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Uranium: Waste or Potential Future Resource?

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Abstract

From the early days of the nuclear power industry, Australia witnessed a "Yellowcake Rush", with prospectors scouring our countryside for uranium resources. Large resources of the metal were identified and a relatively buoyant market led to investment and a uranium export industry, despite a challenging political environment. A prevailing weak market for Uranium since the March 2011 Fukushima incident has slowed exploration, seen some resources change commercial operators and constrained investment in the sector. Drawing on mixed commodity resources which include uranium, a number of companies are developing large mines to extract copper, gold, phosphate and rare earth oxides. Rather than extract the uranium the operators plan to direct it to tailings repositories. While the resources in question may have been developed for uranium with vigour in the past, market conditions dictate an environment whereby several thousand tonnes of uranium resources will be stored in tailings dams. Should the uranium market improve in the future, it is possible that these resources will become readily extractable uranium resources. The expenses of mining, crushing and grinding of ore represent sunk costs. Future developments may be considered where uranium is extracted from the tails resources, by either: inexpensive digging and reprocessing or perhaps chemical extraction will be required.

Case Study –Carrapateena
The Carrapateena copper and precious metals mine is currently being developed by Oz Minerals. Located in South Australia, some 400 kilometres North North West of Adelaide, Carrapateena is a vertical breccia hosted, hematite dominant iron oxide copper gold (IOCG) deposit, covered by 470 metres of Neoproterozoic sediments extending 2,000 metres below the unconformity. Following geophysical targeting of gravity and magnetic anomalies in the Proterozoic basement of the eastern margin of the Gawler craton, drilling discovered the Carrapateena mineralization in 2005. Carrapateena is characterized by sulphides mineralization distributed a disseminated 0.1 to 4 millimeter grains of predominantly pyrite, chalcopyrite and bornite. Rare Earth Elements at Carrapateena are bound in monazite with uraninite bearing uranium. Both monazite and uraninite are closely associated with the bornite. The total reported resource of Carrapateena in November 2016 was 134 million tonnes, with a copper grade of 1.5 percent, gold at 0.6 grams per tonne, silver at 6.6 grams per tonne and an average orebody grade of 239 parts per million for uranium.¹

Milling and processing of Carrapateena ore will recovery primarily copper, gold and silver, but could result in the capture of some uranium which would present as a penalty constituent in the production streams. The project proponent, Oz Minerals estimates that the tailings radionuclide composition will be similar to that of the initial mineralized ore. For the purposes of calculating uranium remaining in the tailings stream a 10 percent recovery is estimated, resulting in 90 percent of the original uranium in processed ore being deposited in the Eliza Creek Tailings Storage Facility (TSF). Over the mine life an estimated 145 million dry tonnes of tailings will be transported to the TSF, resulting in over 31,000 tonnes of uranium being stored in the Eliza Creek TSF. ²

Case Study –Nolans Bore

The Nolans Bore project is currently being developed by Arafura Resources. Located in Australia's Northern Territory, some 140 kilometres North North West of Alice Springs, the 1550-1510 Ma Nolans Bore pegmatite suite is situated in the 1860-1720 Ma metasedimentary rocks of the Aileron Province. First identified in 1995

following a thorium and uranium radiometric survey, the complex Nolans Bore primary mineralization is overprinted by hypogene mineralisation and subsequently supergene mineralisation. Coarse primary fluorapatite crystals (1-8 centimetres) occur within a microcrystalline fluorapatite matrix which dominates the vein texture and contains Rare Earth Elements (REE) and uranium. The second stage of mineralisation tends to exhibit lower grades of REEs and uranium in fluorapatite allanite breccias. The final stage of supergene mineralisation has variable distribution with extensive clay and kaolin alteration. The globally significant Nolans Bore REE deposit is open at depth and is characterized by comparatively high neodymium content. The total resource reported at Nolans Bore in December 2016 was 56 million tonnes, with a total REE oxide content of 2.6 percent, a phosphate (as P2O5) content of 12 percent and a uranium grade (as U₃O₈) of 200 parts per million.³

Project proposals by Arafura in 2010 included the extraction of the uranium and production of uranium oxide, however, later development application by the company excluded this option. Milling and other processing of the Nolans Bore ore to recovery primarily REEs and phosphate could result in the capture of the some uranium, possibly presenting a penalty constituent in the production streams. The project proponent, Arafura Resources estimates that the tailings radionuclide composition will be similar to that of the initial mineralized ore. For the purposes of calculating uranium remaining in the tailings stream a 10 percent recovery is estimated, resulting in 90 percent of the original uranium in processed ore being deposited in the above ground Tailings Storage Facility (TSF). Over the mine life an estimated 56 million dry tonnes of tailings will be transported to the TSF, resulting in over 10,000 tonnes of uranium being stored in the TSF.

