

# Too Heavy A Price To Pay?

a memoir submitted to the

Bureau d'Audiences Publiques sur l'Environnement (BAPE)

concerning a

**Permanent Moratorium On  
Uranium Exploration and Mining in Quebec**

presented by

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*The Canadian Coalition for Nuclear Responsibility (CCNR)  
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The Canadian Coalition for Nuclear Responsibility (CCNR) – also known as Le Regroupement pour la surveillance du nucléaire (RSN) – is a non-profit pan-Canadian organization based in Montreal and incorporated federally.

Founded in 1975, CCNR/RSN is dedicated to education and research on all issues related to nuclear energy, whether civilian or military – including non-nuclear alternatives – especially those pertaining to Canada.

CCNR/RSN has intervened in environmental assessment hearings and provided testimony at public inquiries in every province and territory of Canada, and RSN researchers have given expert testimony in courts of law in both Canada and the USA.

CCNR/RSN has disseminated technical information in laymen’s language on such topics as uranium mining, reactor safety, radioactive waste management, proliferation of nuclear weapons, health effects of atomic radiation, and non-nuclear energy strategies.

CCNR/RSN regularly provides information on nuclear issues, as requested, to journalists, researchers, communities and decision makers.

In Quebec, CCNR/RSN has been a major player on nuclear issues for almost forty years. Here are a few highlights of RSN activities in the province:

- CCNR/RSN submits a substantial position paper on nuclear power and alternative energy to the government of René Lévesque, two years before the government declares a moratorium on any new nuclear reactors in Quebec;
- CCNR/RSN provides speakers for a series of public meetings in the Eastern Townships and Vermont opposing the US DOE proposal to locate a high-level nuclear waste repository in the Northeast USA, culminating in Premier Bourassa’s declaration that Quebec will never allow a permanent nuclear repository on Quebec territory or on its borders;
- CCNR/RSN provides educational materials related to a district-heating nuclear reactor to be donated by AECL to the CHUS (Centre Hospitalier de l’Université de Sherbrooke), resulting in a unanimous decision by the CHUS’ Board of Directors to reject AECL’s offer;
- CCNR/RSN participates in the Public Debate on Energy held under the auspices of the Quebec government, leading to the creation of the Régie de l’Énergie.
- CCNR/RSN intervenes in two separate Environmental Assessment (BAPE) Hearings on nuclear waste storage facilities at Gentilly, leading to a recommendation that the government of Quebec establish a clear policy for the long-term management of radioactive wastes generated by the Gentilly-2 nuclear reactor, before any approval is given for the refurbishment of G-2.

## BACKGROUND RESOURCES

The following background resources are recommended reading.

They have been prepared by CCNR/RSN to communicate important information about uranium in down-to-earth language.

**1.) Uranium – its uses and dangers [September 25, 2014]**

*This slide show gives a rapid overview of relevant concepts.*

<http://ccnr.org/Wendake.pdf>

**2.) Uranium, a discussion guide \_ questions and answers**

[http://ccnr.org/nfb\\_uranium\\_0.html](http://ccnr.org/nfb_uranium_0.html) [English version]

**Uranium, Guide de discussion – questions et réponses**

[http://www.ccnr.org/nfb\\_uranium\\_f.html](http://www.ccnr.org/nfb_uranium_f.html) [version française]

**3.) A Critique of the EIS for the Strateco uranium project [2009]**

[http://ccnr.org/GE\\_Critique\\_EIS.pdf](http://ccnr.org/GE_Critique_EIS.pdf) [English version]

**Une critique de la ÉIE du projet uranifère de Strateco [2009]**

[http://www.ccnr.org/GE\\_Critique\\_EIS\\_f.pdf](http://www.ccnr.org/GE_Critique_EIS_f.pdf) [version française]

**4.) A Summary of Testimony on Uranium [2007]**

[http://ccnr.org/Baker\\_Lake\\_Summary.pdf](http://ccnr.org/Baker_Lake_Summary.pdf) [Nunavut]

**5.) Background Information on Nuclear Issues [1988]**

[http://ccnr.org/CEAC\\_A.html](http://ccnr.org/CEAC_A.html) [Section A: Radioactivity]

[http://ccnr.org/CEAC\\_B.html](http://ccnr.org/CEAC_B.html) [Section B: Health Effects]

[http://ccnr.org/CEAC\\_C.html](http://ccnr.org/CEAC_C.html) [Section C: Nuclear Fission]

***CCNR/RSN urges Quebec to impose a permanent ban on uranium exploration and mining, thereby joining the ranks of two other Canadian provinces – British Columbia and Nova Scotia – that have also banned uranium mining forever.***

## **Costs and Benefits**

Any benefits that could be derived from the mining of uranium in Quebec will be outweighed by the ultimate cost to future generations of Quebecers – and indeed to the global community, since all uranium, once mined, ends up either in nuclear weapons, or as nuclear waste.

Nuclear weapons may exact the ultimate cost on humanity – the destruction of human civilization and the onset of nuclear winter resulting from an all-out nuclear war, threatening the survival of all higher forms of life. Nuclear waste may endanger future generations in a less spectacular and more insidious manner, through the gradual radioactive poisoning of global ecosystems. Humans have yet to learn how to eliminate the existential threats posed by nuclear weapons and by nuclear waste. As a result, a great many people advocate banning nuclear weapons and halting the production and accumulation of ever-larger stocks of nuclear waste.

With the permanent closure of the Gentilly-2 nuclear reactor in December 2012, Quebec has become the first jurisdiction in North America to completely phase out of nuclear power. Since the only significant non-military use of uranium is as fuel for nuclear reactors, Quebec has no need – nor any incentive – to develop a domestic supply of uranium.

***All uranium mined in Quebec will be exported, and the principal economic benefits of its use will go to others. But the voluminous toxic wastes from the mining and milling operations will remain in Quebec as a permanent radioactive legacy for future generations of Quebecers to manage – or, alternatively, to suffer the adverse consequences of forgetfulness and neglect.***

## **Quebec and Nuclear Weapons**

As uranium mined in Quebec will be exported, Quebec will have no direct control over its use. And uranium has only two significant uses: as a nuclear explosive in nuclear weapons, or as fuel for nuclear reactors. Other uses of uranium are very few in number, and none of them is essential.

As the International Physicians for the Prevention of Nuclear War (IPPNW) has emphasized, in the case of nuclear war, the only cure is prevention. IPPNW received the Nobel Peace Prize in 1985 for its leadership in educating the public and decision-makers in all countries about the suicidal nature of these horrible weapons and the need to eradicate them altogether, as specified in the Nuclear Non-Proliferation Treaty (NPT). Because uranium is the key element behind all nuclear weapons, in 2010 IPPNW called for a ban on the mining of uranium worldwide.

<http://www.ippnw.org/pdf/2011-resolution-uranium-ban.pdf>

Many Quebec municipalities are among the 6,332 members of Mayors for Peace, a global organization calling for the total elimination of nuclear weapons by 2020. Because cities are

specifically targeted by nuclear weapons, and since all-out nuclear warfare can destroy all major cities many times over, the Mayors of cities around the world have felt compelled to speak out in defence of their citizenry. They say the only viable defence is to abolish nuclear weapons.

<http://www.mayorsforpeace.org/english/index.html>

Montreal has declared itself a “sister city” to Hiroshima, where the Mayors for Peace movement began. City Council also declared Montreal to be a nuclear weapons free zone in 1986, and had the city’s charter changed so that Montreal could enact by-laws against activities supportive of nuclear weapons programs, such as the manufacture and/or transportation of components for nuclear weapons or for their delivery systems.

[http://montreal.about.com/od/historypeopleplaces/ss/sister\\_cities\\_international\\_montreal\\_jumelage\\_villes\\_5.htm](http://montreal.about.com/od/historypeopleplaces/ss/sister_cities_international_montreal_jumelage_villes_5.htm)  
<http://peacemagazine.org/archive/v04n5p26.htm> - article by K. O’Hara, “Montreal, Nuclear weapons free zone”

There is no doubt that Quebecers would be massively opposed to Quebec fuelling the nuclear arms race by supplying uranium for military use – but this could happen without Quebec’s consent or knowledge.

