



French uranium mining sites remediation

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Abstract. Following a presentation of the COGEMA's general policy for the remediation of uranium mining sites and the regulatory requirements, the current phases of site remediation operations are described. Specific operations for underground mines, open pits, milling facilities and confining the milled residues to meet long term public health concerns are detailed and discussed in relation to the communication strategies to show and explain the actions of COGEMA. A brief review of the current remediation situation at the various French facilities is finally presented.

1. INTRODUCTION

During nearly half a century, France produced about 73 000 tonnes of uranium. Ore deposits were numerous and the ore grades were low, varying from half a kilogramme to several kilogrammes of uranium per tonne.

More than two hundred mining sites produced 165 millions tonnes of waste rock and 52 millions tonnes of ore. Eleven mills were built, either conventional or heap leaching, leading to 22 storage sites for mill residues. COGEMA is the only manager of these sites. Only one mine is still in operation; it is scheduled to shut down next year.

2. REMEDIATION WORKS, A CONCRETE EXAMPLE OF THE ENVIRONMENTAL STRATEGY OF THE COGEMA GROUP

Environmental protection became, from the early seventies, a permanent and priority objective of the COGEMA group during all the steps of its activities. This objective does not ignore the consequences of past practices which occurred at a time when these practices derived from a lack of environmental knowledge and sensibility.

Remediation work applies to facilities left after the end of operations and include mines, mills and the storage of waste rock or milling residues.

For COGEMA, the main objectives of the remediation work are as follows:

- to ensure a perennial stability, in term of security and public health,
- to reduce as low as reasonably possible the residual impacts,
- to prevent any risk resulting from an inopportune intrusion,
- to reduce the surface area that requires rental payments on other use charges,
- to favour the opening of sites for industrial or leisure activities,
- to succeed in landscape reclamation in concert with local intervening parties.

3. A SPECIFIC REGULATORY FRAMEWORK

Uranium mining activities are regulated under the general juridical framework of: the «Code Minier» (Mining code), completed by the «Règlement Général des Industries Extractives» (General Regulation on Extraction Industry), with particularities resulting from the radioactivity of the materials handled. Mills and storage locations are classified as ICPE «Installations Classées pour la Protection de

l'Environnement» (Classified Facilities for Protection of the Environment). These laws are complemented by more general regulations on Water, Air, Wastes, Noise and Landscape Protection.

Their control and supervision are ensured through additional regulations defined by the local «préfets» (prefects) with the help of services that specialize in environmental protection.

4. SITE REMEDIATION ACTIVITIES (see references [1, 2, 3, 4])

4.1. The phases of site remediation

- The first phase consists in defining the strategy best adapted to the local site considering general objectives within the regulatory framework.

The database necessary to define this strategy includes the following items: history of activities, waters circuits, radioactivity mapping, mapping of sampling locations, past studies together with initial topography, geology, hydrogeology and geophysics of the sites.

This initial evaluation phase is complemented by specific complementary studies generally carried out by recognized outside experts. These studies characterize the materials, the storage areas, the potential local impact and the environment. The environmental aspect investigates the geology, hydrogeology and site geophysics, hydrology, ground stabilization and the local vegetalization. Subsequent remediation work includes the following activities:

- A project plan is prepared to define the work required to carry out: earth moving, covering with various types of materials, compacting, site drainage water treatment, special civil works, dismantling of the installations and the disposal of products derived from the dismantling operations. The final status of the landscape is examined by computer topography simulations.
- During the working phase, any necessary adjustments are carried out.
- At the end of the remediation work, the final status includes control of monitoring of the topography, water circuits, radioactive mapping, verifying that the residual radioactivity is consistent with the local regional radioactivity and revegetation.

These activities are complemented by an internal audit using COGEMA's quality assurance procedures.

All of these works are carried out under the supervision of the regulatory authorities (Prefect and its services) which finally deliver an «Arrêté Préfectoral» attesting to the good quality of the work, possibly specifying future complementary work and also defining rules for future site monitoring.

- During site monitoring, regular checks are made to observe the gradual return to a natural and stable equilibrium. After a probatory period, COGEMA may ask for a reduction of the level of controls and eventually obtain permission for a definitive abandonment of the site and for its reuse for other activities by local parties. In all instances, however, the storage sites for milled ore residues storage which must remain under COGEMA's responsibility and supervision.

4.2. Underground mines, security for the public in the long term

At the end of mining operations, the priority is given to long term security for the public. Each communication with the surface is blocked to prevent any intrusion and the stopes are stabilized to

avoid caving. The proposed closure procedures are submitted to regulatory authorities and may be complemented by specific studies.

4.3. Open pits, its landscape impacts

First, the pit is filled with waste rock (several thousands or upto a million tonnes of earth may be moved) and the pit walls may be resloped with explosives for increased stability. In some cases, the pit may be transformed into a water impoundment for irrigation or other purposes.

4.4. Milling facilities

4.4.1. Dismantling and disposal of the dismantled facilities

After cleaning, the mill equipment is dismantled and sent to other identical facilities.

Two types of equipments may be considered:

- (1) front end equipment, related to ore preparation (crushing, grinding...), may be cleaned and sold to the operators of other extractive industries. Before selling, this equipment is checked to confirm that it meets regulatory specifications. Also, the traceability of the equipment is ensured,
- (2) back end equipment (which « saw » uranium solutions) must not be sold; it is buried within the milled ore residues. The location is carefully mapped and the disposal is supervised by regulatory authorities.

The buildings are then dismantled, concrete and other products are also buried within the milled ore residues. The grounds are cleared to the original level and rechecked for radioactivity. Covering and landscaping may complete the operations.

