Submission to Voluntary Planning
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My vision for Nova Scotia is for a clean, healthy environment. As a physician, academic and scientist I am concerned that the idea of uranium mining in Nova Scotia is being seriously considered by government at all. All scientific evidence, as well as simple common sense, indicates that mining uranium carries health risks, and even the most ardent proponents of mining must concede such. The only issue is whether the risks can be justified by the benefits – a simple risk/benefit ratio. Let us, then, examine both sides.

The benefits of uranium mining are fairly clear-cut: uranium has become a valuable commodity on world markets recently, and the province could be expected to reap a good financial return both for the uranium itself, and in terms of jobs. It is important to note, however, that the life of a uranium mine is generally in the order of 10 to 20 years, and can be expected to employ at most a few dozen persons. At the end of its life, the province will be left with a tailings pile or pond containing radioactive materials which will remain dangerous for the next 10,000 years or more.

On the other side of the coin, the risk flows from a number of sources. Mining is a hazardous occupation. Indeed, virtually all human activity carries some degree of risk, and this in itself should not automatically proscribe uranium mining. Uranium mining, however, is qualitatively different in two respects: 1) it imposes hazards not only on the miners, but on the population surrounding the mine, (up to a distance of 400km. according to Küppers and Schmidt[1]) 2) these hazards persist in the environment for tens of thousands of years, long after the brief benefits accruing from the original mining, forming a legacy which will affect generations for as long into the future as the whole of human civilisation to date. Uranium exists naturally in many of the rock formations in Nova Scotia. By the immutable laws of physics, the U-238 in the rock decays through a series of radioactive daughters[*] including radium, radon, and polonium. As long as the material remains locked in the rock none of these products pose any health risk, as the radioactive emissions are all of relatively low energy (alpha and beta), and hence will not travel any distance, nor penetrate into the tissues of living organisms. The problem arises when the rock is dug up and crushed. At this point, the various daughters are released into the environment. Each of these daughters carries specific risks, which I shall address individually.

Radon

Radon is a gas. As long as it remains locked in the rock, it decays (over the brief period of 3.8 days) to a series of solid daughters with half-lives measured in seconds to minutes, to lead-210, which persists for 22 years, before decaying to polonium-210,

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[*] The current gender-neutral nomenclature is "progeny"; I refuse to abandon the more poetic "daughters" in the interests of bureaucratic political correctness

(more of which later). The problem arises when the radon is released from the rock by mining and crushing it. Being a gas, it is impossible to contain it, and it is released into the atmosphere around the mine, drifts for varying distances depending on wind patterns, and is breathed in by both humans and animals. The association between exposure to radon and development of lung cancer is firmly established, and is the basis for the current survey of all public buildings in the province for levels of radon. Unfortunately, the radon in the basements of public buildings or private residences is identical to the radon released by uranium mining, and carries the identical risk of provoking lung cancers.

To understand the reason why radon causes lung cancer we need to go back to the decay chain alluded to above. Humans and animals breathe in the radon, and during the brief period while the inhaled radon is in the lungs, a small amount of it decays into polonium-218 – a solid. This then falls out and deposits on the surface of the lung tissue before decaying into lead-214, bisthmuth-214, polonium-214, and finally lead-210. With each of these decays bursts of radiation are given off, bombarding the lung cells in the immediate vicinity and disrupting the chromosomes of these cells. The chromosomal damage is then manifest in the development of cancers of the cells lining the surfaces of the lungs.

Given that it is impossible to confine the radon released by the mining and crushing processes, the critical question becomes whether the quantities released are sufficient to pose any hazard, and how far does this extend. In answer to the first question, levels of radon measured in the vicinity of a typical mine show an increase in radiation exposure of 2.5 mSv* – approximately doubling the usual background radiation levels, (and hence, simplistically, potentially doubling the cancer risk)†. A more thorough analysis of risk was carried out by Küppers and Schmidt[1], who examined the remarkably detailed records maintained by the Wismut mining company in the former East Germany. Using the measured levels of radon, they calculated a risk of 6 additional lung cancer cases per 1000 population, half of which would occur in the area between 100 km. and 400 km. from the source. That is, the gas drifts sufficient distances to pose a hazard not only in the immediate vicinity of the mine, but also to endanger distant populations. To translate this into very approximate numbers for Nova Scotia, a uranium mine in Lunenburg county could be expected to generate an additional 3000 cases of lung cancer over the next 70 years. Whether this risk is justified by the economic benefits accruing is obviously a political decision. But it is critical that if it is decided to proceed with uranium mining, government recognise that it is not "safe", as they currently maintain publicly. It carries a real risk to public health. A very simplistic economic analysis would suggest that the health care costs alone render the balance against mining: at approximately $15,000 in health care costs per case of lung cancer (from diagnosis, through treatment, to death)[2], the cost of treating these 3000 cases approaches $4.5

* Radiation exposure is measured in units called Sieverts, representing 1 distintegration per second; a milli-Sievert (abbreviated mSv) is 1/1000'th of a Sievert. Background radiation from both natural sources and cosmic rays averages approximately 2.5 mSv. annually.