For example, Canada is currently preparing to resume uranium sales to India, even though India (1) has refused to sign the Nuclear Non-Proliferation Treaty, (2) has no intention of eliminating its nuclear arsenal, and (3) has not committed itself to stop building nuclear weapons. Uranium mined in Quebec could very well end up in India, and indeed, in Indian nuclear weapons.

<http://timesofindia.indiatimes.com/india/India-Canada-clinch-nuclear-deal-in-record-time/articleshow/44819950.cms>

India’s first A-Bomb Test in 1974 used plutonium (a uranium derivative) produced in a uranium-fueled Canadian reactor called CIRUS (Canada-India-Reactor-United-States) that was given as a gift by the Canadian government. The underground explosion was carried out by India despite its solemn prior promise that Canadian technology would never be used for military purposes.

<http://www.atomicarchive.com/History/coldwar/page17.shtml>

By resuming uranium sales to India, the Canadian government is sending a dangerous message – that a country can clandestinely develop nuclear weapons and get away with it; that such a country can still be regarded as a respected ally and trading partner; that signing the NPT is not needed to obtain nuclear cooperation; that maintaining and expanding a nuclear arsenal is no obstacle to acquiring more uranium for a country’s nuclear reactors.

The current government of India promises not to use Canadian uranium for nuclear weapons, but it – or any subsequent government – may break this promise. Even if Quebec uranium is used only as reactor fuel in India, it means that India’s own rather meager indigenous uranium resources are “freed up” to be used in the Indian nuclear weapons program – so Quebec will be, in effect, aiding and abetting India’s nuclear weapons program if Quebec uranium is sold to India.

***As long as Quebec cannot guarantee that uranium mined in this province will never end up being sold to India, CCNR/RSN urges the government of Quebec to extend indefinitely the current moratorium on uranium exploration and mining.***

## Quebec and NATO's Nuclear Doctrine

Quebec uranium may well be sold to NATO countries via the EU.

Not only do the USA, UK and France have their own arsenals of nuclear weapons, but NATO doctrine has declared nuclear weapons to be “essential” to NATO’s military strategy in order to provide security to its member states.

<http://www.acronym.org.uk/49npt.htm>

NATO has even articulated a “first-use” policy with regard to nuclear weapons – that is, NATO reserves the right to be the first to use nuclear weapons in a combat situation where conventional weapons prove inadequate to prevent a military defeat involving NATO forces.

[https://www.armscontrol.org/act/1999\\_07-08/jmja99](https://www.armscontrol.org/act/1999_07-08/jmja99)

By explicitly attaching high military importance to nuclear weapons, and by equating a nuclear weapons capability with national security, NATO doctrine provides a ready-made rationale for every country in the world to acquire such weapons as an “essential” requirement for its own national security. Instead of nobody having nuclear weapons, everybody will have them.

However, Canada and all of the NATO countries are signatories to the Nuclear Non-Proliferation Treaty (NPT). Article 6 of the NPT stipulates that every party to the Treaty is required to work diligently towards the total elimination of nuclear weapons – in the words of the treaty, to negotiate “cessation of the nuclear arms race at an early date, and nuclear disarmament, and a treaty on general and complete disarmament under strict and effective international control.”.

<http://www.un.org/en/conf/npt/2005/npttreaty.html>

The World Court has ruled that this NPT obligation to eliminate nuclear arsenals is real, binding and imminent – Canada and other NATO countries have a legal obligation to do everything possible to get rid of nuclear arsenals, not to justify them or to support them or to ignore them.

<https://www.icrc.org/eng/resources/documents/misc/57jnft.htm>

Without uranium, there would be no nuclear weapons of any description. The primary nuclear explosive in every such weapon is either highly enriched uranium (HEU) or plutonium, a uranium derivative.

Thermonuclear weapons, commonly called H-Bombs, derive most of their enormous destructive power from nuclear fusion rather than nuclear fission. Nevertheless, such weapons must utilize a plutonium explosive as a triggering device. When strategic nuclear warheads are dismantled the plutonium trigger is removed, thereby rendering the warhead useless as a weapon. And plutonium is produced as a byproduct in every nuclear reactor fuelled with uranium, as some of the uranium atoms are automatically transmuted into plutonium atoms by neutron bombardment.

Uranium is the key element for all nuclear weapons. Uranium that is not used for nuclear weapons is used as fuel for nuclear reactors. If a country can import uranium for reactors, the internal demand for uranium as fuel decreases and its availability for weapons use increases.

Canada's involvement in uranium mining began with the World War II Atomic Bomb Project. For more than 20 years, from 1941 until 1965, all of Canada's uranium was sold under military contracts. Most of it was used to build up the US arsenal of tens of thousands of warheads.

In 1959, uranium was Canada's fourth most important export, after wheat, pulp and lumber, and it was all for Bombs. After the military contracts expired in 1965, Prime Minister Lester Pearson declared that, from that date onwards, Canada would only sell uranium for peaceful purposes.

By selling uranium to a country – or to a member of a military alliance like NATO – that maintains a nuclear arsenal, without insisting that that client country comply with the spirit and the letter of the Nuclear Non-Proliferation Treaty, Canada is itself violating article VI of the NPT. Article VI is binding on all signatories to the Treaty and not just the nuclear weapons states. By studiously ignoring this important provision of the Treaty, uranium suppliers like Canada are making a mockery of the moral and legal case against nuclear weapons. Quebec should take no part in this sordid business, which is undermining the moral and legal foundation on which the world's nuclear disarmament hopes depends.

It is widely acknowledged, even among those who have served as heads of civil governments and top military commanders in many countries around the world, that the elimination of nuclear weapons is essential to safeguard the long-term survival of human civilization.

[http://www.ccnr.org/civilian\\_leaders.html](http://www.ccnr.org/civilian_leaders.html)

<http://www.ccnr.org/generals.html>

***Given the positions of NATO and India vis-à-vis nuclear weapons, CCNR/RSN urges the Government to ban the export of uranium from Quebec to such countries. To allow Quebec uranium to be sold to countries unwilling to sign the NPT or unwilling to engage in plans to eliminate their nuclear arsenals in accordance with NPT obligations, is to condone the status quo. This would be a betrayal of the express wishes of Quebec municipalities to confront the nuclear weapons question openly and decisively and to work towards nuclear abolition.***

## **Uranium mine and mill wastes**

It is impossible to extract uranium from an ore body without bringing to the surface two or three dozen other radioactive materials. These are left behind as radioactive wastes with an effective half life of 76,000 years.

The uranium mine and mill wastes contain some of the most radiotoxic substances known to science – radioactive isotopes of thorium, radium, radon, polonium, bismuth and lead. They constitute more than 85 percent of the radioactivity in the ore.

In 1978, two government publications – one from the US Geological Survey, the other from the Ontario Royal Commission on Electric Power Planning – noted that the long-term radiotoxicity of uranium tailings is similar to, and perhaps even greater than, that of high-level nuclear waste (HLW) from nuclear power reactors, per unit of electrical output. While HLW is incomparably more dangerous than uranium tailings for the first thousand years or so, at a certain point in time – well within the prescribed storage period for HLW – they become comparable.

The US Geological Survey report calls attention to

the hazard from uranium mill tailings, which, although more than an order of magnitude more toxic than high-level waste, have customarily been treated in a much more cursory fashion.

Geologic Disposal of High-Level Radioactive Wastes – An Earth-Science Perspective, US Geologic Circular 779, page 10, <http://pubs.usgs.gov/circ/1978/0779/report.pdf>

The Ontario Royal Commission report states:

Uranium mill tailings will constitute an increasing health and environmental problem. An independent review committee should be established to study the problem in depth and prepare a public report for the AECB and the Ontario Environmental Assessment Board. The future of the nuclear programme should be assessed in light of the committee's findings and progress in mill tailings containment technology.