4.4.2. Confining the milled residues for public health

In France the milling residues are generally covered with waste rock (the Forez site, where residues are kept under waters is an exception).

The waste rock cover materials which come from the site, may be complemented with external materials, if necessary for quantity, quality or other exceptional reasons. The purposes of the cover is to:

- ensure a safe mechanical protection, resistant to erosion and to potential intrusions;
- limit the exposure to external radiation and radon emanation.

Preliminary tests are carried out to verify the efficiency of cover products. These tests include both petrographic and geotechnical examinations. Pilot units are also used to test various types of materials, compacted or not, using various cover depths and possibly combining multi-layers disposals.

Based on expert advice, the geometry of the protection dams surrounding the milled residues may be resloped and reinforced to improve the long term erosion stability of these dams.

During the course of studies on various mill tailings, it was discovered through geochemistry and petrographic analyses, that the natural leaching of radium was limited (less than 1% of the radium for stored mill tailings compared to 10% for fresh mill tailings). This can be explained by the rapid development (less than 30 years) of high surface secondary minerals such as smectite, iron oxy

hydroxides and gypsum that can trap 95% of the total radionuclides and associated heavy metals. This can be called « self confinement », which improves the chemical stability of the tailings [5, 6, 7].

4.5. Continuous monitoring

The operator must maintain as low as reasonably possible any impacts on the public and the environment; this includes preventing the dispersion of radioactive products and continuously scrutinizing these impacts through systematic and regular supervision.

This supervision is carried out by monitoring all of the transfer pathways which may be followed by uranium and its daughter products (especially radium and radon) and also by other elements such as heavy metals.

The monitoring requires frequent analyses on samples from the following sources:

- waters (rivers, underground waters, wells...),
- air (external and internal exposures, radon and dusts inhalation),
- the food chain (milk, vegetables, samples of flora and fauna...).

Water quality is a fundamental measure of environment quality. The following monitoring and control operations are used:

- on mining sites, hydrological and hydrogeological studies before and after mining operations produce a satisfactory knowledge of the water chemistry and the flow patterns. Before mine flooding, studies are carried out to predict the locations of seeps and ground water excursions that may require collection and treatment.
- at mill tailings sites, the installation of selective drainage systems allow for the separation of waters requiring treatment from those that do not; this limits the volume of water requiring treatment. Sludges resulting from water treatment are stored on site with other residues of the same nature.

For the long term, it is most important to keep a permanent record of the sites. This involves the following three fold strategy:

- (1) COGEMA remains owner of the storage facilities,
- (2) liabilities are listed in the licence issued at the end of remediation and registered to the « Hypothèques » (Land ownership register),
- (3) a national inventory of radioactive wastes, including residues from uranium ore processing, is updated annually by ANDRA « Agence Nationale des Déchets Radioactifs » (National Agency for Radioactive wastes) [8].

5. COMMUNICATION, TO SHOW AND EXPLAIN THE ACTIONS OF COGEMA

Communication strategies are to conform with the local constraints of each site and the ongoing circumstances (shuting down period, local oppositions, etc...). COGEMA looks for a constructive dialogue with regulatory authorities, local authorities and opponents. This dialogue is achieved by participation in meetings, widespread publication of environmental survey results, site visits etc. A locally assigned COGEMA representative is in-charge of the direct contacts with local populations to hear about the concerns of all stake holders.

Internal communication is important and is not neglected: listening to the staff, the exchange of experiences at various sites, coherence of words and acts and cohesion of various shifts, are all absolutely necessary.

6. MILLING FACILITIES WITH ONGOING OR FUTURE PLANS FOR REMEDIATION ACTIVITIES

Jouac is the only facility still operating in France. It operates through a 100% owned subsidiary of COGEMA, the « Société des Mines de Jouac ». Remediation plans are being updated, because operations will cease in mid-2001.

Remediation activities are still on going at the following facilities: Bessines (the industrial site grouping Lavaugrasse and the various Brugeaud storage sites), Lodève, St Pierre du Cantal and Bertholène.

Bessines is a complex industrial site where underground and open pit mining started in 1955; milling and heap leaching developed after 1958. Lavaugrasse (a ring dyke type impoundment) was the first mill tailings storage facility; subsequently the tailings were stored in the Le Brugeaud open pit. Both of these sites are now covered, but an opening in the cover has been kept on top of Lavaugrasse to store sludges from the water treatment plants at the mill and from mining sites in the vicinity. Remediations work is scheduled to end in December 2000.

Lodève ceased operations in 1997. The mill has been dismantled and the contaminated equipment, scrap materials and the demolition products were stored within a dedicated area atop the tailings. These tailings and the demolition products are now covered: the remediation work is scheduled to end in December 2000.

Remediation is progressing slowly at **Saint Pierre de Cantal**, because covering the last sludge decantation pond is limited to summer operations due to the presence of unconsolidated clays.

In **Bertholène**, remediation is on stand by. At this heap leaching facility, the cover material is rich in sulphides which have not been completely leached. Consequently, after resloping, installation of the final cover has been postponed in order to allow for continuation of the natural decomposition of the sulfide minerals. The water treatment plan is being kept in operation to continue the treatment and release of waters that meet regulatory limits. The sludges are filtered and trucked to Jouac for uranium recovery.

7. CONCLUSION

Following the remediation of mining sites, the chief objective of COGEMA is to support future development of the mining areas.

This can be carried out through reindustrialization operations, helping with new installations or assisting local industries by reusing existing facilities such as offices or other facilities.

Open pits often occupy large surface areas in rural locations where water management is an omnipresent question. Water impoundments in these pits can be designed for irrigation purposes and the development of the aquatic fauna or for more original purposes such as fishing reserves for rare species or diving centers.

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