Uranium mining legacies remediation and renaissance development: an international overview

Peter Waggitt

Am Modena Park 12/8, A-1030, Vienna, Austria

Abstract. The uranium mining industry has a record of environmental management that has been very variable over the past 50 years. Although there have been examples of good remediation in some countries, sadly there are many examples of poor or no remediation that remain as a legacy from former times. As the industry is going through a renaissance interest in remediating such legacy sites is increasing significantly. This paper provides a brief overview of some remediation activities at legacy sites in various regions of the world and how international organisations, including the International Atomic Energy Agency, national regulating authorities and the mining companies are working together to address these very important matters in a number of locations.

Introduction

The modern uranium mining industry really began in the late 1940s at a time when there was little thought for protecting the environment. Apart from some laws about protection of water resources there was effectively no environmental protection legislation. As uranium production increased so did the number of locations affected by mining. But in the 1960s there was a decline in activity as major nations fulfilled requirements for weapons programmes. Many uranium mining sites were simply abandoned in these times with no attempt at remediation, thus creating the legacy sites that are still a problem today. Many of these sites have ongoing environmental problems including radiation from discarded tailings and low grade ores or waste rock, or contamination due to seepage from tailings and waste rock, sometimes associated with acid rock drainage from reactive materials.

Concern about these sites and their impacts grew and legislation to control the environmental impacts appeared in many jurisdictions. In Australia, for example,

the Environment Protection (Impact of Proposals) Act came into force in 1974. But these laws were not retroactive, so legacy sites remained untreated.

In the mid 70s the uranium mining industry had a surge of activity meet the demands of a growing nuclear power industry. But not all of these mines were being developed under situations where environmental legislation was applied. In many centrally planned economies of Central Asia, for example, the maintenance of production was all important and environmental and health and safety rules were only a secondary concern at best. As a consequence some of the former legacy sites became larger and new legacies were created in addition.

But the drive for nuclear power stalled and many organisations stockpiled uranium so the demand for new production eased in some quarters. Again sites were abandoned but now there were laws requiring remediation and in some locations such work was done, but only usually where the mining had been recent. Old legacy sites remained untouched for the most part. In Central Asia production continued for some years but as the political tensions eased the strategic need for uranium declined. The result was a large scale closure of mines and processing facilities that now had to compete on the open world market. Few of these mines could achieve the production volumes and efficiencies to do this and so another round of legacy sites was created.

Again the market cycle moved on and in the early days of the 21st century the market for uranium has undergone a renaissance. Uranium production is only about 66% of current market demand. To meet this shortfall` new uranium resources are required and these are being sought all over the world. In many instances developers have turned to former uranium production sites to see if they are likely to be capable of economic production in the new situation. But many of these sites still offer legacy conditions and so in the race for development the need to include legacy remediation has to be borne in mind. For new resources the lessons to be learned from the past must be acknowledged and the creation of new legacies avoided at all costs.

There are many lessons to be learned from the past and this paper sets out some selected examples of good and not so good remediation experiences that the uranium industry should take into account when planning the development and exploitation of resources in this new round of activity.

The history of neglect

Today's legacy problems arose because due to the lack of legislation in earlier times. With no obligation to plan for, or undertake remediation and with no funds having been put aside to carry out the work, remediation did not happen. This last point is a major issue when legacy remediation programmes are discussed or efforts are made to plan work. Mining legacy remediation is a very expensive business, more so when uranium is involved. For example in Germany the cost of remediation of the former uranium mines and associated of the WISMUT company will be about €6.2 billion, a sum of money that few economies could hope to

have available for mine remediation - let alone those recently emerged from years of central planning. Thus, few of the countries most affected by the uranium mine legacy issue have adequate finance or resources and infrastructure in their regulatory networks to plan, develop and manage such programmes. Neither do many of the countries most affected have sufficiently well developed environmental protection laws and resources.

So the diagnosis is one of neglect and lack of resources. The prognosis is not very good at first glance due to the vast amounts of financial support required at a time when there are many other priorities for Governments expenditure in many of the most affected nations. Public health, education and re-building economies are all activities competing for the money available. But all may not be lost if legacy remediation can be incorporated with other development plans.

