Making Uranium-Mining More Sustainable – The FP7 Project EO-MINERS

W. Eberhard Falck[1], Henk Coetzee[2]

[1] Laboratoire REEDS, Université de Versailles St. Quentin-en-Yvelines, France
[2] Council for Geoscience, Pretoria, South Africa

Abstract. Every mining operation impacts the environment and the adjacent communities to a lesser or greater degree and minimising such impacts is at the core of initiatives to make mining, including uranium mining more sustainable. Over the past two decades work has focused on remediating uranium mining legacies in the wake of mine closures. However, with the demand for uranium increasing again, old mines are revived and new mines opened. In order to avoid the mistakes and poor practices of the past, we need to look into methods to make uranium mining operations more sustainable.

The European Commission Framework Programme 7 project EO-MINERS aims to support stakeholder dialogue by providing independent information based mainly on earth-observation techniques with a focus on remote sensing. Typical information that can be gathered includes mine land-use, the state of remediation including recultivation success, the dispersal of acid mine drainage, surface radioactivity, risks from spoil heaps and dams, landscape fragmentation due to mine infrastructure encroachment of informal settlements on mine-affected land, etc.

This paper describes the processes and procedures that are being developed in the EO-MINERS project for making such earth-observation techniques useful for deliberative stakeholder processes.

Introduction

For centuries mining has been and continues to be one of the bases of economic and social development. It is the starting point of many value chains. Due to their ever increasing energy demand, the demand for uranium is expected to shift gradually from the old 'nuclear' countries towards emerging economies, such as China and India. Exploration is increasing and various countries are joining or re-joining the league of (potential) uranium producers (NEA and IAEA 2010). Most of these activities take place outside Europe as it has become increasingly difficult to obtain social license for new mining operations or even the extension of existing ones. In addition, uranium ore grades in Europe are generally low, making exploitation not economically viable under current market conditions.

The underlying challenges with which mining in general is confronted are land-use and resource use, as well as socio-political conflicts. Indeed, throughout the world, mining faces public acceptance challenges and growing social criticism in both, developed and developing countries. These can be traced back to environmental issues caused by a nonchalant attitude in the past of many mining companies towards environmental protection. Mining can have a significant impact on the surrounding environment and often devalues large areas of land. Historically, inadequate actions were undertaken to remediate mining-affected landscapes (IAEA 2005). Today, however, at least in the more developed countries, closure and remediation plans are an integral element of the operational license and financial securities are required to obtain it. Furthermore in developed countries, political and financial pressure often forces foreign operators have to apply the same stringent regulations abroad that would apply at home. However, having regulations in place is not sufficient and their enforcement remains a critical issue.

The global dimension of mining impacts is increasingly being recognised in the EU and world-wide. Various initiatives aimed at making mining more sustainable have been launched (e.g. European Commission 2011). For uranium mining, international organisations, most notably the IAEA, have supported the development and application of good practice (e.g. IAEA 2010). Otherwise industry itself is recognising the issues and undertakes to address them on a voluntary basis through self-commitment, for instance as members of the International Council on Mining & Metals (ICMM, http://www.icmm.com/).

The Group on Earth Observations (GEO, http://www.earthobservations.org/) is concerned with the responsible management of natural resources. Sound environmental management of mining and milling can avoid environmental and social impacts and the resultant high remediation costs. Understanding and monitoring the impacts is, therefore, of concern to all stakeholders (government bodies or agencies, local authorities, industry, environmental groups, individual citizens). However, the technology platform to support such environmental monitoring is diverse, geographically inconsistent, site specific, lacks integration across technologies and is hence far from complete. A gap also exists within GEO's Global Earth Observing System of Systems (GEOSS) that currently concentrates on natural hazards and climate change (http://www.earthobservations.org/geoss.shtml/).

Uranium production life-cycle impacts

Any materials flow due to (uranium) mining is likely to cause some environmental impact. A careful engineering of the life-cycle (Fig. 1) of mineral resources-based products can help to minimise such impacts (Falck 2006,2009). Minimising (waste) material flows is also in the interest of mine operators, as they are a significant cost factor. There are, however, limitations to this, as high-grade resources close to the surface gradually become depleted world-wide, requiring reliance on lower-grade ores and to those at greater depth. Both factors result in more unwanted extraction, though certain techniques applicable to uranium ores, such as *in situ*-leaching (ISL) can keep this low (IAEA 2004). While a trend to lower-grade ores is unavoidable, responsible management of the resulting mining and milling residues will help to reduce the land-use and environmental impacts.

