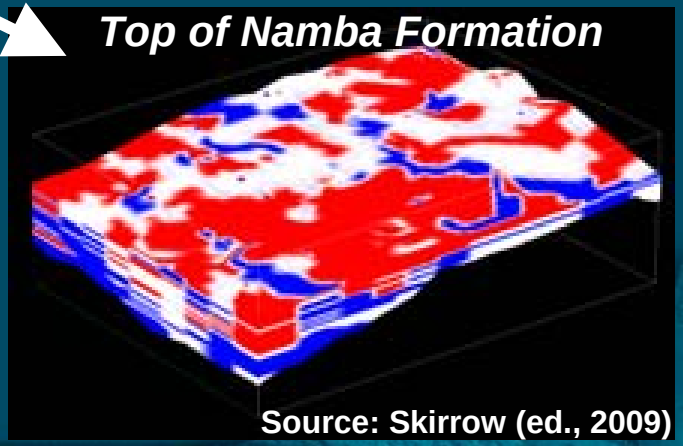
TEMPEST depth of penetration

Source: Williams et al. (in press)

Lake Frome region, SA:
Paleochannel and redox mapping in 3D beneath cover

- Drill hole logs interrogated
- Reduced zones = Fe^{2+} minerals, reduced-C, reduced-S, “black”, etc
- Oxidised zones = Fe^{3+} minerals, “red”, etc