In today's market this has increased interest in the possibility of re-treating tailings, and perhaps other residues from legacy sites, to extract uranium. A number of proposals are being considered by mining companies and governments in former uranium mining centres around the world. Such plans should only be considered if they are a component of a comprehensive remediation programme. Any new processing scheme should be designed to ensure that the end state of the project will be a remediated site i.e. no new legacy is created.

Case histories

In developing this paper a relatively small number of case histories from around the world were selected to show a cross-section of both the problems being encountered and the solutions being implemented. It will be shown how some options have succeeded and whilst others failed.

Over the past 20 years in Western Europe and North America, there have been significant campaigns undertaking the remediation of uranium mines, especially legacy sites. Such programmes include work at Wismut in Germany, Elliot Lake in Canada, the UMTRA programme in the USA and the work in France at the mines of the Limousin district. All these activities are considered to have had some success and are well been documented in addition to being the main topic of meetings such as those held in Schlema and Gera by Wismut GmbH in 2000 and 2007.

Although uranium mining is a global activity, case histories from only 3 continents are depicted here: Asia, Africa and Australia. There are also legacy sites in Europe and the Americas, both remediated and un-remediated, but space is limited and the histories presented are hopefully some of the more interesting ones.

Case histories from Asia

The former Soviet Union operated a large number of uranium mines throughout Asia, in particular in Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan, and Mongolia.

Between 1961 and 1995 many of these operations closed down, but rarely was any remediation undertaken, unless sites were close to significant population centres. In Tajikistan for example, the Ghafour waste rock pile, located in an urban area with apartment buildings located less than 50 metres away, was shaped and given a nominal 1 metre soil cover which reduces radon emanation and gamma dose rates considerably; whereas the Degmai tailings repository, located only 2 kilometres from the nearest settlement, has not been covered, has livestock grazing on the pioneer vegetation establishing directly in the tailings and is subject to invasion by persons recovering scrap metal from the tailings.

There appears to have been little or no provision for remediation at many of the former Soviet Union's operations, so there is now no specific funding available to improve the radiological safety situation. The first stage in what is likely to be a long process has been for the International Atomic Energy Agency (IAEA) to provide some suitable equipment and training to enable the local supervising authorities to strengthen their capabilities. In particular to obtain a good set of monitoring and surveillance data to enable authorities to update their characterisation of the wastes contained in the various legacy sites as well as the sites and their surroundings, including ground water. Once obtained, such data will provide a suitable basis for the development of comprehensive remediation plans. Such plans can then be submitted to appropriate funding agencies.

Throughout the four Central Asian countries mentioned above the pattern of abandonment was similar. However, the story since the mid 1990s has differed. Whilst Tajikistan and Kyrgyzstan have no current uranium mining operations, both Uzbekistan and Kazakhstan do. Kazakhstan for example is now the third largest uranium producer in the world and has undertaken a significant amount of remediation work in the former mining areas in the north of the country. Current uranium production in both Kazakhstan and Uzbekistan generally uses in-situ leach technology. Consequently solid waste production is now effectively nil.

Kyrgyzstan had several uranium mining areas, but the sites around Mailuu Suu in the south west of the country have attracted the most attention. In this valley 23 waste rock dumps and 17 tailings piles were left behind with varying degrees of remediation. The relocation of some of these tailings is the focus of a World Bank funded project. Some smaller tailings piles in other parts of Kyrgyzstan have also been remediated e.g. at Kadji Say and Min Kush.

Programmes to plan the remediation and monitoring of these and other sites are in place with assistance from a number of multi-lateral agencies. Again the long term remediation will require considerable finance which is currently beyond the national resources ability to supply.

The area around the former mining and processing site at Taboshar in Tajikistan is another serious example of legacy contamination. Over the years since the abandonment building components and scrap materials have been removed from the site piecemeal to the extent that very little is left that can be easily moved by hand. Much of what is left is in a dangerous state and presents a significant physical safety hazard, and possibly a radiological hazard in some cases. The site is dominated by a pile of yellow process residues (tailings) that are uncontained and continue to erode through wind and rain action. More serious is the use by the

local population of water contaminated by the seepages as a potable supply and for irrigating food crops. The IAEA, in conjunction with other agencies, is working to improve surveillance and monitoring and to advance plans for remediation.

In Uzbekistan and Kazakhstan the current uranium production operations are aware of their environmental responsibilities and there is a willingness to undertake the monitoring and surveillance that will provide the data necessary for remediation planning. Whilst the current and future operations are looking to provide remediation plans the legacy issues remain to be adequately addressed. A lack of funds for remediation is the major constraint.

