

Uranium, Rare Earths and NORM: Mining and current prospects in Australia's Northern Territory

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Abstract. The Northern Territory of Australia (NT) has a long association with mining, including the mining of uranium. Current activity includes all aspects of the uranium production cycle including many exploration projects, the Ranger Uranium Mine and a number of remediation sites. There are also a number of rare earth projects approaching the development phase and some NORM related projects which are equally approaching development status.

The paper describes the current state of uranium exploration activities and progress on remediation works in the NT before providing an update on the ongoing development and remediation-related activities at the Ranger Uranium Mine. The paper will also provide an update on recent changes in the regulatory regime.

Introduction

Whenever any natural material or mineral is mined or processed there will always be the potential for the radiation exposure of the workforce and/or the surrounding community to increase. This is because natural raw materials all contain naturally occurring radioactive material (NORM). Admittedly it is only in a small percentage of such situations that it will be necessary to introduce changed work practices and radiation protection plans. However, it is important that the radiation risk is assessed in order to ensure the protection and of individuals and the environment as well as facilitating determination of the appropriate level of regulatory supervision to be applied. International Atomic Energy Agency (IAEA) published Safety Report Number 49 (IAEA, 2006) published in 2006 provides a complete overview of this whole issue. This report lists the most common industries and activities concerned where the matters of NORM and subsequent risk of increased radiation exposure are most likely to be encountered, with the exception of uranium mining for which there is a separate and extensive range of IAEA documents.

In the Northern Territory of Australia (NT) the economy is based on three “hubs”, tourism, primary industry and mining, of which mining is the most important. For this reason issue of NORM is frequently under scrutiny by the various authorities and agencies responsible for regulating the industry.

The Northern Territory and NORM

There is a significant history of NORM related industrial development in the NT; this is primarily related to the uranium mining industry since 1945. More recently other NORM-related industries have begun developing. Currently there are exploration, development and recently closed operations involving NORM. These projects include rare earths, mineral sands and phosphate deposits as well as ongoing activities related to all parts of the uranium production cycle. The major elements of the uranium related activities were described recently in a paper by Waggitt (2013) and are not discussed at length here.

The NT has an active and developing oil and gas industry with three active oil fields in the southern NT at Palm Valley and East and West Mereenie with three more not yet operational. In addition there are offshore oil and gas production fields which use Darwin as a supply base as well as the operating LNG plant at Wickham Point and the new LNG plant presently under construction for the Ichthys project at Blaydin Point, both located on Darwin harbour. Offshore oil and gas activity is regulated by the Australian Government.

All of these developments and projects have the potential to produce NORM related exposures, primarily arising from the cleaning of pipes and tanks involved in the pumping of associated or formation waters. These potential exposures are managed in accordance with the requirements of the regulating authorities and taking heed of the guidance provided by the IAEA in the relevant Safety Report (IAEA, 2003). The radiation protection issues are regulated through the Radiation Protection Act, which is administered by the NT Department of Health.

Mineral Sands

The NT had only one minerals sands project which was operated by MZI Resources Limited. The company has other mineral sand interests in Western Australia and recently completed operations at the Lethbridge South site in the Tiwi Islands located in the Arafura Sea just 50 km to the north of Darwin. MZI operated in the Tiwi islands 2009-2013 and produced some 33,000t of heavy mineral concentrates which were sold mostly to China. The mines in the Lethbridge series on Melville Island ended operations in 2013 but the approvals process for a new

mine at Kilimiraka on Bathurst Island has begun with a full feasibility study expected to be completed later in 2014. In recent statements the company has described an inferred resource of 56.2 Mt grading at 1.6% heavy minerals and an anticipated heavy mineral content of 894,000 t. The process would be a standard excavation and wet separation in spirals; and to date there have been no significant radiation protection issues. However, the operator is aware of the potential for such issues to arise and appropriate safety measures are in place. In early 2013 the company submitted a Notice of Intent for the new project at Kilimiraka and the environmental impact assessment process was set in train by the NT Environmental Protection Authority in March. Heritage, environmental and native title works have begun and the Scoping and Feasibility study is planned to commence later in 2014.