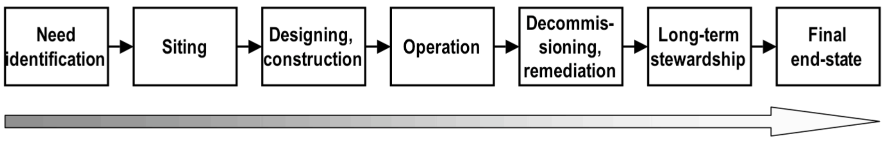

Fig.1. The life-cycle of a uranium production facility (IAEA. 2006)

Major impacts can arise at all stages of the life-cycle:

- ***Exploration*** – including surveys, field studies, drilling and exploratory excavations; some impacts and waste generation already occur at this stage.
- ***Project development*** – includes construction of roads, access tunnels and shafts, erection of hoisting machinery, treatment plants and ancillary buildings (laboratories, administration, social), construction of service infrastructure (process and drinking water supply, sewerage, power generation and distribution), and construction of waste management facilities (mine waste dumps, tailings ponds, leach pads).
- ***Mine operation*** – underground or open-cast excavations, mine dewatering, *in situ* or heap-leach operation.
- ***Beneficiation*** – on-site processing may include comminution to reduce particle size, flotation using selected chemicals, ore leaching with a variety of chemical solutions; associated transport and storage of ore and concentrates may be a handling risk and can result in localised site contamination.
- ***Mine closure*** – remediation is best done progressively rather than at the end of life of the mine. While the closure and remediation is intended to mitigate environmental impacts, it is important that it does not itself create secondary effects through excessive fertiliser use, spread of weeds, silting and incompatible landscape features.
- ***Long-term stewardship*** – the chosen remediation strategy and associated technical solutions for mining and milling residues have to monitored for their continued effectiveness; failure of technical solutions and the stewardship programme supporting them can lead to environmental impacts.

The project EO-MINERS

Though not specifically addressing uranium mining, the European Commission Framework Programme 7 project EO-MINERS (http://www.eo-miners.eu/) aims at integrating new and existing Earth Observation (EO) tools to improve best practice and to reduce mining-related environmental and social impacts by

- introducing innovative EO tools and services to the mining industry,
- providing accuracy and quality measures for EO products,
- demonstrating the application of EO in different case studies,
- fostering the dialogue between mining industry and environmental organisations based on EO-derived information, and
- generalising the results obtained for use in operational mining applications.

Forecasting impacts, land-use and relevant remediation measures requires the development of predictive tools. GIS using EO data will enable the visualisation of prospective evolutions over time. Cumulative impacts must be adequately addressed at regional scale.

The scientific and technical objectives of EO-MINERS include *inter alia*:

- To assess policies and strategies of different stakeholders (operators, regulators, public) and resulting information needs;
- To assess environmental, socio-economic and other sustainable development issues surrounding mining operations and to define indicators for their development that can be addressed using EO-techniques;
- To further demonstrate the capabilities of integrated EO-based methods and tools in monitoring, managing and thus contributing to reducing environmental and social impacts of mining during its whole life-cycle;
- To provide reliable and objective information on affected ecosystems and societies that will serve as a basis for a sound dialogue between industry, regulators and the public;
- To summarise and document procedures of both, technical and social nature as a baseline for a compendium of best practices that will assist and inform the ongoing dialogue between the public, regulators and the industry.

Three study sites in the Czech Republic (open-cast lignite mining), South Africa (open-cast coal mining) and Kyrgyzstan (gold mining) provide the focus for the development work.

Enabling stakeholders through information

Different stakeholders are informed to different levels about issues relevant to mining or milling. Lack of information, especially independent and unbiased information can hinder effective processes of social decision-finding. This problem not only affects the general public, but also local or regional authorities who are not directly involved in licensing procedures, but whose area of jurisdiction is or will be affected by the operations. Providing reliable and objective information is one element in enabling stakeholders to partipate in decision finding processes in a meaningful way. Information is more than data; it is the context (i.e. reference cases, benchmarks, best practice examples, etc.) that gives meaning to the data, generating understanding and knowledge for stakeholders who may not have the training to understand or interpret (raw) data (IAEA 2002).

Meaningful information on complex environmental or social issues can often be provided in the form of indicators. Indicators provide a metric of the state of (complex) systems or of issues, or for trends of their development when measurements are repeated over time. Indicators are useful tools to reduce a complex set of diverse data into a manageable set for policy making and to monitor changes during policy implementation.

Hence, indicators must be based on measurable quantities in order to be useful and as such can be intensive or extensive properties, being either independent of or dependent on the size or volume of the system under consideration. For instance, the pH-value is an intensive property of water and can indicate the general state of surface and groundwaters for instance with respect to their life-supporting functions. Conversely, the number of schools in a particular region has to be related to some meaningful extensive property, e.g. the number of people living in that region, in order to be an indicator for the provision of education. One has to carefully to distinguish between intensive and extensive properties. For instance, the amount of mine waste generated is meaningless as indicator, if not put into relation to e.g. the total of metal value recovered. If related to the ore grade, it would allow the assessment of the efficiency of the exploitation of the resource. Even then it will need to be related to the quality of mine waste management since sometimes a smaller quantity of poorly managed waste could pose a higher environmental risk than a larger quantity of well managed waste.

Thus indicators can be single parameter values, requiring a single measuring technique only, or may need to be compounded from various parameters that are measured using different techniques.