*A Race Against Time – Interim Report on Nuclear Power in Ontario, Major Findings and Conclusions, p. xiii, <https://archive.org/details/interimreponuclear00onta>*

At about two or three year intervals the nuclear power programme, and in particular the uranium mining and milling part of the fuel cycle, should be assessed in the light of the findings of this review committee.

*A Race Against Time, p. 73*

Both reports include graphs showing the toxicity of high-level nuclear waste over a period of ten million years, illustrating the comparative toxicity of uranium mill tailings as a function of time.

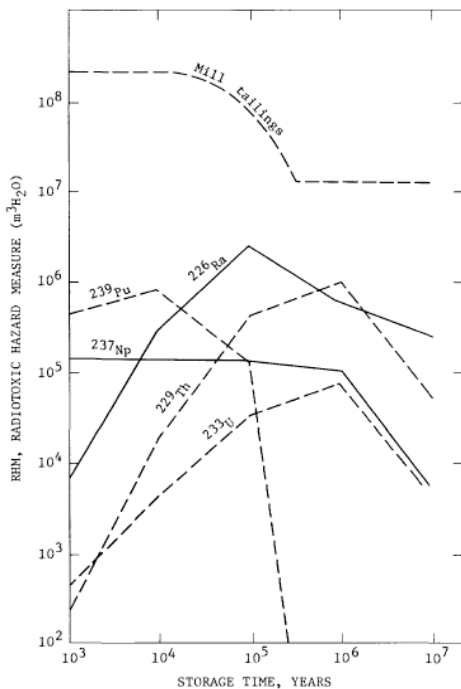


Figure 1, p.10, USGS Circular 779  
 This time scale starts at 1000 years.  
 The top line represents mill tailings.  
 The other lines represent HLW fractions.

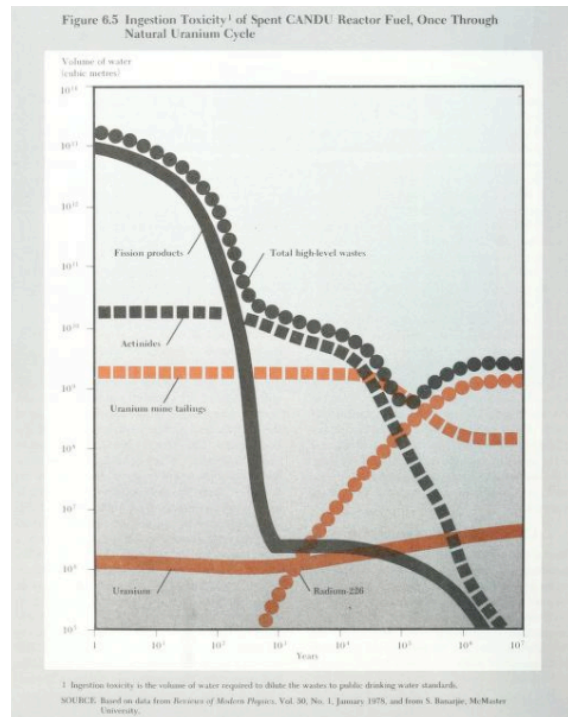


Figure 6.5, p.92, A Race Against Time  
 This time scale starts at one year.  
 The middle line represents mill tailings  
 The other lines represent HLW.



*Of course there will be jobs and economic activity associated with uranium exploration and mining for a few decades, but eventually the radioactive uranium wastes will be abandoned. That's when the real long-term problems begin. Abandoned uranium wastes have posed major environmental cleanup problems in such places as Port Radium, NWT; Uranium City, Saskatchewan; Elliot Lake, Ontario; and Port Hope, Ontario. Is Quebec prepared for this?*

## **Long-Term Remediation Costs**

In the 1970s, the Wall Street Journal described the 200 million tons of abandoned uranium tailings in the USA as “an environmental and ecological time bomb”. These wastes have been such a burden in the United States that a special federal initiative was launched in 1978 by the US Congress, called the Uranium Mill Tailings Remedial Action (UMTRA) project. UMTRA is currently operating on a budget of more than \$30 million annually and deals with dozens of abandoned sites requiring remediation for environmental and health reasons.

UMTRA remediation efforts at one site alone – the Moab site in Utah – involve the relocation of 16 million tons of uranium mill tailings away from the Colorado River to a special engineered facility at Crescent River, Utah. The relocation, which began in 2009, is approximately 45 percent complete by mid-2014 (7 million tons of radioactive waste have so far been removed). The pace of this remediation effort – one of dozens – is slowing down due to lack of funding.

No such legislated initiative exists in Canada. Remediation efforts in this country are sporadic and uncoordinated, driven as much by political expediency as by the need for long-term environmental protection. Such efforts are not funded in any consistent manner.

At Port Hope, the Canadian government has financed the most extensive – and expensive – environmental remediation project ever undertaken in Canada. The estimated cost has already gone from 800 million dollars to 1800 million, and may end up much higher. But other sites similarly contaminated with uranium wastes do not always enjoy such lavish treatment.

For example, at Port Hope Ontario, steel walls are being installed around the harbor to minimize radioactive contamination of the perimeter during dredging operations to remove uranium wastes that were dumped into the harbour decades earlier. But uranium wastes that were dumped into Great Bear Lake at the Port Radium site in the Northwest Territories, and uranium wastes that were dumped into Beaverlodge Lake at Uranium City in Northern Saskatchewan, are not being removed but are being left in place.

<http://environmentalsociety.ca/wp-content/uploads/2014/08/Beaverlodge-Legacy-of-Contamination.pdf>

The Port Hope “cleanup” involves not only dredging the harbor to remove radioactive sludge, but also excavating radioactive soils to be packaged and stored as radioactive waste, demolishing radioactively contaminated buildings and storing the rubble, retrieving radioactive waste from numerous deep ravines and ditches around town, and even tearing up some contaminated roadways – all for the purpose of consolidating and packaging some 800,000 tonnes of uranium refinery waste in a special facility just north of town, intended to hold them safely for 500 years.

As the Port Hope wastes will remain dangerously radiotoxic for many tens of thousands of years, the radiological hazard will far outlast the facility being built to contain the hazard. Presumably this costly radioactive repackaging operation is only the first in a long series of such endeavours.

***It is not practicable to balance the short term economic benefits of uranium mining in Quebec – some jobs and economic activity for a few decades – against the long-term economic costs of management and remediation and/or offsite contamination and detrimental health effects.***

## **Misuse of Uranium Wastes**

Radioactivity, as such, cannot be detected by any of our senses. Without sophisticated equipment it is impossible to know whether a given material is radioactive or not. Thus ordinary people – men, women and children – are unable to protect themselves against harmful exposure to atomic radiation resulting from prolonged contact with materials that are not recognized as radioactive. Such exposures may be external to the body, or internal, as a result of inhaling, ingesting, or otherwise absorbing radioactive materials into the body.

There are numerous documented stories of dangerously radioactive materials that were found, handled and even taken home by individuals out of innocent curiosity, thereby exposing themselves and their families and friends to life-threatening doses of atomic radiation in the form of penetrating gamma radiation. In one case, a radioactive cobalt-60 source from a hospital therapy machine found its way into a Mexican scrap yard where it was inadvertently melted down and incorporated into scrap metal. The resulting gamma-emitting radioactive metal was shipped all over North America, finding its way into numerous consumer products that had to be recalled for safety reasons, including metal cafeteria table legs in Winnipeg.

Uranium mining operations result in a vast inventory of waste rocks that are radioactive, but whose uranium content is too low to be classified as ore. These rocks and stones can deliver significant radiation doses over long periods of time if they are used in gardens or residential settings without knowledge of their harmful nature, as has happened in many instances in France.

When the most radioactive rock –the ore – is milled to extract uranium, enormous volumes of very fine sand-like radioactive wastes are produced. These are the uranium tailings. Both the waste rock and the mill tailings will remain radioactive for hundreds of thousands of years.