Rare Earth Elements

The NT has a good prospectivity for rare earth deposits and extensive exploration activities are taking place in several areas. The most advanced prospects include the Nolans Bore deposits, being developed by Arafura Resources Limited, and the Charley Creek deposits being evaluated by Crossland Strategic Metals Limited. The NT Department of Mines and Energy (DME) is responsible for regulating mines through the Mining Management Act (MMA) and refers all operators, be they explorers or miners, to the IAEA Safety Report No. 68 (IAEA, 2012) when considering the preparation of their Mining Management Plan (MMP) and the included (radiation Management Plan (RMP).

The Nolans Bore deposit has published resource information as shown below which shows that there may be possibilities for by- and co-production of other materials. However, much of that will depend on market conditions for the respective materials in the future. The original plan was for the project to produce a beneficiated concentrate on site, about 500,000 t annually, which would then be transported to the company's Rare Earths Complex to be built at Whyalla, in South Australia.

Table 1. Nolans Bore Resource Classification

	Mt	REO%	REO kt	P2O5%	U3O8 lb/t
Measured	4.3	3.3	144	13	0.57
Indicated	21	2.6	563	12	0.42
Inferred	22	2.4	511	10	0.37
Total	47	2.6	1,217	11	0.41

(Source: <http://www.arafuraresources.com.au>)

The project has recently been re-scoped to concentrate on on-site beneficiation and no off-site processing. The company hopes to recover 848,000 t of rare earths (lanthanum, cerium, praseodymium, neodymium, samarium, europium, gadolinium, terbium, dysprosium, and yttrium) in addition the deposit contains 3.9 Mt of phosphorus pentoxide and 13.3 M lbs (6,045t of uranium oxide. The mining operation would be regulated under the Mining Management Act which will require an annual Mining Management Plan (MMP) to be submitted for approval and that MMP will be required to include a Radiation Management Plan (RMP).

The Charley Creek project is being investigated by Crossland Strategic Metals Limited in partnership with Pancontinental Uranium Corporation of Canada with a scoping study currently being completed with hopes to commence development soon, including a degree of local processing. The project was originally exploring for uranium but it became apparent that the deposit contains significant amounts of rare earth oxides and is thought to contain 17% of the heavier, and more keenly sought after, elements amongst the rare earths, rather more than is usual. The Total Rare Earth Oxide (TREO) resource is inferred at 121.1kt from an ore mass of 418Mt with an average of 289ppm TREO. In addition there are reported resources of 30.6kt Xenotime, 167.2kt Monazite and 219.9kt Zircon. To date only a small portion of the deposit has been explored and so the potential is considered to be considerable. Another interesting point is that the deposit appears to contain low levels of radionuclides associated with the rare earths and it is thought unlikely that there will be any significant radiological protection issues for the operators.

Phosphates

Phosphate deposits are being investigated at a number of locations within the NT. The evidence has been that all the deposits identified to date have been found to be low in natural radionuclides and radiation protection issues have been minimal.

One deposit is the Amaroo project being developed by Rum Jungle Resources Limited where the total of measured, indicated and inferred resources has been reported as 1.08 Bn t at an average grade of 14% P_2O_5 with a cut off at 10% P_2O_5 . This is a significant increase in previous statements as it now includes the adjacent resources of the Arganara deposit, formerly owned by Central Australian Phosphate, which was taken over by Rum Jungle Resources in 2013. Throughout both deposits the uranium levels are reported as being between 19 and 31 ppm which is why the radiation risk is deemed to be low.

Rum Jungle Resources is also exploring for potash deposits at the Karinga Lakes area south west of Alice Springs. The salt lakes are a possible source of potassium and potassium magnesium sulfates. The project is in early stages and as yet no resource data are available.