- Gridded in 3D
- North-south paleovalleys in Namba Fm as well as Eyre Fm?





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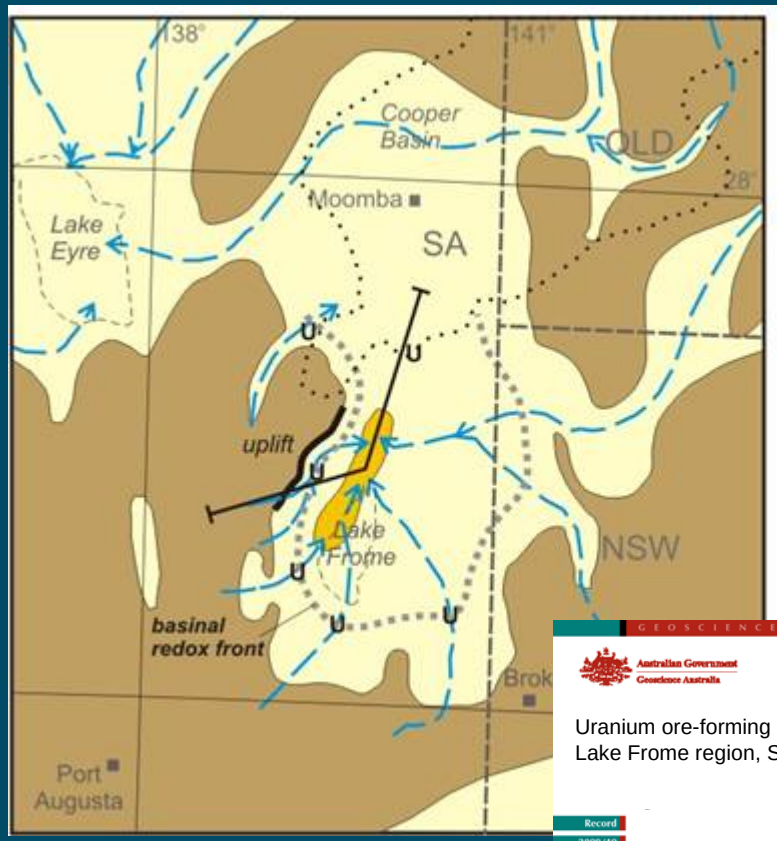
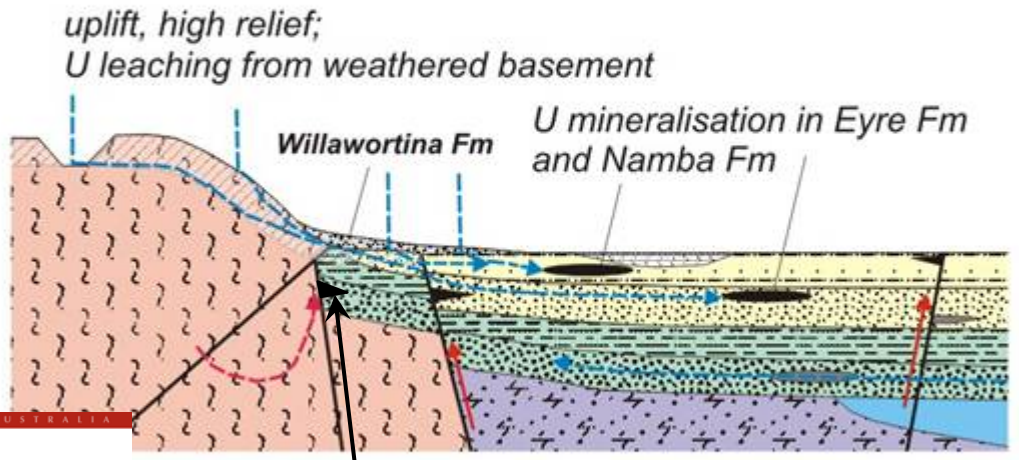
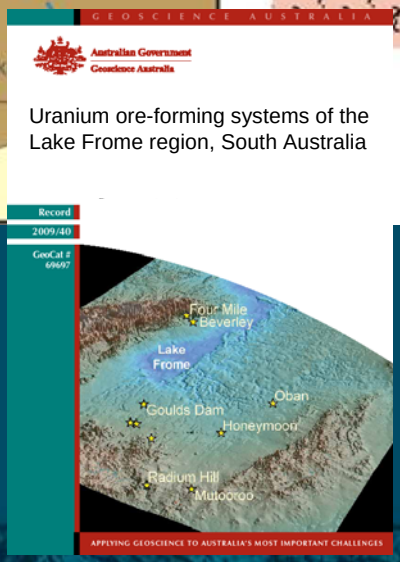
FROME URANIUM PROVINCE EVOLUTION: 3 potential U systems since Mesozoic