Case Study –Toongi

The Toongi mine is operated by Alkane Resources to export rare earth and hafnium product streams from Australia. Located in New South Wales, about 300 kilometres North West of Sydney, the Jurassic age Toongi rare metal deposit is part of a 100 km2 Jurassic aged alkaline trachyte volcanic province intruding and overlying a folded Siluro-Devonian volcanic-sedimentary sequence. Weakly radioactivity in the area was identified in 1951 by the Bureau of Mineral Resources (Geoscience Australia) and fieldwork identified trachytic volcanics as the source the following year. Following up on the potential identified in regional exploration in1982 for a resource of zirconium, hafnium, niobium tantalum, yttrium, uranium and REE within the Toongi trachyte, commercial testing commenced in 2000. The Toongi orebody some shallow weathering and minor oxidation down to 40 metres, and some chill margins at the boundary of the trachyte. Mineralisation is generally fine grained with some crystal clusters, veinlets and vug fill. The total resource reported at Toongi is 73.2 million tonnes with 1.96 percent ZrO2, 0.04 percent HfO2 and 0.75 Rare Earth Oxides (REO).⁴

The project proponent at Toongi, Alkane Resources has indicated no interest in the recovery and production of uranium from the resource for a number of reasons, not least of which is current ban on mining and production of uranium in New South Wales and that the additional capital requirements and process flowsheet development costs are simply not economic. The company comprehensively addresses the risks of radioactivity at Toongi, but has not sought approval to produce uranium. Current mining of Toongi to recover primarily REEs and hafnium may result in the capture of the some uranium, possibly presenting penalty constituents in the production streams. The tailings radionuclide composition is estimated to similar to that of the initial mineralized ore. For the purposes of calculating uranium remaining in the tailings stream a 10 percent recovery is estimated, resulting in 90 percent of the original uranium in processed ore being deposited in the above ground Tailings Storage Facility (TSF). Over the mine life an estimated 60 million dry tonnes of tailings will be transported to the TSF, resulting in over 7,000 tonnes of uranium being stored in the TSF.

Historical Case Study –Rosebery Mine Tasmania

The reprocessing of old tailings can lead to increased product recovery and improved financial outcomes for some mining operations. For example, through the early 1990s the Rosebery mine was able to reprocess tailings produced from the 1880s to the 1930s in order to produce additional gold/silver dore. The older processing technology had recovered the majority of the zinc, lead and copper from the finely crystalline Rosebery ore. However, significant quantities of gold and silver remained in the crushed tailings. The tailings were readily dug from the old dams around the Rosebery mine site and transported to the mill for reprocessing. Utilising advance recovery technology not available to earlier generations, the Rosebery mill successfully treated the fine grained crystalline sulphides and recover additional saleable gold/silver dore. An additional benefit from the tailings reprocessing was environmental, as the tailings repositories that were reworked were readily rehabilitated with a rock then soil cover which facilitated the growth of vegetation, in particular, improving the visual impact of the older tailings dams.

Other global examples of tailings reprocessing projects include;
De Beers Consolidated Mines to extract overlooked diamonds from 360 million tons of old tailings surrounding the Kimberley mines in South Africa,
DRD Gold's South African Witwatersrand operations to extract gold from tailings utilising new recovery technology, South African projects to recover platinum group elements (PGEs) and chrome from Bushveld complex tailings, and Carbine Resources feasibility work on recovering gold and copper from tailings at Mount Morgan in Queensland.

Conclusions

The technology for reprocessing tailings left behind from old mining operations has proven profitable for a number of corporations globally. Advances in metallurgical technology, changing social, environmental or aesthetic considerations and changes in commodity prices could be the catalyst that initiates projects to recover value from old tailings. The Carrapateena, Nolans Bore and Toongi developments in Australia will each leave significant amounts of potentially valuable uranium in their respective tailings facilities. Each of the project proponents for economic and political reasons has chosen to not extract the uranium value at this stage. Should political or market conditions for uranium change in the future, the tailings repositories at Carrapateena, Nolans Bore and Toongi could represent significant potential commercial value for a project proponent. Geoscience Australia provides authoritative independent advice to the Australian Government supported by holdings of resources data over several decades. A record of potential resources including those with altered physical characteristics is maintained by Geoscience Australia, ensuring a complete picture of evolving circumstances is available to government and the public.

¹ Australian ore deposits, Phillips (ed.), Australasian Institute of Mining and Metallurgy (AusIMM) Publisher, September 2017.

² Carrapateena Project Environment Protection and Biodiversity Conservation Act 1999 Referral of Proposed Action, Oz Minerals March 2017 (EPBC Referral).

³ Australian ore deposits, Phillips (ed.), Australasian Institute of Mining and Metallurgy (AusIMM) Publisher, September 2017.

⁴ Australian ore deposits, Phillips (ed.), Australasian Institute of Mining and Metallurgy (AusIMM) Publisher, September 2017.

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Primary author: Mr KAY, Paul (Geoscience Australia)

Presenter: Mr KAY, Paul (Geoscience Australia)

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