The EO-MINERS strategy to derive indicators

It is widely recognised that the development of indicators that are meaningful to a wide variety of stakeholders is a social and not an engineering process. The social process defines what has to be indicated for whom and why. However, scientists and engineers, who themselves are stakeholders in the process, have to evaluate whether the candidate indicators can be related to measurable quantities, thus making the indicators operational. Hence, several work packages (WPs) in EO-MINERS inform the process of deriving and defining indicators. EO-MINERS employs a multi-pronged approach to develop candidate indicators (Falck et al. in prep), consisting of a heuristic development by expert elucidation (WP 1), examination of site-specific conceptual models for the three study sites to inform the indicators (WP3), and a semi-deliberative approach (WP1/5), elucidating input from stakeholders outside the project team. In this way not only the various technical stakeholders within EO-MINERS will contribute to a valid and useful set of indicators, but also a wide variety of stakeholders outside the project team. This process is going through several iterations in order to consolidate the set of indicators. This consolidated set of candidate indicators, after it is reviewed by EO specialists in order to assess their measurability using EO techniques, will inform the process of EO services development and will be subject to a final stakeholder evaluation towards the end of the project. Table 1 gives the an overview over the categories for candidate indicators.

Table 1 Categories of candidate indicators for possible mining-related impacts.

Category		Category	
A	Land-use	G	Geotechnical hazards and accidents
B	Mass Flows	H	Industrial and other accidents
C	Energy Flows	I	Social impacts
D	Air quality and other nuisances	J	Regional development
E	Water quality	K	Economic vulnerability/resilience
F	Transport		

Pertinence in an uranium production context

EO offers a unique opportunity to collect spatial data for better assessment of mining-related environmental and social impacts during all phases of a facility's life-cycle. The tools and processes under developmen will help to inform deliberative decision-finding procedures as stipulated by agencies such as the in IAEA or local regulators. The IAEA have noted that in order to arrive at sustained and accepted long-term solutions, in particular in a remediation context, all stakeholders have to be involved in the decision-finding processes (IAEA 2002,2006).

Decision-making along the life-cycle of a uranium production facility faces a number of technical and societal challenges. There are

- uncertainties regarding the result of site assessment under normal conditions leading to the decision today (e.g. data gaps in the inventory, insufficient site characterisation, integrity of engineering, …), and
- uncertainties about the future; this covers both nature and the range of natural phenomena / 'events' in the future and the influence of time on the internal evolution of the designed structures / 'processes'.

At the same time managers are faced with the challenge to

- obtain and maintain public trust;
- achieve institutional constancy or to ensure continuity of e.g. long-term stewardship activities over many generations; and
- learn from past and ongoing experience as technological and management means for implementation are developed.

Independent access to information about the site concerned will support the development of mutual trust, allowing the public and the regulators to monitor whether the site develops as indicated and anticipated by the operator. It also facilitates mediation in the case of dispute. Taylor-made earth observation services in particular allow the monitoring of important parameters of site development at relatively low cost and often in near real-time. Such aspects can be crucial in maintaining mutual trust, as often critical changes, e.g. to the geotechnical state of tailings ponds or to the distribution of surface radiation are not readily visible from the surface or not observable without a dedicated measurement campaign.

Monitoring and surveillance of environmental impacts, including radiological impacts, tend to be more closely scrutinised in a uranium production context than in the context of other raw material production. Though this is not necessarily valid from a scientific point of view, this is certainly the case from a public perception and often from a regulatory perspective. Adequately visualised EO products allow the general public and often also the regulators to better 'see' what is happening at a site. GIS-supported visualisation also allows the stakeholders to better see how site developments might relate to their personal situation, e.g. distances to and possible impacts on their private home or their community.

Conclusions

The project EO-MINERS is still at an early stage. However, first experiences with stakeholder interaction and confronting stakeholders with possible EO-services have been gained. Though the situations at the study sites may not be as controversial as perhaps at uranium production sites, the situation in South Africa may be confrontational enough to draw some conclusions. The fact that during a second round of stakeholder interaction in South Africa very few suggestions for amendment to the candidate list of indicators were made, places a certain confidence into their relevance with respect to scope and coverage.

A particular conceptual difficulty arises insofar as the project team interacts with local mining-related social processes and may itself become a stakeholder in these. The project naturally has only a limited life-time and it is not clear, if and how a stakeholder dialogue will or can be sustained by the local project partners beyond the project life-time. The risk is that processes are started and expectations are raised among the various stakeholders that cannot be fulfilled by a research project. Furthermore, these project-induced processes may interfere with already existing mining-related social processes and may turn out to be counterproductive. Indeed, it was the fear of some stakeholders interviewed, in particular the mine operators, that the project would upset the local situation. Nevertheless some local interest groups expected that the project would help them to achieve their interests and goals. These expectations indeed indicate the need for shared information and in this sense validates the project's objectives. In a real situation, beyond the study sites, it would be essential that a clear mandate is given to those developing and fostering these social processes.

In a sense, projects such as EO-MINERS are 'a solution in search of a problem'. This is typically the starting point encountered in the interaction between the project team and outside stakeholders. The majority of stakeholders interviewed had not been aware of the possibilities of EO techniques and in particular of remote sensing techniques. This clearly indicates the need for a sustained dialogue between EO service providers and stakeholders outside the project, if the project aim of enabling these stakeholders should be achieved.

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