Uranium mineralization in Western Australia

by

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Western Australia is well endowed with uranium mineralization, with total known resources of 188 000 t of contained U_3O_8 in 28 projects (Table 1). Uranium deposits and prospects are scattered throughout the State, in a variety of mineralization styles. The significant styles are: calcrete-hosted, such as at Yeelirrie, Lake Way, Centipede, Thatcher Soak, and Lake Maitland; unconformity-associated, such as Kintyre; roll-front-related or sandstone-hosted, such as at Manyingee, Oobagooma, and possibly Mulga Rock; and carbonatite-hosted, such as at Cummins Range. Styles of lesser importance are pegmatite-hosted, and vein- and conglomerate-hosted deposits.

Calcrete-hosted uranium is the dominant type of uranium mineralization in Western Australia. The term 'calcrete' is used for limestone deposits associated with valley-fill sediments in ancient valleys and existing trunk-drainage systems. Calcrete occurrences are concentrated in the northeast of the Yilgarn Craton, north of the so-called 'Menzies line', which is a line of separation between groundwaters of different compositions. North of the line the groundwater is typically neutral to alkaline and less saline than groundwater south of the line. The calcrete has been eroded west of the 'Meckering line' (Fig. 1) due to rejuvenated south- and west-flowing river systems (Butt et al., 1977).

Uranium enrichment takes place at the final stage of calcrete formation from the precipitation of carnotite, with occurrences generally restricted to areas of granitic bedrock containing high background levels of uranium ('hot' granites). North of about latitude 30°S, but south of the 'Menzies line', carnotite mineralization is present within playa lakes without the development of calcrete.

Three types of calcrete-hosted mineralization have been documented by Butt et al. (1977), namely: trunk-valley calcrete, with mineralization in channels, platforms, and channel deltas; playa lakes with near-surface gypsiferous and calcareous clays or carbonaceous sediments below the surface enriched in uranium; and dissected calcrete containing uranium mineralization in terraces above the present watertable.

Most of the calcrete-hosted uranium deposits were discovered in the early 1970s. Yeelirrie is the largest, containing in 1993 an estimated 35 Mt indicated resource of uranium, with an average grade of 1.5 kg/t U_3O_8, to give a total of 52 000 t of contained U_3O_8. This is the largest uranium deposit in Western Australia, and possibly the largest of its style in the world. Other major calcrete-hosted uranium deposits include Hill View, Hinkler Well, Lake Maitland, Lake Way, Nowthanna, and Thatcher Soak (Table 1).

Located in the Neoproterozoic Paterson Orogen, the Kintyre uranium deposit is an unconformity-related type with pitchblende the dominant uranium mineral in veining within chloritized schist. In section, the Kintyre deposit is a shallow-dipping lens with a maximum depth of 150 m below the surface. The estimated resource (indicated plus inferred) for Kintyre is 35 000 t of contained U_3O_8, with an average resource grade of 1.5 kg/t U_3O_8, making it Western Australia's second largest uranium deposit.

Uranium mineralization related to a roll-front is formed at the interface between rocks or groundwater under reducing conditions and oxidized, uranium-enriched groundwater, and thus marks the oxidation interface or redox boundary. Major deposits of this type include Manyingee, Oobagooma, and possibly Mulga Rock.

Uranium mineralization at Oobagooma, in the form of uraninite and pitchblende, is hosted by the Lower Carboniferous Yampi Sandstone of the Canning Basin. Keats (1990) reported that two mineralized levels are present, with the upper level containing higher grade zones in classic roll-fronts. The total indicated uranium resource is estimated as 8.2 Mt, with an average resource grade of 1.2 kg/t U_3O_8, for 9900 t of contained U_3O_8.

A number of roll-front uranium deposits are present within Permian and Cretaceous sandstone formations of the Southern Carnarvon Basin. The most significant is the Manyingee deposit within the Cretaceous fluviodeltaic Birdrong Sandstone in paleochannels cut into basement granite and overlain by shale (Keats, 1990). Inferred plus indicated resources are estimated as 14.7 Mt, with an average grade of 0.8 kg/t U_3O_8, for 12 000 t of contained U_3O_8. Significant exploration potential exists in the Southern Carnarvon Basin, particularly adjacent to the Gascoyne Complex along the eastern margin of the basin.

