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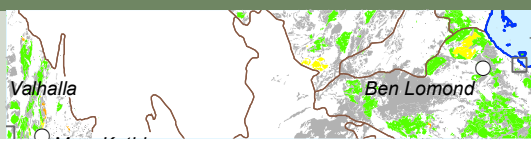
# New views of Australia's uranium mineral systems

## *Recent releases will assist uranium explorers in area selection*



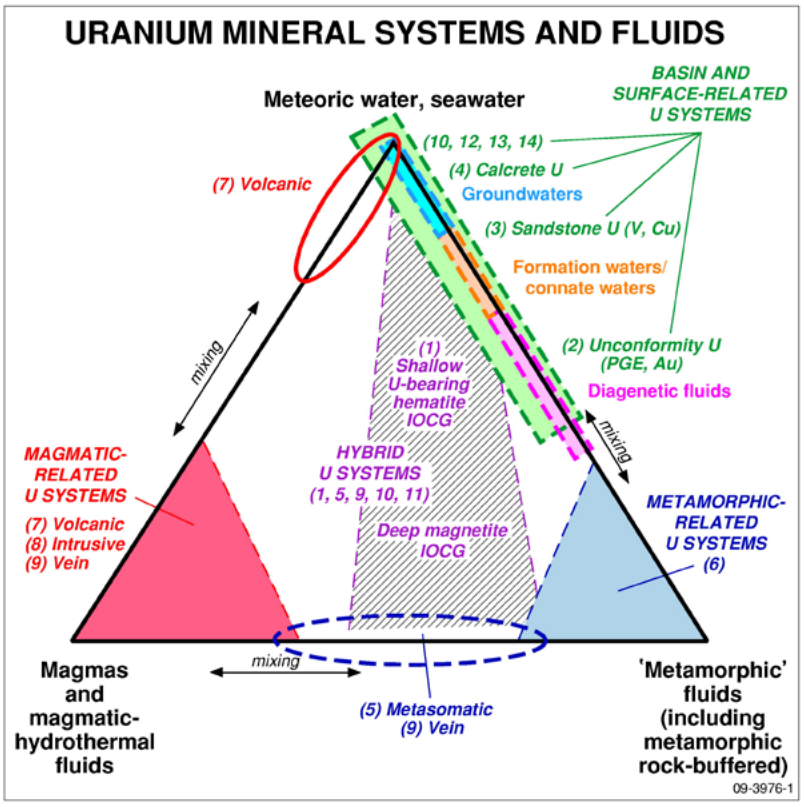

*Roger G. Skirrow*

Geoscience Australia's Onshore Energy Security Program is delivering pre-competitive data to boost investment in exploration for onshore energy resources such as petroleum, uranium, thorium and geothermal energy. As part of this Program, Geoscience Australia has recently released two reports and a series of maps which will support uranium explorers in area selection at the continental and regional scales.

## Uranium mineral systems

Australia holds the world's largest identified resources of uranium recoverable at low cost, with uranium mining constituting an important and growing part of the nation's mineral export industry.

The key geological and geochemical processes controlling where and how uranium mineralisation occurs in Australia and globally are examined in *Uranium mineral systems: processes, exploration criteria and a new deposit framework* (Geoscience Australia Record 2009/20).




This report provides a revised conceptual framework for a fresh assessment of Australia's uranium mineral potential as well as key exploration criteria of practical value. It outlines generalised models for families of uranium mineral systems, with shared characteristics, based on an understanding of the fundamental processes in uranium mineral systems and descriptions of well-documented ore systems.

The new classification framework in *Uranium mineral systems* outlines three families of uranium mineral systems: magmatic-related, metamorphic-

**Figure 1.** Schema showing the three families of uranium mineralising systems and the three end-member fluid types. A continuum of deposit styles may exist between these end-members, represented by hybrid styles of uranium mineralisation such as iron oxide-copper-gold-uranium (IOCGU) deposits. Uranium deposit types from the IAEA Red Book classification are numbered in order of economic importance to Australia (McKay and Miezitis 2001): 1) breccia complex (IOCGU); 2) unconformity-related; 3) sandstone; 4) surficial (including calcrete); 5) metasomatite; 6) metamorphic; 7) volcanic; 8) intrusive; 9) vein; 10) quartz-pebble conglomerate; 11) collapse breccia pipe; 12) phosphorite; 13) lignite; 14) black shale.

