Radiological hazards from uranium mining.

Bruno Chareyron

Nuclear Physics Engineer and manager of the laboratory of the French Commission de Recherche et d'Information Indépendantes sur la Radioactivité (CRIIRAD), Bruno.chareyron@criirad.org

Uranium and its by-products

All natural uranium isotopes (^{238}U, ^{234}U, ^{235}U) are radioactive. The most common isotope, ^{238}U, decays naturally into a succession of 13 other radioactive nuclides. All are metals (thorium 230, radium 226, lead 210, polonium 210, etc) except one, radon 222, which is a radioactive gas.

Uranium and its decay products emit various ionizing radiation such as alpha and beta particles and gamma radiation.

The earth's crust has a typical ^{238}U activity of about 40 Becquerels per kilogram (Bq/kg). Since the creation of the Earth, this level of radiation has decreased by two-fold because ^{238}U half-life is very long and equal to the age of the planet earth (4.5 billion years).

This presence of natural uranium in the earth crust, and therefore to a lot of building material made out of natural minerals, is the main source of exposure of mankind to ionizing radiation.

This is especially due to the diffusion of radon gas from the soil and materials containing uranium- and its accumulation in the air inside buildings and dwellings. This radiological hazard is now well documented and International (The International Commission on Radiological Protection, ICRP) and European (Euratom) regulations determine action levels and recommendations in order to lower radon concentration inside buildings and reduce cancer risks.

The health impacts of ionizing radiation even at low doses include the increase of various types of cancers , genomic instability, life-shortening and negative impacts on all the body functions.

Uranium extraction increases health risks from now ….

The activities of uranium ores have an important variability. Typical ore with a uranium content of 0.2 % has a ^{238}U activity of about 25,000 Bq/kg. The total activity, including all the ^{238}U by-products and the ^{235}U decay chain will therefore exceed 360,000 Bq/kg. Such material should be managed with a great deal of caution due to the risks of exposure to ionizing radiation.

As long as the ore remains buried underground - the depth being a few tens and even a few hundreds of meters - the radiation levels at the surface of the earth remain low and usually have the same order of magnitude as of typical natural radiation levels. Except in places where the ore reaches the ground surface (typically a few square metres), the protection offered by the soil is sufficient to reduce the risks for the people living in the area :

- Alpha and beta particles are stopped by a thin layer of soil (much less than 1 cm.)
- Even penetrating gamma radiation does not cross a layer of soil of a few meters.
- Most of the radon gas remains trapped inside the soil. Because of its short half-life (3.8 days) it disintegrates inside the soil during its migration before reaching the biosphere.
- The amount of nuclides in underground water remains low if the minerals containing uranium are trapped in unpermeable layers.

But the radiological situation is reversed as soon as the uranium extraction begins:

- Radioactive dust is transferred to the atmosphere by mining operations, the extraction and crushing of ore, uranium milling, management of waste rocks and tailings. This has to be emphasised because some of the nuclides contained in the uranium decay chains (such has thorium 230) are very radiotoxic when inhaled. When inhaled, a given activity of actinium 227 (part of the ^{235}U decay chain) gives a radiation dose 5 times higher than the same activity of plutonium 238.

- Radon gas is transferred to the atmosphere by the vents of the mines and by diffusion from radioactive rocks and tailings.
- Surface and / or underground water is contaminated by uranium and its by products. Some of them are very radiotoxic when ingested. Lead 210 and polonium 210 for example are among the most radiotoxic elements. When ingested, a given activity of polonium 210 gives a radiation dose 4.8 times higher than the same activity of plutonium 239.
- Huge amounts of waste rocks, with activities exceeding the normal activity of the earth crust by one to two orders of magnitude are dispersed into the environment and may be used for landfill, road construction or even building.
- Huge amounts of radioactive tailings (with typical total activities exceeding 100,000 and even 500,000 Bq/kg) are generated.

… to an indefinite future.

Even decades after the shut down of uranium mines and mills, the radioactive contamination of the environment will remain.

This is due to the fact that ^{238}U half life is very long (4.5 billion years). But even the tailings - whose uranium content is lower than the initial uranium concentration in the ore - will remain radioactive on the long term because of the presence of thorium 230 and radium 226 whose half lives are 75,000 years and 1,600 years respectively.

This long term impact will occur in many ways.