Minemakers Limited are the owners of Australia's largest undeveloped rock phosphate deposit at Wonarah and so far only 15% of the deposit has been explored sufficient to make a resource statement which has 78M t of measured resources at 20.8% P_2O_5 , and inferred and indicated resources of 933M t at 13% P_2O_5 with a 10% cut-off. The ore body contains uranium at an average of 18ppm although the maximum recorded concentration was 75 ppm. Work carried out by the company as part of the preparation of the environmental impact statement have indicated that the levels of uranium are not sufficient to warrant further investigation as the ore will neither be beneficiated nor concentrated. Thus the product and the residues are not considered to present a radiological risk for the proposed project with direct shipping of ore. The company also has a development plan which would employ the Improved Hard Process at the site to produce super-phosphoric acid as a higher value added product.

Thus, for both these projects the possibility exists that there may be a change from an emphasis on direct shipping of crushed ore to some form of processing which is likely to involve phosphoric acid production and possibly even further downstream processing to fertilizers or similar products. Such developments would require a re-assessment of the radiological implications, especially in relation to NORM scales building up in pipework and reaction vessels etc. Both projects could also include creation of a fertiliser plant in later stages of development which would also need to be assessed for radiological risks. However, it is unlikely that such a plant would be located on a mining tenement and would there not be subject to regulation under the MMA.

Uranium

Uranium mining activity has been a feature of the Northern Territory economy for many years. The "modern" era of uranium mining began with Rum Jungle and the South Alligator operations of the 1950s and 1960s. These have been well documented elsewhere (Waggitt, 2012, Waggitt, 2013). In the late 1960s exploration in the Alligator Rivers Region discovered several deposits of which four, Jabiluka, Ranger, Koongarra and Nabarlek were of economic significance. The political situation in Australia at the time was changing and as a result only Nabarlek and Ranger were brought into production.

Nabarlek was a small resource but of relatively high grade (2%) and operated from 1979 to 1988 producing about 10,800t of Uranium Ore Concentrates (UOC- U_3O_8) over that period. The site was remote and an early example of the modern Fly in-Fly out (Fifo) style of operating. The site was remediated in 1995/6 and is currently still under assessment for completion of closure. The lease area has also been the location of a number of exploration operations many of which have extended considerable distances into the surrounding countryside and some of which

are still ongoing. To date no new resource suitable for development in the current economic climate and state of the industry has been found.

Koongarra is a deposit that is located on country that has been handed back to the Kakadu National Park by the Aboriginal Traditional Owner and will not now be further exploited.

Jabiluka is a significant deposit owned by Energy Resources of Australia Limited (ERA), the owners and operators of the adjacent Ranger Uranium Mine (RUM). The deposit was explored as part of a feasibility study and EIS preparation in the 1990s but agreement could not be reached with the Aboriginal Traditional Owners and so work was halted and the site remediated to await possible development at some time in the future. This will not be before operations at RUM have been completed

Ranger began operating in 1980 and has since produced more than 100,000t UOC from two open pits, #1 and #3. Pit #1 was mined from 1980 to 1995 and Pit #3 was operated from 1997 until November 2012 at which point mining ceased. Pit #1 has been back filled with tailings and Pit#3 has recently been partially filled with 30Mcu.m. of low grade mineralized waste rock as part of the preparations for the in-pit disposal of tailings which will commence in January 2015. This operation will also involve the relocation of some 50Mcu.m of tailings from the existing tailings storage facility (TSF) which is a 1 kilometer square dam containing about 50m depth of tailings. This operation is planned to commence later in 2015.