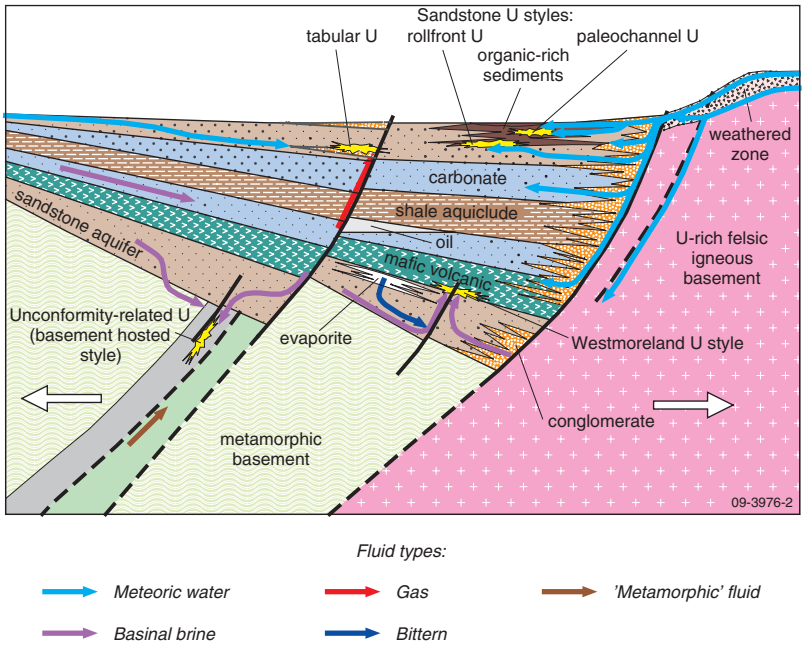



**Figure 2.** Basin-related uranium mineral systems, for a hypothetical basin, during extension or sag phase.

related, and basin- and surface-related (figure 1). Each family is related to one of three fundamentally different types of crustal fluid (magmatic-hydrothermal, metamorphic and surface-derived, such as rain, seawater). The families of mineral systems contain a range of uranium deposit styles, most of which are familiar to exploration geoscientists. Basin-related mineral systems, for example, contain the variants of 'sandstone-hosted' deposits ('roll-front', 'tabular', 'paleochannel' etc), as well as the so-called 'Westmoreland' style and 'unconformity-related' styles (figure 2). This new process-based framework can accommodate the 14 deposit types in the well known classification of the International Atomic Energy Agency's biannual 'Red Book', which are based mainly on host rock type. The inter-relationships between deposit types are emphasised rather than the differences. Indeed, the tripartite framework explicitly includes hybrid deposit types, and predicts a continuum of deposit styles between end-member types. The giant Olympic Dam iron oxide-copper-gold-uranium (IOCGU) deposit, which holds the world's largest single resource of uranium, is viewed as a hybrid type of deposit. This is because its formation involved fluids of both deep-sourced origin (magmatic-hydrothermal and/or metamorphic rock-reacted fluids) and surface-derived origin. The latter fluid most probably leached uranium from felsic igneous host rocks.

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## Uranium content and potential of igneous rocks

Geoscience Australia is currently undertaking a range of studies of uranium mineral potential at national scale and in selected regions, applying the mineral systems-based approach outlined above in combination with empirical data. One of these studies is reported in the recently released *Uranium content of igneous rocks of Australia 1:5 000 000 maps: Explanatory notes and discussion* (Geoscience Australia Record 2009/17) which describes and discusses the data presented in an accompanying series of three 1:5 million scale maps of Australia. The maps use whole-rock geochemical data compiled from Geoscience Australia's OZCHEM database, supplemented by data from relevant state and territory geoscience agencies. Map 1 shows the uranium concentrations of igneous rock samples plotted on igneous rock polygons from Geoscience Australia's new 1:1 million scale *Surface Geology of Australia* dataset. Map 2 shows the average uranium content of each surface geology polygon, which is calculated from geochemical data points

occurring within each polygon. Map 3 uses a similar methodology, but shows average uranium contents for solid geology polygons. This map is expected to be particularly useful in assessing those large areas of the continent where igneous rocks are concealed beneath a cover of sediment or regolith.