Because uranium tailings and waste rock appear to be inoffensive materials, there are many cases where these dangerous materials have been used inappropriately. One of the worst of these reported cases involves the community of Grand Junction, Colorado, where over 4000 properties were contaminated with uranium mill tailings that had been used in construction. The severe and very complicated radioactive contamination problems resulting from this particular misuse of uranium mill tailings was one of the spurs that led to the creation of the UMTRA Project.

See <http://www.wmsym.org/archives/1998/html/sess29/29-07/29-07.htm> and <http://energy.gov/sites/prod/files/2014/09/f18/Defense-RelatedUraniumMinesReporttoCongress-FINAL.pdf>

In Canada, the federally-owned Crown Corporation Eldorado Nuclear Limited allowed the use of radioactive uranium wastes from its Port Hope refinery to be used as fill at construction sites in

and around town over a period of many years. In 1975 a scandal erupted when it was revealed that many homes and some schools in Port Hope were so radioactively contaminated that they had to be evacuated. Dozens of contaminated buildings were destroyed and hundreds more were remediated by removing much of the radioactive waste that had been donated by Eldorado to its employees. The chairman of the Atomic Energy Control Board, Jon Jennekins, promised that all this radioactive waste material would be permanently removed from the community by 1977.

Ten years later, the waste had still not been removed. The Government created a federal agency, the Siting Task Force, to find a suitable site somewhere in Ontario for the permanent storage of the Port Hope uranium wastes. A willing host community would receive substantial economic benefits in exchange for allowing a state-of-the-art nuclear waste storage facility to be built in their municipality for storing these Eldorado legacy radioactive wastes.

Eighteen Ontario communities signed up initially with the Siting Task Force. Each candidate community set up a Community Liaison Committee and engaged in a self-directed learning process, using funds provided by the Task Force, to educate local citizens regarding the pros and cons of providing a home for the Port Hope wastes. But after spending three years and three million dollars, the Task Force came up empty-handed. No one wanted the Port Hope wastes.

Today, 39 years after the scandal first erupted, all of the so-called “legacy radioactive wastes” from Port Hope are finally being retrieved and packaged for storage in a specially designed facility just a little bit north of town, as mentioned earlier in this memoir. So after four decades of sporadic efforts, the Port Hope legacy uranium wastes are still there, and there they will remain.

[https://www.google.ca/search?tbo=p&tbm=bks&q=inauthor:%22Canada.+Siting+Process+Task+Force+on+Low-Level+Radioactive+Waste+Disposal%22&gws\\_rd=ssl](https://www.google.ca/search?tbo=p&tbm=bks&q=inauthor:%22Canada.+Siting+Process+Task+Force+on+Low-Level+Radioactive+Waste+Disposal%22&gws_rd=ssl)

***Is Quebec ready and willing to stand on guard over the huge volumes of uranium tailings and waste rock that will be produced in many diverse locations across the province if uranium mining is allowed to proceed, in order to prevent their removal from the site and/or their misuse in construction projects? What ongoing mechanism of monitoring and control will be deployed by Quebec, in light of the fact that these dangerous radioactive materials can be misused by ignorant or opportunistic individuals at any time in the next 100,000 years?***

## **Radon Gas in Buildings**

One aspect of the environmental and health risks associated with uranium wastes is the ongoing generation of a radioactive gas called radon. Radon is a chemically inert substance belonging to the family of “noble gases” that includes helium, neon, and argon. None of these gases undergo any kind of chemical reactions or form chemical compounds. As such radon is odorless, tasteless and colourless. Moreover, it cannot be filtered out, precipitated or otherwise removed by any kind of air purification process. There is no way to detect radon gas without special equipment.

Radon gas is continually created by the radioactive disintegration of radium atoms. Radium is a radioactive heavy metal – one of the principle constituents of all uranium mine and mill wastes. Thus the use of uranium wastes in the construction of homes and schools results in the buildup of radioactive gas inside the building. Because radon is seven times heavier than air, it accumulates

especially in basements, and stays closer to the floor than the ceiling, thereby delivering elevated radiation exposures to infants and children, who are much more radiosensitive to begin with.

Chronic exposure to radon gas over a prolonged period of time is the leading cause of lung cancer deaths among non-smokers. As in the case of cigarette smoking, and asbestos exposure, existing scientific evidence indicates that there is no “safe threshold” for radon exposures because the number of lung cancer cases is directly proportional to the “population dose”. The population dose refers to the cumulative integrated exposure of an affected population – that is, the sum total of all the individual doses.

In plain language, this means that if a given population is exposed to twice as much radon, there will be twice as many cases of radon-induced lung cancer. It also means that if two populations, one larger than the other, are exposed on average to the same level of radon gas per person, the larger population will show a proportionately larger incidence of lung cancer. Thus the public health burden is directly related to the degree of dispersal and dissemination of the “source term” – a technical phrase referring to the radon-generating uranium waste materials.

The US Environmental Protection Agency estimates that between 20,000 and 30,000 Americans die every year from lung cancer caused by breathing radon gas at home. The US government has declared radon-induced lung cancer to be a major public health issue in the USA and urges all its citizens to have indoor radon levels assessed and to take remedial action in case of high readings.

Radon is a naturally occurring radioactive material – highly dangerous to be sure, but ubiquitous. Radon cannot be eliminated, but measures can be taken to reduce its concentration in the living environment and thereby limit the health risks. Remediation and prevention are key. Radon can be inhibited from entering living quarters by using impermeable barriers and good ventilation.

In many cases high indoor radon levels arise from purely natural causes, but in important cases the use of radioactively contaminated building materials from mining residues plays a major role. In any case, the population and authorities must be educated as to the nature of this silent killer.

***CCNR/RSN urges the Government of Quebec to ensure that all citizens have their indoor radon levels measured and to assist citizens to undertake remedial measures where warranted. Failure to remediate the hazard ends up costing the public health system exorbitantly.***

## **The Quebec Experience**

Although Quebec has had no prior experience with uranium mining, there have been some unhappy encounters with radioactive mine residues. Some ores are rich in uranium, but not rich enough to justify uranium mining; when such ores are processed, the tailings are qualitatively similar to uranium mill tailings. They contain the same radioactive materials as those in uranium tailings, but at a less concentrated level – and they are, like uranium tailings, radon-generating. Such is the case with the columbium mill tailings at Oka. Columbium is an earlier name for the element now known as niobium, which happens to have a geochemical affinity with uranium. The carbonatite formation where the columbium ore body is located is quite radioactive, with significant levels of uranium. See [http://www.inspq.qc.ca/pdf/publications/352-radon\\_rapport.pdf](http://www.inspq.qc.ca/pdf/publications/352-radon_rapport.pdf).

The St Lawrence Columbian Mine operated there, just outside of Oka, from 1961 to about 1977, leaving behind a large deposit of uranium-bearing radioactive tailings that were abandoned and neglected. There was no signage warning people about radioactivity. There was no fencing capable of excluding visitors. There was no impermeable cover to limit radon emissions or dust.

People hiked and picnicked on the tailings. Kids played and rode bicycles on the tailings. A company named Oka Aggregates saw a huge reservoir of clean, fine sand, perfect for their purposes, and began carting away truckloads of the stuff. About 200,000 tonnes of these radioactive wastes were used in construction projects in Oka and in the Montreal area. One home in Oka was so contaminated by the use of the columbian tailings that, according to an inspector from the Quebec Government, one could obtain an annual gamma ray exposure greater than the maximum allowed for members of the public by sitting in a chair on the front lawn the whole time. Of course, radon levels in such contaminated buildings were extraordinarily high.

Meanwhile, a new housing subdivision was being built right beside the radioactive carbonatite formation. The radon levels in these new homes were alarmingly high. As awareness of the radon hazard grew, the government stopped issuing building permits. But the developer sued, maintaining that the government had no legal right to withhold the permits, and won his case.