Some examples are given below, based on studies performed by the CRIIRAD laboratory since 1992 in France and Niger:

- Accumulation of radioactive metals in sediments and plants of **rivers, ponds, and lakes** by contaminated waters from former mines, tailing deposits, uncovered waste rock deposits, etc.. In many cases, sediments, aquatic plants and soil from river banks have such a contamination that they deserve the terminology: “radioactive waste” (^{238}U activity or the activity of some of its by-products were exceeding 10,000 Bq/kg).
- **Radioactive minerals** from the mine are kept by local people or former workers unaware of the radiological hazard. CRIIRAD discovered recently in France that an inhabitant was keeping a sample of waste rock from a former mine with a dose rate of 1 milliSievert per hour. Staying at a distance of 1 meter during only 10 minutes per day will lead to exceeding the annual maximum permissible dose for members of the public i.e. 1 milliSievert per year.
- Re-use of **radioactive waste rocks** for landfill. Recently CRIIRAD demonstrated that several places near a French uranium mine were contaminated including the car park of a restaurant, the yard of a farm, several sawmill buildings, kilometres of path and roads, etc. In one case a sawmill building had been built directly on the radioactive waste rocks taken at the mine. Due to gamma radiation and radon gas accumulation, the radiation dose inside the building could exceed the annual maximum permissible dose for members of the public by a factor exceeding 20. The mining company had therefore to pay during year 2003, for the evacuation of 8,000 m3 of radioactive waste rock from the sawmill back to the former open pit.
- Dispersal of contaminated **scrap metal** from the mines or mills. During 2003, CRIIRAD discovered in Niger that radioactive scrap metal was sold in Arlit city. One piece was a pipe from the uranium mill. It was sold without previous decontamination and the ^{226}Ra activity of the crust inside the pipe exceeded 200,000 Bq/kg. The mining company COGEMA (now known as AREVA) stated that before 1999, no radiation limit was used for scrap metal recycling. Later, a dose limit of 1 microGray per hour at a distance of 50 cm had been applied. Such a limit is much too high. If someone uses such metallic pieces inside his house – which is common in African countries –staying 3 hours per day at a distance of 50 cm will lead to exceed the annual maximum permissible dose for members of the public.

- The situation in France and Niger, shows that the disposal of **radioactive tailings** and their control on the long term, has not received yet satisfying solutions.

Conclusion

At all the French uranium mines where it made radiological surveys, the CRIIRAD laboratory discovered situations of environmental contamination and a lack of proper protection of the inhabitants against health risks due to ionizing radiation.

This is due to the lack of proper regulations, a poor awareness of the radiological hazards associated with uranium and its by products, insufficient monitoring practices, the lack of controls by the local and national administration, etc. When the mines are shut down, the radioactive waste remains, and it seems that the costs for managing this radioactive legacy will have to be largely supported by the society, not the companies.

If such a situation occurs in a so-called "developed country" one should fear what could actually happen in other parts of the world.

The preliminary mission made by CRIIRAD to Niger confirmed this fear.

In Gabon, the improvement of the conditions in which tailings are disposed is being paid for by the European Community and not by the mining company. The former workers and local population do not benefit any more from medical care and they receive no compensation when they become sick, years and decades after the mine shut down.

A1 / Short presentation of CRIIRAD and its laboratory

CRIIRAD (Commission de Recherche et d'Information Indépendantes sur la RADioactivité / Commission for Independent Research and Information about RADiation) is a non-governmental and non-profit organisation that operates according to the 1901 French law and works to improve **information and protection of the public** against **ionizing radiation**.

CRIIRAD objectives are:

- to give people an access to scientific information about the impact of ionizing radiations and the actual radiological contamination of their environment,
- to improve people's ability to participate (as citizens) to the actions and decisions in the field of environmental protection, protection of public health, the rights of future generations,
- to give people scientific tools in order to help them to make independent preliminary assessments of a radiological contamination (CRIIRAD is organising seminars "how to use your own Geiger Muller counter),
- to circulate information on radioprotection through a web site (www.criirad.org, leaflets and brochures, books, lectures, seminars, videos, etc.(see a selection of written material).

CRIIRAD was created in **May 1986** by French citizens willing to obtain reliable data on the actual intensity of radioactive fallout from **Chernoby**l, the consecutive food chain contamination and the related risk for their health. At that time, the French Government stated that absolutely no radioactive contamination from the Chernobyl Nuclear Plant could have reached the French territory.