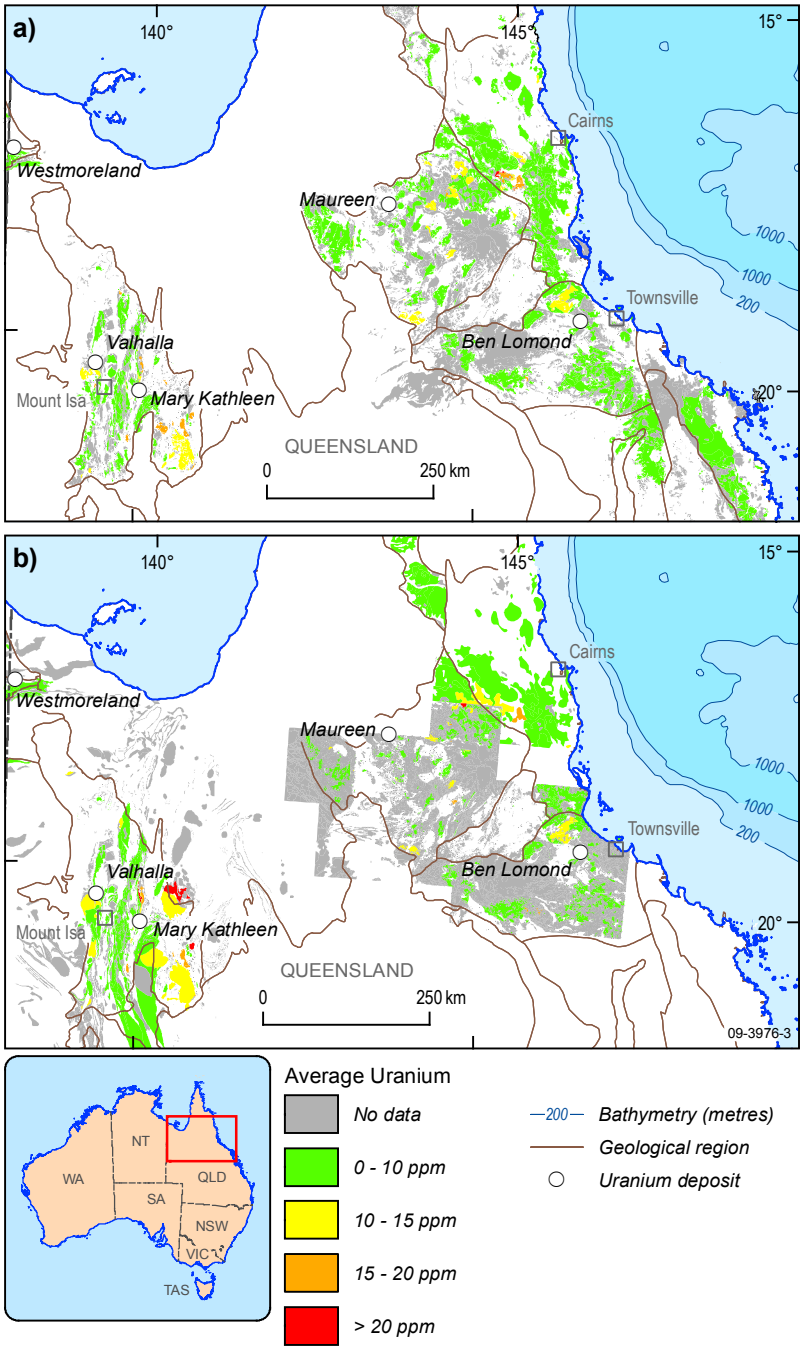


**Figure 3.** Average uranium content of igneous rocks from northern Queensland. The top image shows the average uranium content of igneous rocks occurring at the surface. The bottom image shows the average uranium content of igneous rocks extracted from solid geology, providing constraints on the distribution of uranium-rich igneous rocks under cover. The compilations show high levels of uranium associated with felsic igneous rocks in the area around Mount Isa and eastern north Queensland.