Forced into a corner, the government disbursed three million dollars of taxpayer's money to compensate the developer for agreeing not to build any further houses in the subdivision. In addition, measures were taken to stabilize the tailings, halt the use of such materials for construction, and make the tailings less accessible to intruders. However, no remedial work was undertaken with regard to the 200,000 tonnes of materials that had already been removed.

A similar situation was unfolding in Varennes, involving radioactive phosphate wastes from the Erco fertilizer plant. The phosphate ore, originating from Florida, is heavily contaminated with uranium. Whether because of natural uranium levels in the soil, or the misuse of radioactive wastes from phosphate mining, or both, radon is a major problem in the Florida housing market.

Radon-contaminated buildings are so common that no building can be sold in Florida, by law, without a certificate specifying the radon levels in the building as measured by a certified agent. Indeed, the extensive indoor radon problems in Florida are what galvanized the US government into taking the radon problem seriously, making it a national public health issue.

Just as at Oka, an enterprising entrepreneur was helping himself to hundreds of truckloads of radioactive phosphate wastes at Varennes and using the radium-laced materials in countless building projects, mostly on Montreal's South Shore. Clifford Lincoln, who was then Quebec's Environment Minister, ordered the company to cease and desist, but the company ignored the order and continued to make off with radioactive residues for use in construction. It took several months before the Minister could get the needed legal muscle to force the company to comply. Again, no remediation work was undertaken regarding the large volumes of radioactive residues that were used in construction. No doubt residents in many of these dwelling are living in a radon-contaminated indoor environment with no understanding of the fact that their home has become a life-threatening radioactive hazard, or how this was allowed to happen.

*These instances of radioactive contamination through the misuse of radium-bearing mining residues indicate that Quebec is not at all prepared, either legislatively or technically, to deal with the challenge of protecting citizens and the provincial health system from needless life-threatening diseases caused by the careless use of uranium mill tailing and/or waste rock in the future if uranium mining is allowed to go ahead in Quebec.*

## **The Linear Non-Threshold (LNT) Model**

There is a natural background level of radiation exposure that is unavoidable. “Excess radiation exposure” refers to any exposure over and above that background level. Similarly, there is a natural background level of cancer incidence; the phrase “excess cancers” refers to cancers over and above that background level.

The Linear Non-Threshold Model of radiation carcinogenesis states that the number of excess radiation-induced cancers in an exposed population is directly proportional to the excess radiation exposure experienced by that population. It is a logical corollary of LNT that there is no absolutely safe level of exposure to atomic radiation. The LNT model (Linear Non-Threshold Model) is often attacked by nuclear proponents for that reason.

However, the LNT model has been repeatedly and convincingly verified by data from many countries over a very wide range of radiation exposures from quite large to quite small. The LNT model has also been adopted as the basis for radiation protection by all regulatory agencies in the world, including the Canadian Nuclear Safety Commission (CNSC).

Just as there are people who deny the theory of biological evolution despite overwhelming evidence in its favour, and others who deny the theory of human-driven climate change despite a staggering amount of information corroborating that thesis, so there are many – often in the nuclear industry and/or governments that promote nuclear power – who deny the “non-threshold” part of LNT. Although LNT cannot be corroborated down to the lowest conceivable levels of exposure due to technical problems, that’s no reason to reject the best scientific evidence we have.

So far, every attempt to establish the existence of a safe threshold – that is, a level of exposure so low that harmful health effects do not result – has failed. In a 2007 press release announcing the publication of the US National Academy of Sciences’ BEIR-7 Report on the Biological Effects of Ionizing Radiation, we read:

*WASHINGTON (June 2007) – A preponderance of scientific evidence shows that even low doses of ionizing radiation, such as gamma rays and X-rays, are likely to pose some risk of adverse health effects, says a new report from the National Academies’ National Research Council. . . .*

*In living organisms, such radiation can cause DNA damage that eventually leads to cancers. However, more research is needed to determine whether low doses of radiation may also cause other health problems, such as heart disease and stroke, which are now seen with high doses. . . .*

*The study committee defined low doses as those ranging from nearly zero to about 100 millisievert (mSv) – units that measure radiation energy deposited in living tissue. The radiation dose from a chest X-ray is about 0.1 mSv. In the United States, people are exposed to average annual background radiation levels of about 3 mSv.*

*The committee’s report develops the most up-to-date and comprehensive risk estimates for cancer and other health effects from exposure to low-level ionizing radiation. In general, the report supports previously reported risk estimates for solid cancer and leukemia, but the availability of new and more extensive data have strengthened confidence in these estimates.*

*Specifically, the committee’s thorough review of available biological and biophysical data supports a “linear, no-threshold” (LNT) risk model, which says that the smallest dose of low-level ionizing radiation has the potential to cause a small increase in health risks to humans. In the past, some researchers have argued that the LNT model exaggerates adverse health effects, while others have said that it underestimates the harm. The preponderance of evidence supports the LNT model, this new report says.*

*“The scientific research base shows that there is no threshold of exposure below which low levels of ionizing radiation can be demonstrated to be harmless or beneficial,” said committee chair Richard R. Monson, associate dean for professional education and professor of epidemiology, Harvard School of Public Health, Boston. “The health risks – particularly the development of solid cancers in organs – rise proportionally with exposure. At low doses of radiation, the risk of inducing solid cancers is very small. As the overall lifetime exposure increases, so does the risk.” The report is the seventh in a series on the biological effects of ionizing radiation.*

It is important to note that the LNT model is applied not just to atomic radiation, but to chemical carcinogens as well. That’s why second-hand smoke is banned altogether; there is no serious debate about an “acceptable level” of second hand smoke. Similarly for asbestos, and for all other carcinogens – in every instance, the only absolutely safe level of exposure is zero. If zero exposure is not attainable, then the lowest possible exposure level should be the goal.

In the case of atomic radiation, random damage to the DNA of a single cell can lead to cancer many years later. If that cell is able to reproduce with damaged genetic instructions, eventually it may produce a colony of clones – a mass of defective rogue cells that we call a malignant tumour. The time that elapses from the initial microscopic bit of radiation damage to the macroscopic manifestation of cancer is referred to as the “latency period”. In the case of radon-induced lung cancer, the latency period is typically around 20 years.

If a population is exposed to sufficiently high levels of radon, the first radiation-induced lung cancers will begin to appear about 20 years later, and from that time onwards an increased incidence of lung cancer will continue to manifest itself year after year in that same population. The British Columbia Medical Association refers to this phenomenon – well-documented in underground mining cohorts – as “a gradually flowering crop of radiation-induced cancers”.

## A Brief History of Radioactivity

In 1896, Henri Becquerel accidentally discovered radioactivity. He kept an undeveloped photographic plate wrapped in black paper in the same drawer where he had stored a rock from Czechoslovakia. Some weeks later he was amazed to find that the plate had become exposed by its proximity to the rock. Evidently this rock – it was actually a chunk of uranium ore – apparently inert, was emitting some kind of invisible light that could penetrate right through that black paper as if it was transparent. Becquerel carried this marvelous rock around with him in his shirt pocket, and as a result developed a very nasty radiation burn on his chest – a painful and ugly injury that was very resistant to healing. ***So from the very beginning, as early as 1896, it was clear that exposure to radioactive materials could cause harmful biological effects.***

Shortly afterwards, Marie Curie did a chemical analysis. She crushed the rock and extracted uranium using sulphuric acid as a solvent – something very similar to what uranium mining companies do today. She found that uranium is indeed radioactive, but that the crushed rock from which the uranium had been extracted – the uranium residues – are much more radioactive than the uranium itself. ***So from the outset, even before 1900, it was demonstrated that uranium residues are at least 6 or 7 times more radioactive than uranium itself.***

Madame Curie realized that the uranium residues must contain additional radioactive materials, hitherto unidentified. In 1898 she discovered two new elements that she named “radium” and “polonium”. Each was millions or billions of times more radioactive than uranium per unit mass. Radon, a radioactive gas, was discovered later when it was found in the air near radium samples. But neither Madame Curie nor M. Becquerel had any idea where these new elements came from. ***But it was known even then that radon gas emanations are inevitable from uranium residues.***

In 1899 Ernest Rutherford, working in England, demonstrated that radioactive atoms actually disintegrate, very suddenly and very violently, like miniature time bombs that explode without warning. At the very instant of disintegration, an electrically charged particle is given off from the nucleus of the atom – a kind of subatomic shrapnel. In some cases a massive positively charged particle is emitted; Rutherford called it an alpha particle. In other cases a much less massive negatively charged particle is emitted; he called it a beta particle.