In order to provide such information, CRIIRAD set up in Valence (France) an **independent laboratory** [1]specialised in radiological analysis and radio-ecological studies. Since 1986, the CRIIRAD labora-

[1] The CRIIRAD Laboratory is equipped with 2 gamma spectrometry devices in order to measure gamma emitting radionuclides, a liquid scintillation counter in order to measure tritium and alpha and beta emitters and on site equipment (portable radiation meters, doserate meter and gamma spectrometer, radon monitor). The CRIIRAD gamma spectrometry laboratory regularly participates in French (IRSN) and international (IAEA) programs of intercomparaison and proficiency tests. It is certified by the French

tory has implemented more than 20 000 measurements by gamma spectrometry and hundreds of environmental studies in France and abroad.

The CRIIRAD laboratory demonstrated that the French territory (soil, food chain) had been contaminated by radionuclides to values exceeding health standards. Due to the lack of proper information and protection of the public, CRIIRAD and the French Association of Thyroid Disease Sufferers (AFMT) made a complaint in March 2001 to the Court of the French Republic.

As is illustrated hereafter (Annex A1-1 references), the CRIIRAD laboratory is experienced in the surveillance of levels of **radioactivity in air, water, soil and the food chain,** whatever be the source term (natural radiation, enhanced levels of natural radiation, nuclear fuel cycle, research facilities, military facilities, hospitals, non nuclear industry).

The CRIIRAD laboratory is used to make independent and critical analysis of monitoring facilities and environmental assessments established by National authorities or plant operators.

Since 1986 CRIIRAD demonstrated **weaknesses of official monitoring systems** in many areas : Chernobyl fallout, impact of uranium mining and milling, nuclear plants, reprocessing plants, military plants, nuclear research centres, hospitals, etc.

CRIIRAD is devoting its work at improving knowledge on actual radioactive discharges, environmental impacts and dose calculations in order to contribute strongly to the optimisation of doses to **workers and the public**.

For this purpose CRIIRAD is conducting research and radiological expertise as well as training cessions and seminars[2].

CRIIRAD is totally **independent** from the State, National Authorities and the Nuclear Industry.

Its funding comes from the **citizens** which are supporting the controls (approximately 4 000 citizens) and the customers for which the laboratory is working (justice, city councils, county councils, regional councils, NGO's, private citizens, companies, administration, etc…)

CRIIRAD experience is now recognised internationally and people from abroad ask for CRIIRAD scientific support. For example, during the last 4 years, the CRIIRAD laboratory conducted studies :

- In **Nige**r for a local NGO called AGHIR IN MAN (see pictures below). This mission was organised in order to help the local NGO for making an independent evaluation of the radiological impact of the **uranium mines** and mills situated at Arlit. CRIIRAD discovered several problems : radioactive scrap metal from the uranium mill was sold on the city market, uranium contamination of drinking water exceed WHO standards, radioactive tailings from the uranium mill were stored in the open air, etc.
- In **Italy** (Sardinia) for local NGO's (WWF) in relation with the potential radiological impact of a **US nuclear submarine** base.
- In **Spain**, at the request of an independent journalist. CRIIRAD demonstrated that a company (ERKIMIA) was manufacturing **food additives** (bicalcic phosphates) containing elevated concentrations of radioactive Lead 210 and Polonium 210.
- In **Japan** for Greenpeace International and Greenpeace Japan. The mission was designed to evaluate the radiological situation before starting of a **Reprocessing Plant** at ROKKASHO Mura. Through press conferences and meetings, CRIIRAD also tried to improve people awareness about the future radiological contamination to be induced by radiological discharges to the atmosphere and the Pacific Ocean.
- In French **Polynesia** at the request of a special commission set up by the local Parliament and dealing with the consequences of past atomic tests.

CRIIRAD support is required by many individuals and organisations in France and Abroad. But CRIIRAD resources are not sufficient to provide help to all the organisations that need it.

Department of Health for the measurement of gamma emitting nuclides in the environment and the food chain and for radon diagnosis in public buildings.

2 CRIIRAD organised in April 2005 a Seminar at the Conseil Régional Rhône-Alpes in Lyon (FRANCE) : "Radioactive Contamination and people protection" with International experts (Dr Baverstock, Prof Goncharova, Prof Lajuk), NGO representatives, etc..

To contact CRIIRAD laboratory:

CRIIRAD
Commission de Recherche et d'Information Indépendantes sur la Radioactivité.
Immeuble CIME
3eme étage
471 av Victor Hugo
26 000 Valence
FRANCE

E-mail : bruno.chareyron@criirad.org
Phone : (33) 04 75 41 82 50 (general number)
Phone (33) 04 75 41 82 57 (B Chareyron, direct number)
Fax : (33) 04 75 81 26 48
Web site : www.criirad.org