As outlined in *Uranium content of igneous rocks of Australia*, Geoscience Australia is applying an understanding of how uranium is concentrated during magmatic processes, combined with the empirical geochemical data, to help identify areas with high potential for magmatic-related uranium mineralisation (including magmatic-hydrothermal systems). Australia appears to lack major resources of magmatic-related uranium mineralisation, despite the abundance of uranium-rich igneous rocks. Some of the largest uranium deposits globally, such as the giant Rössing deposit in Namibia, are associated directly with magmatic processes. Consequently this type of deposit has been targeted for study. Preliminary assessment of the uranium potential of north Queensland, the focus of another recent Onshore Energy Security Program activity, has identified a number of areas with a favourable combination of characteristics for magmatic-related uranium mineralisation. Follow-up fieldwork is planned to ground-truth the initial results. Similar assessments elsewhere in Australia will be undertaken to build a continental-scale map depicting the potential for magmatic-related uranium mineralisation.

## Uranium mineral occurrences update

Geoscience Australia's MINLOC database holds basic information on mineral occurrences in Australia, including uranium. This database has recently been updated with more than 300 newly documented uranium occurrences with significant additions for Western Australia and the Northern Territory. These data, along with other national datasets, such as the *1:1 million Surface Geology of Australia* and the recently-released *Radiometric Map of Australia*, are fundamental to uranium exploration efforts and to Geoscience Australia's assessments of uranium potential.

## Basin-related uranium systems

Globally, some of the largest resources of uranium are hosted by sandstones and other clastic units in basins of Tertiary or Mesozoic age, for example, in Kazakhstan. Increased production from a number of giant deposits has recently elevated Kazakhstan to the world's second largest producer after Canada and ahead of Australia. Although Australia has several significant deposits of this type, including the recently discovered Four Mile deposit in South Australia, no giant deposits have yet been discovered despite apparently favourable characteristics in a number of basins.

Consequently, Geoscience Australia is generating 3D models of selected basins with high potential, including 3D maps of those geological, geochemical and hydrological components that are considered to be critical in the formation of basin-related uranium mineralisation. As a result, structural architecture and spatial variations in the oxidation-reduction potential of the sedimentary rocks and basin fluids are being mapped in 3D. Insights on the location of possible mineralisation are being gained from numerical modelling of fluid flow and ore-forming chemical reactions. It is planned to report regularly on the results over the next 12 months through the Geoscience Australia website (see Related websites/articles).

### For more information

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### References

McKay AD & Miezitis Y. 2001. Australia's uranium resources, geology and development of deposits. AGSO-Geoscience Australia. Available at: www.ga.gov.au/image_cache/GA9508.pdf

### Related articles/websites

Geoscience Australia's Uranium Systems Project

www.ga.gov.au/minerals/research/national/uranium/index.jsp

Uranium mineral systems: processes, exploration criteria, and a new deposit framework (Geoscience Australia Record 2009/20)

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=69124

Uranium content of igneous rocks of Australia (Geoscience Australia Record 2009/17)

www.ga.gov.au/products/servlet/controller?event=GEOCAT_DETAILS&catno=68762

Surface Geology of Australia 1:1 000 000 scale

www.ga.gov.au/minerals/research/national/nat_maps/nat_geol_maps.jsp

Radiometric Map of Australia

www.ga.gov.au/minerals/research/national/radiometric/

MINLOC database (mineral occurrences in Australia)

www.australianminesatlas.gov.au/?site=atlas&tool=search

*AusGeo News 89*: Association of large sandstone uranium deposits with hydrocarbons

www.ga.gov.au/ausgeonews/ausgeonews200803/uranium.jsp