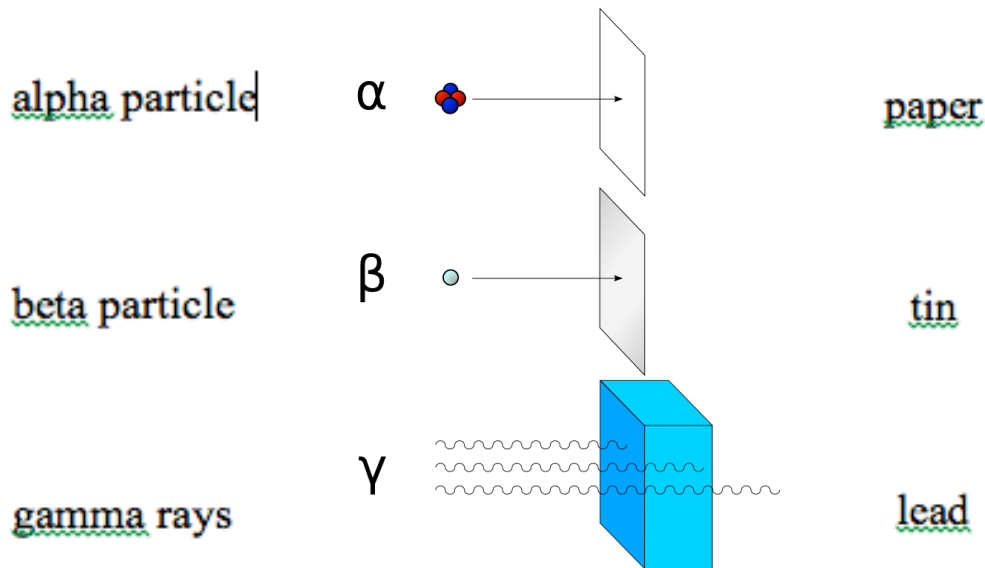
*The two commonly used units of measurement for radioactivity are the Becquerel and the Curie. One Becquerel indicates one radioactive disintegration per second. One Curie is equal to 37 billion becquerels – that is, 37 thousand million disintegrations every second. As it happens, one Curie is precisely equal to the radioactivity of a gram of pure radium.*

Every radioactive material is either an alpha emitter or a beta-emitter. (In a few rare cases both types of disintegration are possible, but even then, either an alpha particle or a beta particle is emitted – not both.) In 1900 Pierre Villard in France discovered that there is sometimes a highly penetrating electromagnetic ray, similar to an x-ray but much more powerful, given off by a disintegrating atom. He called it a gamma ray in keeping with Rutherford’s nomenclature.

An alpha particle is about 7000 times more massive than a beta particle. It can be stopped easily – by a single sheet of paper, for example. Thus “alpha rays” (as they are somewhat misleadingly



called) are regarded as a non-penetrating form of atomic radiation. Because alpha particles have a short path and are easily blocked, they are often quite difficult to detect with radiation monitoring equipment. Nevertheless, alpha particles do a great deal of damage when in close contact with living cells inside the body. A beta particle is so much lighter than an alpha particle that it is a lot more penetrating. It can pass through several millimeters of tin or several centimeters of soft body tissue. Gamma rays have the greatest penetrating power of all, requiring a thick lead wall or some similar barrier to screen out most of the rays. It is impossible to shield completely against gamma radiation, as some of the rays will inevitably get through.



Rutherford moved to Montreal in 1899 to take up a research post at McGill University, where he worked closely with a British chemist named Frederick Soddy. In 1902, Rutherford and Soddy published a ground-breaking paper showing that whenever a radioactive atom disintegrates, it is actually transmuted into a completely different chemical element. It assumes a new identity!

For example, when a radium atom disintegrates by giving off an alpha particle, it turns into an atom of radon gas; for this reason radon is called a “decay product” of radium. But the radon atom is also radioactive, and when it disintegrates by giving off another alpha particle, it turns into an atom of polonium – so polonium (which by the way is also an alpha-emitter) is a decay product of radon. By extension, both polonium and radon are considered decay products of radium, while radium itself is a decay product of uranium. So every atom of polonium was once an atom of radon gas, and before that it was an atom of radium – and a long time before that, it was an atom of uranium. Radium, radon and polonium are also called uranium progeny.

## Understanding Half-Lives

In 1907, just before leaving McGill to return to England, Rutherford discovered that every radioactive element has a characteristic “half-life” – that’s the time required for half of the atoms to disintegrate. For example, radon has a half-life of 3.8 days, while radium has a half-life of 1600 years. But this concept, the half-life, requires careful thought if it is to be used correctly.

Consider one gram of radon gas trapped in an airtight container. After 3.8 days, there is only half a gram of radon left in the container, and half a gram of something else – the decay products of radon. After another 3.8 days, there is just a quarter of gram of radon gas, and three quarters of a gram of decay products. After another 3.8 days, there is only one eighth of a gram of radon, and seven-eighths of a gram of decay products.

Continuing in this fashion, and using a hand calculator if necessary, one can see that after ten half-lives – that is, 38 days – there will only be about one milligram of radon left in the container. That's because when you multiply "2" by itself ten times you get the number 1024, which is almost equal to 1000. So, the amount of radon is diminished by a factor of about 1000 when ten half-lives have elapsed. And one-thousandth of a gram is a milligram.

Continuing in this way, if we wait for another 38 days – that's a total of 76 days – there will be about one microgram of radon gas left in the container, and 999,999 micrograms of decay products. Note that the total mass remains one gram of material, no matter what.

So, after a few months, the radon gas is just about completely gone. But that doesn't mean the radioactivity is gone, because one of the decay products of radon gas is a radioactive variety of lead called lead-210, and it has a half-life of 22 years! It so happens that, by the time the radon gas has all but disappeared, the mass of the residual lead-210 is just about equal to the original mass of radon gas that we started with, and is very radioactive, with 2.5 trillion disintegrations per second. Because of the two-decade half-life of lead-210, it will take over 200 years for its radioactivity to diminish by a factor of 1000, to 2.5 billion disintegrations per second. Many centuries are required for the radioactivity of the residual lead-210 to drop to negligible levels.

The previous example involved radon gas in isolation, all by itself. But we know that radon gas is actually produced by the radioactive disintegration of radium atoms. So what happens if we have a gram of radium inside a sealed container? In that case the rate at which new radon atoms are being created is exactly equal to the rate at which old radium atoms are disintegrating. And, since radium has a half-life of 1600 years, the rate of disintegration of radium atoms changes very, very slowly. During one or two years, or even one or two decades, the rate at which the radium atoms are disintegrating is hardly changed at all. The same remark applies to the rate at which new radon gas is being produced. A little thought will show that the rate at which radon atoms are being created will not drop to half of the original rate until 1600 years have gone by!

In practice, then, the concept of the "half-life" is tricky to use in any given situation. That's because radioactive atoms are constantly changing into other atoms that might also be radioactive. Since different radioactive materials may have vastly different half-lives, it is necessary to consider the entire "decay chain" – the entire family of radioactive materials that are being produced by the on-going process of radioactive disintegration.