In northern Kazakhstan much mine remediation has been done but at sites in the west of the country action much remains to be cleaned up. The centralised tailings storage facility at Stepnogorsk, in the north of the country, remains to be remediated and whilst plans are in hand to deal with this issue, funding remains as the major sticking point.

A similar situation exists in Uzbekistan, which is now the world's seventh largest uranium producer. The former soviet mines were mainly hard rock operations whereas current production is dominated by in-situ leach technology. Some of the former waste rock dumps and mine sites are being remediated but many remain untouched. These materials are at risk of being removed by the local population for use as building materials. The tailings storage facility at Navoi is still used for disposal of gold processing tailings but the uranium mill tailings there still need to be remediated.

In Mongolia, uranium mining was undertaken at Dornod, in the north eastern part of the country. The operation was abandoned in 1995. Since abandonment the railway lines and much of the infrastructure that had been installed to support the mining in a very remote area have been removed.

In 2004 IAEA set up a technical cooperation project to assist in the development of remediation plans for this site. However, by the time field work began in 2006 the renaissance of the uranium market had caused a number of overseas mining companies to begin exploration operations in the vicinity. It now seems likely that these companies will wish to commence uranium mining operations either at new sites or, most likely in the first instance, at the old sites in the Dornod vicinity.

As is commonly the situation in the former Soviet Union states the departure of the original operators has left little experience amongst the staff of regulatory bodies, with no current operations available for these people to observe and learn from, or to help train new personnel. The IAEA is supporting a programme of training and assistance in the development of a suitable regulatory infrastructure

Case histories from Africa

The uranium mining industry has been fairly widespread in Africa with mining taking place in the Saharan region, central Africa, east Africa and in the southern and south western areas. Whilst current operations are making preparations for eventual remediation, the recent renaissance of uranium mining has raised

concerns about the creation of new "legacy sites". There are already some legacy sites, in Zambia and the Democratic Republic of Congo for example, but there are also examples of remediation as at Mounana in Gabon.

At Shinkolobwe in the Democratic Republic of Congo (DRC) the uranium mining operation ran from the 1920s until about the mid 1960s when the site was closed out by the operator. There was little remediation and the main structures were left standing, whilst waste rock and tailings piles were abandoned as they stood. The underground workings were sealed off by plugging the shafts with concrete and the open cut was left as it was with some water in the bottom. The site was open to pubic access and many local footpaths criss-cross the site. Since then artisanal miners have returned to the site from time to time. This activity took place most notably in 2003 and 2004 when miners were seeking the cobalt-rich mineral heterogenite, which also contains uranium. Clearly if the current market boom for uranium continues there may well be pressure to re-open the mine on a commercial basis. Should this happen then the issues of managing and remediating the legacy wastes will need to be fully addressed before the new operations start to ensure that both legacy and new waste management will be integrated into a programme that meets international safety standards.

Case histories from Australia

Uranium mining in Australia really became established in the late 1940s with the mine at Rum Jungle. When operations ceased in the 1960s this site was not cleared up. Severe environmental impacts in the nearby Finniss River were blamed on the uranium mine but in fact it was the presence of acid rock drainage from the sulphidic waste rock and the dominance of copper from the poly-metallic ore residues in that seepage that were the main problem. An initial clean up was undertaken by the Federal Government in the 1970s but this was not satisfactory. Thus in 1982 a more comprehensive remediation programme was undertaken. The work has some immediate effects and although it was more than 5 years for the benefits of the work to be fully apparent all seemed to be well. Unfortunately by the late 1990s the performance of the covers in restricting rainfall infiltration had begun to degrade significantly with a consequent increase in acid drainage emissions. Problems also arose with the sustainability of the non-native and agricultural species used for revegetation ands weed invasion was very widespread on the site. A report has been prepared on the need for remedial works. Remediation regarded as a "leading edge technology" solution less than 25 years ago has shown itself to be unsustainable. It should be stressed that much valuable information has been gained from this experience which is being applied to other remediation programmes, in particular in the wet-dry tropics.