Hosted by organic-rich clay within an Eocene buried paleochannel, the Mulga Rock uranium deposit is the third

Table 1. Major uranium deposits in Western Australia (as at January 2009)

Deposit	*Type*	*Resources*		*Contained*
		Mt	*Average grade* U_3O_8 *(kg/t)*	U_3O_8 *(kt)*
Yeelirrie Uranium	Calcrete	35.000	1.500	52.500
Kintyre	Unconformity	23.333	1.500	34.999
Mulga Rock	?Roll-front	44.630	0.556	24.820
Lake Way–Centipede	Calcrete	25.830	0.419	10.823
Lake Maitland	Calcrete	32.700	0.330	10.791
Oobagooma	Roll-front	8.300	1.200	9.960
Manyingee	Roll-front	13.400	0.610	8.175
Thatcher Soak	Calcrete	17.000	0.290	4.930
Hillview	Calcrete	27.600	0.174	4.802
Dawson–Hinkler Well	Calcrete	20.600	0.228	4.690
Nowthanna Uranium	Calcrete	10.368	0.450	4.666
Thatcher Soak/Eleckra	Calcrete	16.100	0.174	2.801
Abercromby–Millipede	Calcrete	3.410	0.662	2.258
Anketell Uranium	Calcrete	2.700	0.680	1.836
Mopoke Well–Lake Raeside	Calcrete	6.950	0.260	1.807
Lake Mason	Calcrete	7.900	0.170	1.343
Wondinong/Aura	Calcrete	6.500	0.185	1.203
Bennett Well	Roll-front	0.621	1.610	1.000
Lakeside–Lake Austin	Calcrete	2.624	0.317	0.832
Angelo River Uranium	Unconformity	0.644	1.241	0.799
Cummins Range	Carbonatite-hosted	3.580	0.216	0.772
Lyndon Uranium	?Calcrete	1.430	0.500	0.715
Windimurra Uranium	Calcrete	0.880	0.707	0.622
Yuinmery Uranium	Calcrete	1.580	0.370	0.585
Yinnietharra–Minindi Creek	Calcrete	3.500	0.123	0.430
Turee Creek Uranium	?Unconformity	1.050	0.350	0.367
Cogla Downs Uranium	Calcrete	0.100	0.780	0.078
Lake Raeside/Esso	Calcrete	0.110	0.409	0.045
		314.860	**0.597**	**187.877**

SOURCE: Department of Mines and Petroleum MINEDEX database <http://www.dmp.wa.gov.au/minedex>

largest in Western Australia. The uranium mineralization in the paleochannel is interpreted to be the result of the absorption of uranium-bearing complexes by fine-grained carbonaceous sediments, and is spatially controlled by redox boundaries (Keats, 1990). Total resources are currently estimated at 10.8 Mt, averaging 1.4 kg/t U_3O_8, for 15 000 t of contained U_3O_8.

Between June 2002 and September 2008 the right to mine uranium ore (and even to explore for uranium) was excluded from the 1475 mining leases granted in Western Australia. During the same period, exploration for uranium on other tenement types was not prohibited. Following the recent State elections (and change of Government), uranium mining is now permitted in Western Australia, and action is being taken to remove the uranium exclusion from the mining leases granted between 2002 and 2008.

Uranium mining and export require both State and Commonwealth Government approvals and need to address actual risks, while taking into account community concerns. Besides the usual State mining requirements, approvals are required under Australia's Environmental Protection and Biodiversity Conservation Act, the Nuclear Non-Proliferation (Safeguards) Act, and the Radiation Protection and Nuclear Safety Act. Under the Customs (Prohibited Exports) Regulations, an export licence is necessary for the export of radioactive material, and the transport of uranium must be conducted in accordance with the Commonwealth Radiation Protection and Control (Transport of Radioactive Substances) Regulations. Using best practice developed in other Australian jurisdictions, the Western Australian Department of Mines and Petroleum will ensure that all State and Commonwealth approvals are integrated.

Uranium should be considered as just another commodity and uranium mining as just another mining operation, albeit one with particular regulatory requirements to meet Australia's international obligations and to cover the radioactive nature of the material.

References

Butt, CRM, Horwitz, RC, and Mann AW, 1977, Uranium occurrences in calcrete and associated sediments in Western Australia: Australia, CSIRO, Division of Mineralogy, Minerals Research Laboratories, Report FP16, 67p.