## **Radium Jaw, Anemia and Septic Infections**

In the mid 1920's, a number of dentists reported a phenomenon called "radium jaw" among some of the hundreds of young women workers – teenagers, mostly – in radium glow-in-the-dark dial-painting factories. The jaw bones were quickly deteriorating, becoming soft and porous, often suffering spontaneous fractures. Teeth were breaking and falling out. Gums were very sore and

septic with bacterial infections. These symptoms were often accompanied by a profound anemia. In 1925, Harrison Martland, a forensic pathologist, concluded that radium jaw was caused by minute amounts of radium which the women swallowed by "pointing their brushes" with their lips (a practice soon discontinued). He cited, in evidence, the faint but detectable gamma radiation emitted from their living bodies and the radon gas detected in their exhaled breath.

Several of these women died in their 20s or 30s from anemia or from septic infections which were resistant to treatment. Autopsies clearly revealed alpha activity concentrated in the bones, spleen and liver. Radium, being chemically similar to calcium, had followed the same biological pathways as calcium and ended up mainly in the skeleton. The women's bones were sufficiently radioactive that images of them could be made simply by resting the bones on photographic paper in a dark room overnight.

Martland attributed the young women's fatal anemias to radiation damage done to the bone marrow, exhausting its ability to produce red cells. These fatalities were similar to those of Marie Curie and her daughter Irene, both of whom worked with radium, and both of whom died of aplastic anemia. In the case of the dial painters, a marked impairment of the body's natural resistance to bacterial infection was evidently a side effect. It was linked to the drastic reduction in white blood cells, whose primary function is to fight infection.

***CCNR/RSN urges the Quebec government not to allow radium bearing wastes from uranium mining to be brought to the surface and abandoned, given the potential for this material to be disseminated into the environment through the agency of dust blowing downwind, burrowing animals, accidental spills, freak weather conditions, and human intrusion.***

## **Radium-Induced Cancers of the Bones and Head**

Some of the affected dial painters seemed to recover from their initial illnesses. Others displayed no noticeable ill effects, despite significant radium contamination. However, in later years, many of these same women developed crippling inflammations of the skeleton degenerating into bone cancer at a multitude of different sites, such as knee, arm, foot, mandible, rib-cage, pelvis, and eye socket. Spontaneous fractures and deformities of the spine were not uncommon. Such effects were generally experienced years, or even decades, after the women had quit their jobs as dial painters. Bone cancer is an exceedingly rare disease, yet it was epidemic among the dial painters. There was no doubt that radium was the cause.

Autopsies revealed that the fatal dose was between 10 and 180 micrograms of radium. This amount – invisible to the naked eye, too small even to be detected by chemical means – had been metabolized by the digestive tract and distributed throughout the skeleton. It was impossible to discover exactly how much radium had been ingested; most of it would have been excreted in the feces. Subsequent bone cancer victims have shown amounts of radium as small as 1.5 micrograms in their skeletons.

Over 90 percent of the ionizing energy emanating from the deposits in the bone was alpha radiation. By comparison, the tiny amounts of beta and gamma radiation were negligible. Martland summed it up by writing: "Alpha particles are probably the most potent and destructive

agent known to science." He noted that 10 micrograms of radium found in a skeleton today will still be releasing 160,000 alpha particles per second 2,000 years from now.

Although Martland couldn't know it, a substantial number of the dial painters (about half as many as those who eventually contracted bone cancer) would later die from cancers of the soft tissues in the head. Radon gas, generated inside their bodies by the decay of radium, collected in their sinus and mastoid cavities. There the radioactive gas and its short-lived progeny bombarded the surrounding soft tissue with alpha particles, causing cancer.

Many other radium workers suffered from ailments similar to those of the dial painters, but their cases received far less publicity. The upshot is that radium, which in the 1920s sold for \$120,000 per gram, was judged too dangerous a material to be handled by humans. As a result it is now discarded as a waste byproduct in uranium tailings.

***While individual radium exposures comparable to those of the dial painters are most unlikely, the Linear Non-Threshold Model implies that if a population 10 times as large is exposed to average individual doses that are 10 times lower, the same number of cancers will occur – since the integrated population dose in each case is the same. That larger population does not have to be exposed in the same temporal period, but could be stretched over a few generations. Such an insidious long-term health hazard is unacceptable given what we know about radium.***

## **Radon Gas and Cancer of the Lung**

In the 1930s, a mysterious, ancient epidemic of lung cancer was linked to radon gas. Beginning in the 16th century, it had been reported sporadically that generations of underground miners near Schneeberg, Germany, suffered from an extraordinarily high incidence of fatal lung disease.

By 1897, it had been demonstrated both anatomically and clinically that from half to three-quarters of these miners were dying of lung cancer, while most of the rest were dying of other lung diseases. This level of lung cancer incidence was much higher than among the surrounding population, where it was virtually unknown. The ores were coincidentally rich in uranium.

By the late 1930s, a similar statistic – fifty percent mortality from lung cancer – was found among the miners in Joachimsthal, Czechoslovakia, whence Marie Curie and Henri Becquerel obtained their first supplies of uranium-bearing ore. The German and Czechoslovakian mines in question are located on opposite sides of the Erz Mountains ("Ore Mountains").

Several scientific papers published before 1940 clearly indicated that airborne radioactivity in the mines was the likely cause of these lung cancer epidemics. The principal culprit was thought to be radon-222, an alpha-emitting gas, rather than radioactive dust, because other kinds of workers chronically exposed to comparable radioactive dust showed no such increases in lung cancer.

Animal experiments confirmed the extraordinary effectiveness of radon in causing lung cancer, compared with inhalation of radioactive dust. However, scientists found it difficult to understand how radon-222 could deliver a radiation dose sufficient to account for such a large increase in lung cancer.

Being a gas, radon behaves predictably. It mixes easily with air and dissolves easily in water. It is exhaled as easily as inhaled. Although the concentration of radon gas in the mines was highly variable, there was a well-defined range of measured values, so the radon dose to the lungs could be roughly estimated. Yet many other people had received much larger doses of x-rays to the chest, without experiencing any noticeable increase in lung cancer. Why were the lungs of the miners suffering so much damage from this alpha-emitting gas?

## **Grappling with the Radon Progeny**

The answer was a long time in coming. In the early 1950s, two American scientists made the elementary observation that the miners were inhaling, not just radon gas, but its short-lived progeny as well. It is surprising that no one flagged this before, since the decay chain for radon-222 was worked out shortly after the discovery of radium-226, and was very well known.

As radon-222 accumulates in the mine atmosphere, there is a gradual build-up of short-lived radon progeny. Charged atoms of radioactive bismuth, lead and polonium hang suspended in the air. By electrostatic attraction, many of these charged atoms attach themselves to airborne dust particles and to droplets of respirable size. The others remain unattached, but airborne. Once the radon progeny were taken into account, the estimated dose turned out to be hundreds or even thousands of times larger than earlier calculations had indicated. The size of the final estimated dose depends on a number of assumptions.

The largest dose results when the radon is in equilibrium with its short-lived progeny; this occurs if the gas is allowed to stagnate in an unventilated space for several hours. Under such circumstances, the gas contributes only slightly to the total dose. Most of the damage is done by the attached and unattached decay products, especially the alpha-emitting polonium isotopes. They all lodge in the respiratory tract, and some end up delivering high doses of radiation to the bronchi, where most lung cancers originate.

Complete equilibrium between radon and its short-lived progeny is seldom achieved, but in poorly ventilated spaces it is often a good approximation.

## **Radon Migration From Uranium Tailings**

Radon is a naturally occurring radioactive gas created by the disintegration of radon atoms. When the radium is contained deep inside a hard rock formation or is located deep underground, very little of the radon gas is able to migrate to the surface because of the short 3.8 day half-life. However, when the radium is brought to the surface and ground into a fine powder, the radon has much easier escape routes and much better access to the atmosphere. Once airborne, radon can easily travel 1000 miles in a light 15 mile-per-hour wind in a period of 3.8 days.