Exploration across the Ranger Project area (about 65 sq.km.) has continued throughout the life of the mine and a number of interesting anomalies have been found. In 2013 ERA commenced an underground exploration campaign adjacent to pit#3 to investigate a deposit named Ranger 3 Deeps (R3D). It has been stated that the initial resource at R3D is about 32,000t UOC and a \$57M pre-feasibility study has been commenced. Work underground to date has included a decline and about 2000m of tunnel with many side drilling locations to increase the knowledge about the orebody. The complete campaign will extend to 2400m plus a bulk sampling exercise to enable various characteristics of the ore to be checked for future processing options. The current mining agreement with the Federal Government and the Aboriginal Traditional Owners will expire in 2021 with ERA required to have stopped mining in 2012, and have the site remediated by 2026. As the future of the operation beyond that time is not assured at present ERA is hoping to be able to exploit a good proportion of R3D within the present mining agreement time frame.

Major issues at RUM have always centered around water management and in 2013 the company commissioned a Brine (BC) at a cost of \$220M as a means of rapidly reducing the inventory of process water on site. The plant is operating and

reduces volume of water by 2/3 with the remainder being a waste brine that will be injected into the rockfill in the bottom of pit#3. The 1.8GL clean water condensed annually from the BC is released from the site in compliance with a strict series of protocols developed by the regulators of the operation in consultation with major stakeholders. The BC will continue to operate for the rest of the mine life.

Other Mining Operations

When one considers the list of NORM related industries in IAEA Safety Report No.49 (IAEA, 2006) it is necessary to understand the possibility that there could be a need for radiation protection issues in any potential mining operations other than uranium or the industries described above. Many of the mineralizations that exist in relation to uranium, for example, are often associated with other valuable deposits. The uranium mines at Guratba (Coronation Hill) and the other South Alligator Valley deposits also produced gold in the 1960s (Fisher, 2002); these sites were also explored in the 1990s when a gold, platinum and palladium mineralisation was identified at a number of locations. However, the sites are all located in an area that is now Stage 3 of the World Heritage listed Kakadu National Park and no further mining activity will be permitted.

The site at Rum Jungle was primarily a copper mine that also produced uranium (Barrie, 1982)], in fact several of the uranium related radiological anomalies in and around that district are now areas where gold mining has either taken place or is still in progress. For this reason all underground mines in the Pine Greek geosyncline are regarded as having the potential for exposing workers to doses in excess of 1 mSv/y and the DME recommends and advises that operators carry out suitable monitoring and screening programmes and then discuss the results with the Department of Health where appropriate. For example the Cosmo Howley operations of Crocodile Gold are on tenements which include the former Fleur-de-Lys uranium mine (Annabel, 1971). The site is known to the workforce and there are appropriate procedures in place. To date there have been no results of significance reported, although the presence of uranium in some drainage waters indicates that the matter cannot be ignored and ongoing surveillance is required. The DME's Environmental Monitoring Unit checks many legacy sites as well as active mines which are also required to submit monitoring data to DME periodically. Any anomalous results, most usually found in water chemistry data, are discussed with the operators, where applicable. Such data may also be referred to the Department of Health and/or the NT Worksafe authority as appropriate. The data are also shared with the Legacy Mines Unit of the DME so that a risk assessment can be undertaken to ensure that the site is appropriately classified in the legacy mines inventory for the NT.

Conclusion

The Northern Territory of Australia has a long and strong association with the mining industry that continues to the present time. Many of the minerals mined in earlier times contained NORM although the risks associated with these substances were not always recognised. More recently the NORM industry in the NT has been dominated by uranium mining where world class leading practices in radiation protection are a regular part of operations.

As the world has become more interested in rare earth elements and the demand for fertilisers has grown so suitable mineral deposits related to these commodities have been discovered in the NT. Most of these deposits are associated with NORM minerals that occur in varying concentrations. Several of these deposits are likely to be developed in the near to medium future and the DME are ensuring that the potential risks associated with NORM are clearly explained to operators who in turn are adopting suitable monitoring programmes and radiation protection plans where appropriate.

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