Keats, W, 1990, Uranium, *in* Geology and mineral resources of Western Australia: Geological Survey of Western Australia, Memoir 3, p. 728–731.

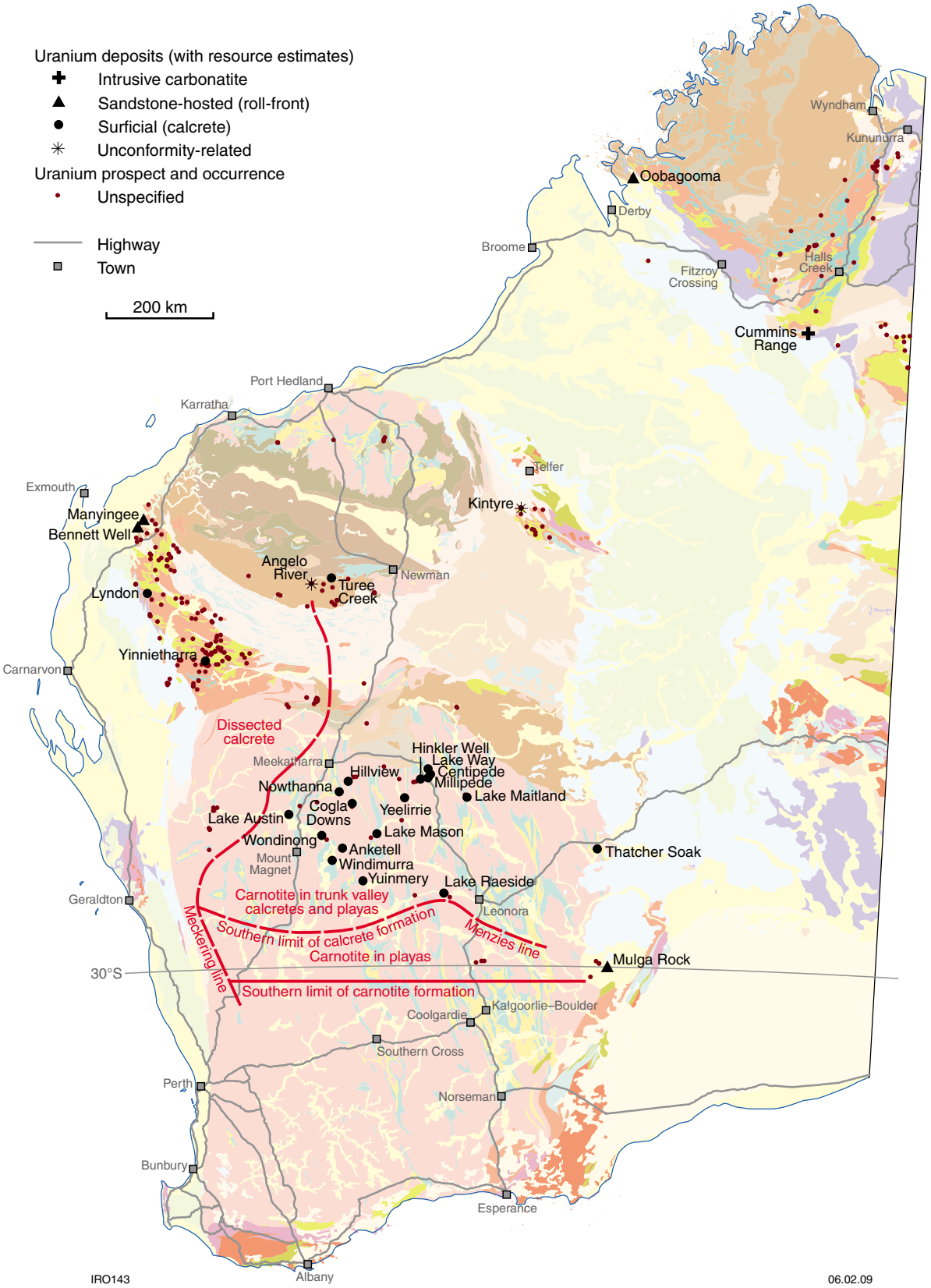

Figure 1. Uranium mineralization in Western Australia