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

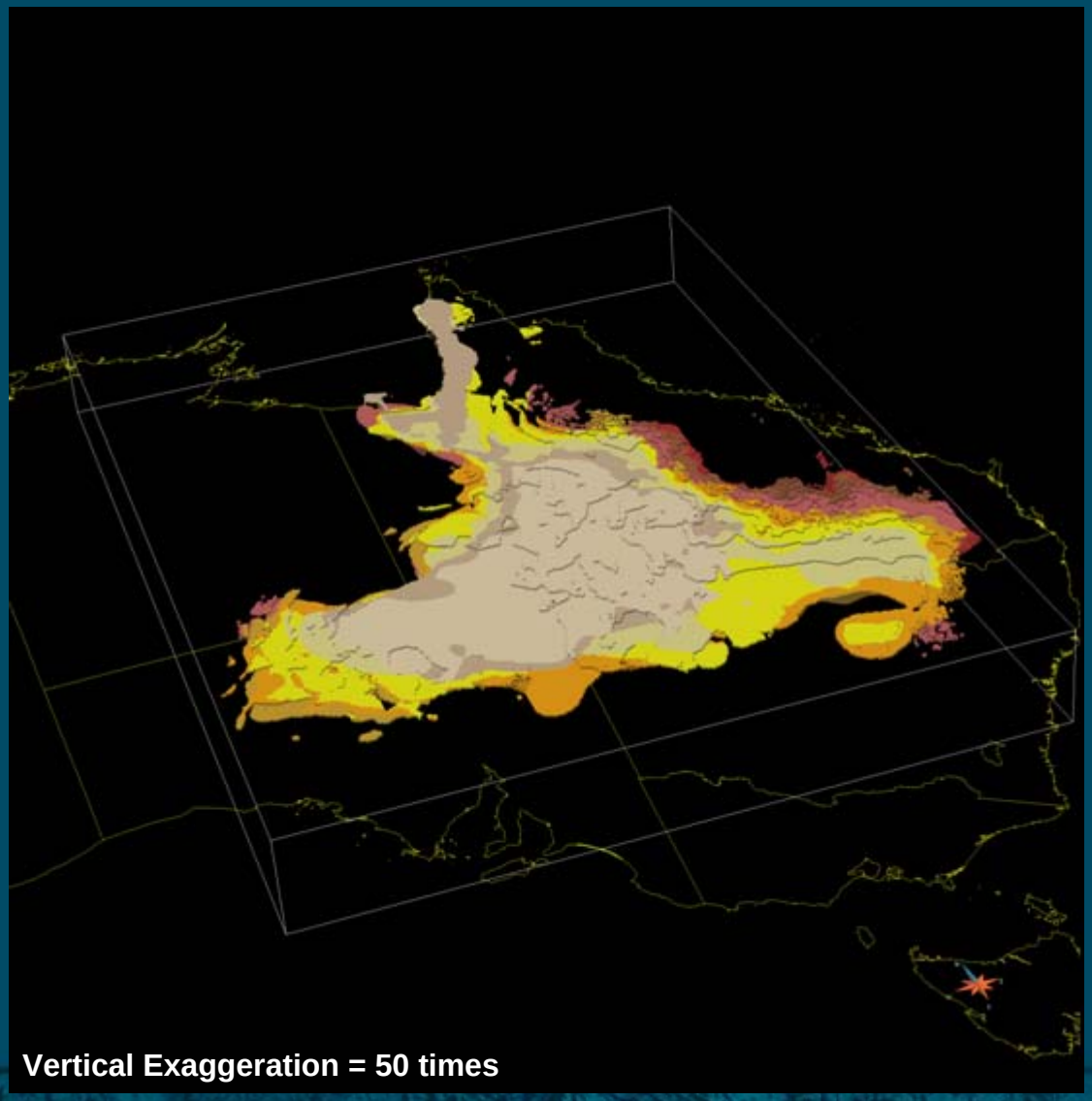


From Skirrow (ed., 2009)



Probable hybrid U deposit style (Four Mile)

Eromanga Basin 3D model



Vertical Exaggeration = 50 times

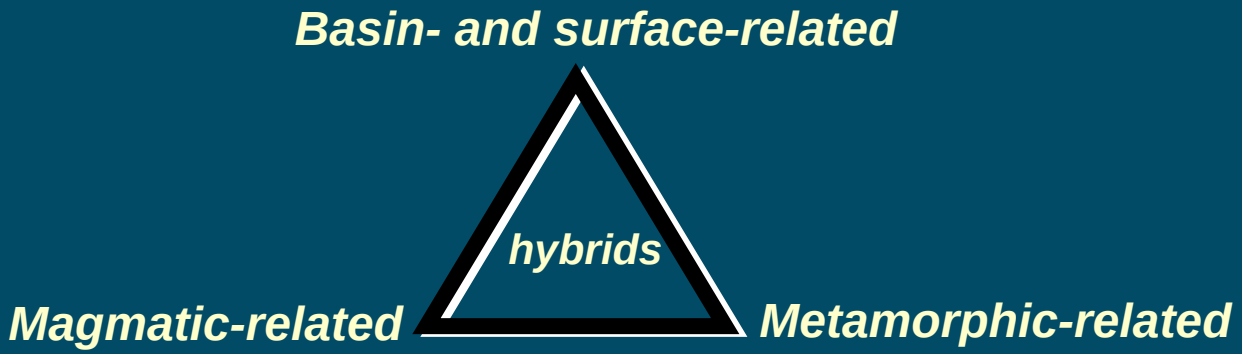
A framework for uranium & geothermal exploration, and groundwater studies

Mesozoic stratigraphic units displayed from old to young, as 3D voxet model.

Source: van der Wielen et al. (2009 & in press)

Conclusions

- **3 families of U mineral systems in ternary scheme, based on fundamental fluid types and settings:**



- **GA (+State/NT) OESP datasets and new concepts available for U targeting & exploration**
- **Australia has the right geology for discovery of giant basin-related and magmatic-related U deposits**

Acknowledgements

Geoscience Australia:
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