The mines of the South Alligator Valley dated from the 1960s when over a few years about 850 t of uranium was produced from 13 small deposits. Again, at the end of the mining work, the sites were abandoned. In the late 1980s the area was incorporated into Kakadu National Park (KNP), a World Heritage National Park, and then the land ownership was returned to the Aboriginal Traditional Owners

(TOs). As part of the KNP lease-back agreement the TOs required that the 13 mine sites and any other legacy evidence of mining be remediated before 2015. Various studies were carried out in the period 2001 to 2005 involving extensive consultations with the TOs. This was necessary to ensure that the proposed works not only met required international safety standards, but also did not compromise the traditional values and cultural beliefs of the TOs. Also there were some natural heritage issues to manage, such as not collapsing mine tunnels which had become the habitat for endangered bat species. As always finance was an issue and it was not until 2006 that the Federal Government finally agreed to grant $7 million for the works programme. The design work was completed by early 2007 and the first phase of the remediation at some of the sites was completed before the onset of the rains in November 2007. The balance of the work will be completed over the next year or two. The works are uncomplicated as there are few radiological safety issues and much of the effort will be in relocating scrap material and some process residues from a variety of locations to a single, specifically designed, containment.

The resurgence of the uranium mining industry

Since late 2003 the uranium mining industry has shown an ever increasing level of activity. Today as many as 600 companies worldwide seem to be expressing an interest in the exploration and development of uranium resources. In the "quiet times" since the last boom period of the late 70s the industry had been very stagnant in terms of development. Now exploration and mine development are activities that are increasing significantly on a global scale. Projects in Africa, for example, include one new mine in Namibia and one under construction in Malawi and several prospects e.g. in Namibia, South Africa and Zambia. Much of the exploration has begun at "brownfield sites" many of which could also be classified as legacy sites. Abandoned previously as being uneconomic with low ore grades, several of theses sites now appear to offer the possibility of a quick start up to exploit a known resource which could provide cash income to finance further exploration and development in regions associated with uranium mineralization.

Even the re-treatment of tailings is being actively pursued in some locations, particularly at legacy sites. The economics look good at first glance with the cost of milling already taken care of and uranium market prices staying around $55-60/lb U_3O_8. The danger to the environment is that such new activities may not consider the costs of final remediation in their economic analyses as the sites are already "legacy sites". The authorities must be firm in their resolve and allow developments such as these to proceed only if they result in an overall better situation from the aspects of safety and environmental protection. This will require strong regulatory processes and infrastructure, and adequate resources and, above all, sufficient numbers of trained staff.

This last point is very serious. Whilst the industry was in apparent decline few young people were keen to join as they saw little future in an apparently moribund industry. As a result there are frequently 20 year gaps in the staffing profile of uranium mining activities which now need to be filled very quickly. This applies

to both operators and regulators. For example, radiation protection workers are in short supply everywhere, as are uranium exploration geologists. The boom in uranium mining calls for increased numbers of persons with these skills to work for both regulators and operators. Consequently all sides of the industry need to attract new staff and set up comprehensive training systems. This will help to ensure that there will be continuity when the older generation, many of whom are now retiring, are no longer available to provide the knowledge and experience that the situation is demanding today and into the future.

Where to from here?

The major lesson to be learned from all of these case studies is that where uranium mining activity is being undertaken, on new or re-activated sites, there needs to be a suitable legislative regime in place to deal with all these issues and prevent the creation of new legacy sites. So how should the uranium mining industry stakeholders move forward to deal with legacy issues and the development surge?

The question of how to assess liability for existing environmental impact and how to address requirements for remediation are questions that are testing the regulatory systems worldwide. Obviously the existing legacy of environmental degradation cannot be blamed on new operators; equally new operations should do nothing to worsen the situation. In addition new projects' remediation plans should be required from the outset to incorporate an approach that will assist with the improvement of the existing situation to the greatest extent practicable. These plans must include guarantees for the financial resources required for remediation.

The most important point is to ensure that today's uranium mining industry is not allowed to create any new legacy sites for the future. For example, where former mining sites are re-activated, every effort should be made to incorporate the remediation of any associated legacy sites into the remediation of the current operation, to the maximum extent practicable.

The uranium mining industry is taking up a new lease on life and is now commonly seen as one part of the integrated solution to meet future global energy needs. By providing the fuel for nuclear power plants uranium mining may be seen to be contributing positively to the battle to reduce CO_2 production and, consequently, global warming. This may an important objective, but it must not be allowed to distract any of the industry's stakeholders from their responsibility to ensure that uranium is always mined in an environmentally responsible manner.