As the radon gas migrates off the tailings piles and wafts through the air, it tends to stay low to the ground (being 7 times heavier than air) and leaves a trail of the highly radioactive metals that are the decay products of radon – radioactive isotopes of polonium, bismuth and lead. While the short-lived radon progeny (polonium-218, lead-214, bismuth-214 and polonium-214) disappear rather quickly due to rapid radioactive disintegration, the sequence starting with lead-210 (the

lead-210 → bismuth-210 → polonium-210 chain) remains in the environment for centuries, even if the radon migration is halted. In particular, lead-210 & polonium-210 have lots of time to work their way into the food chain. These radon progeny are a form of radioactive fallout.

In Canada, the Inuit have measurably higher concentrations of polonium-210 in their bodies than other Canadians because they eat a lot of caribou meat, and the caribous eat a lot of lichens, and lichens take their mineral nutrition directly from the air, and so they are exceptionally good at accumulating radioactive fallout. That has been documented before in the case of radioactive fallout from atomic bomb tests in Nevada and in the case of radioactive cesium-137 from the Cherniobyl nuclear accident in the Ukraine. In this case, however, the fallout is from radon gas being liberated into the atmosphere and drifting across the tundra.

## **The Dangers of Polonium-210**

Polonium is undoubtedly the most toxic of all the naturally occurring elements. It is thousands to billions of times more toxic than hydrogen cyanide. Like radium, uranium, and radon, polonium is an alpha emitter. When we say that radon gas causes lung cancer, it is really the polonium-214 and polonium-218 – radon decay products – that do 85 percent of the biological damage.

Polonium-210 is another alpha-emitting solid with a half-life of 138 days (about 4 ½ months). That's a long enough time to allow an assassin to carry a tiny amount of polonium-210 in a sealed container from Russia to England, in order to murder an ex-KGB agent named Alexander Litvinenko by stirring the polonium-210 into his tea. Since polonium-210 is a pure alpha emitter – no gamma radiation! – and since alpha particles cannot penetrate even a sheet of paper, this dangerous radioactive poison can be carried safely by the assassin, and security officials will be unable to detect any radioactivity no matter how sophisticated their equipment may be.

Once in the body, however, the polonium-210 attaches itself to red blood cells and courses through the body, shutting down the internal organs one after the other by blasting the living cells with alpha particles. It took about 30 days for Litvinenko to die, but he was a dead man as soon as he finished drinking his tea.

According to the American Health Physics Society – comprised of professionals who specialize in radiation monitoring and radiation protection in industry and medicine – polonium-210 is responsible for up to 90 percent of the deaths normally attributed to cigarette smoking.

There are minute amounts of lead-210 and polonium-210 present when the tobacco leaves are harvested and cured. Since lead-210 has a 22-year half-life it is undiminished when the tobacco is rolled into cigarettes, packaged, marketed and smoked. When the smoker takes a drag on the cigarette, the tip glows extra hot and vaporizes the lead-210 and polonium-210. The radioactive vapour is inhaled. Some of it lodges in the deepest recesses of the lungs, contributing to lung cancer, and some of it crosses into the bloodstream, contributing to heart attacks and strokes. Remember, polonium has an affinity for red blood cells.

When smokers' bodies are autopsied and plaque is removed from their arteries, it is found to be alpha-emitting – because of the polonium-210, which is an alpha emitter. Alpha radiation is

known to cause fibrosis, a kind of toughening of the tissue, and that leads to an accelerated accumulation of the plaque that leads to heart attacks and strokes. But how did this radioactive material get into the tobacco plants in the first place?

Tobacco plants are grown in sandy soil. Radium atoms in the soil, and in the fertilizer – made from radioactive Florida phosphate ore – undergo radioactive disintegration, producing radon gas. The heavy gas hangs low and collects under the unusually thick canopy of tobacco leaves. The radon atoms disintegrate, producing highly radioactive radon progeny one atom at a time.

The new atoms are so small they remain airborne. Because they are electrically charged, they cling to floating dust particles or grains of pollen. These larger particles get attached to the sticky resinous hairs found on the underside of tobacco leaves, and when the tobacco is harvested so are the decay products. The short-lived products disappear rather quickly, by radioactive disintegration, but not the long-lived lead-210. And as long as lead-210 is there to continually replenish the supply of polonium-210, the latter acts as if it also had a half-life of 22 years.

There would be less polonium-210 in cigarette smoke if there were less radioactivity in the fertilizer that is used on the crops. As long as smoking tobacco remains legal, governments would be well-advised to require fertilizer plants or phosphate ore processors to remove the radium from the phosphate before it gets to market. The number of smoking-related deaths would very likely drop substantially after a number of years have gone by. The separated radium will constitute a small volume of highly dangerous material that can be treated with expensive methods – i.e. incorporating it into ceramics or using vitrification techniques – but there would be no more radon emissions from phosphate tailings and a lot less polonium in cigarettes.

***If Quebec is not prepared to ban uranium mining altogether, serious consideration should be given to requiring all uranium processors to remove the radium from the uranium tailings as a preventative measure, thereby drastically reducing the potential for atmospheric radon emissions and unnecessary lead-210/polonium-210 buildup in the food chain. Regulations would need to be developed for the safe and secure long-term storage of separated radium.***

## **Conclusion**

There are too many unanswered questions about the potential economic costs and benefits of uranium mining in Quebec to make the venture worthwhile. On the other hand, there is a good deal of evidence regarding the long-term negative repercussions of uranium mining – more than enough to justify extending the existing moratorium indefinitely.

Quebec has its own problems to deal with. Deliberately allowing the dumping of millions of tons of radioactive wastes to be managed for hundreds of thousands of years into the future does not seem to be a wise choice, especially given the fact that uranium markets are very soft and unpredictable, the future of the nuclear power industry is highly problematic both here and abroad, and the threat of nuclear weapons proliferation is growing rather than shrinking.

The population of Quebec has given many signs that it does not want uranium mining. Hundreds of municipalities have passed resolutions against uranium mining; a significant cadre of doctors

and health professionals has spoken out strongly against uranium mining. First Nations communities, both in Eeyou Istchee and in the rest of Quebec and Labrador, have said they do not want it and will not allow it. Hundreds of expressions of concern and opposition have been received by the BAPE.

The National Assembly has spoken out against accepting the permanent storage in Quebec of nuclear wastes that were produced for the benefit of others. If uranium mining is allowed to go ahead in Quebec we will be doing exactly that – accepting the thankless task of managing huge volumes of radioactive wastes from an activity that will be of no lasting benefit to Quebec

*The Canadian Coalition for Nuclear Responsibility (CCNR), also known as Le Regroupement pour la surveillance du nucléaire (RSN), calls on the government of Quebec to declare a permanent ban on uranium exploration and mining in Quebec.*

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## Les travaux parlementaires

38<sup>e</sup> législature, 1<sup>re</sup> session

(début le 8 mai 2007)

**Débats de Assemblée nationale Le jeudi 30 octobre 2008, 15 h 25**

**Le Vice-Président (M. Picard):** M. le député de Vachon.

**M. Bouchard:** M. le Président, je demande le consentement de cette Chambre pour présenter, conjointement avec la ministre des Ressources naturelles et de la Faune et le député de Marguerite-D'Youville, la motion suivante:

«Que l'Assemblée nationale demande au gouvernement d'interdire l'enfouissement sur le territoire du Québec de déchets et de combustibles irradiés en provenance de l'extérieur du Québec.»

**Le Vice-Président (M. Picard):** Merci, M. le député. Est-ce qu'il y a consentement pour débattre de cette motion?

**M. Pelletier (Chapleau):** Il y a consentement pour qu'elle soit adoptée sans débat.

**Le Vice-Président (M. Picard):** Cette motion est-elle adoptée sans débat?

**Des voix:** Adopté.

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### ***Rough Translation:***

**M. Bouchard:** Mister Speaker, I ask for the consent of this Chamber to present the following motion, jointly with the Minister of Natural Resources and Wildlife and the member from Marguerite-D'Youville:

"That the National Assembly ask the government to forbid the burial on Quebec territory of nuclear wastes and/or irradiated nuclear fuel coming from outside Quebec."

***The resolution was adopted without debate by unanimous consent.***

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