† The actual risk is probably significantly greater than this, as alpha radiation, because it is delivered to a small, concentrated area of tissue, has a greater biologic effect than the background gamma radiation.

million. While the mine may generate a comparable profit, that profit will not remain in Nova Scotia, while the costs to treat the victims will fall on the public purse.

Lung cancer induced by inhaled radon is not the only hazard engendered by the radon released by mining and milling. As noted above, the radon released into the atmosphere decays over a period of days into a series of solid materials, which are then washed out by precipitation onto the vegetation. Several of these daughters are bio-concentrated by certain plants, and when grazing animals eat the vegetation, these isotopes are further concentrated by the animals. This phenomenon is sufficiently significant that Thomas and Gates[3,4], studying caribou in northern Saskatchewan in the vicinity of uranium mines concluded that the livers of the caribou contained so much polonium-210 (300-500 Bq) that consumption of more than one caribou liver per year by the aboriginal population would increase the risk of induced cancers unacceptably. No studies have been done on the effects of this burden of radioactive material on the caribou themselves, but it is entirely reasonable to conclude that it is likely to have deleterious effects. Nor is this phenomenon likely to be confined to northern populations; the deposition of radioactive decay products on the vegetation, consumption by herbivorous animals, and subsequent consumption of the animals by humans are all processes common to all environments, including Nova Scotia. In the case of ingestion of these daughter products the hazard is two-fold – the radioactive substances emitting alpha radiation irradiate the cells lining the gut, exactly the same as the lung cells exposed to deposited products. This leads to bowel cancers. These same substances are then absorbed into the body and irradiate the soft tissues, particularly the liver, where they are concentrated, again causing cancers. Of the daughters present, by far the most dangerous is polonium-210. This is roughly 20,000 times more toxic than cyanide, and is the same material used to kill the Russian agent, Alexandr Litvinenko recently.

The Tailings

While there is no way to confine the radon emitted during mining and milling, the other radioactive materials present are at least potentially controllable, even if not practically so. The rock dug up from the mine contains equal quantities of the two isotopes of uranium (U-238 and U-234) plus small amounts of U-235 (which is the isotope which is actually in demand for use both as nuclear fuel and for weapons). In addition, however, it also contains the same quantities of all the daughter products, such as thorium, radium, radon, and polonium. These additional substances are of no commercial value, and after the uranium has been extracted from the ore, the remaining material is simply thrown away, forming a huge deposit of radioactive material. In the past this was piled up to form huge piles which then blew around as radioactive dust, as well as exhaling radon on an ongoing basis. To obviate these problems, the practice of burying the tailings in large water-filled ponds was adopted. This does indeed prevent the release of the radon into the atmosphere, but one is still left with a large lake of radioactive material admixed with water, generally confined by a series of dams or dykes. Two problems arise here: the confining dams break (and there is not a single uranium mine site which has not sustained spills from tailings ponds), and the water with the dissolved radio-isotopes leaches through the bottom of the pond into the water table. The current technology to deal with this last consists of burying pipes under the tailings pond to collect the water leaching through the bottom, and pumping it back up into the pond. This does, indeed, work in preventing contamination of the water table, but the problem is that it will be necessary to keep these pumps going for the next 10,000 years, a highly improbable scenario. It is doubtful that any company is going to trade 10-20 years of production in the mine for 10,0000 years of pumping of the tailings pond. In practice, the history of the industry has been consistently to walk away from the contamination, leaving the public purse with the task of trying to clean up the mess.

Now, does this matter? From the perspective of public health (which is my focus), yes, very much. Given the virtual certainty of contamination of surface waters (from rupture of dams) and of the water table (from leaching), we must consider the effects of each of the various isotopes present. There are 14 steps in the decay sequence of U-238 to lead-206 (the stable end-product) of the decay series). Leaving aside consideration of radon and its short-lived daughters, (addressed above), there remain only four which are significant from a human (and animal) health perspective: uranium itself, radium-226, lead-210 and polonium-210.

Uranium (which remains present in small quantities in the tailings) has been shown to be both chemically toxic, causing renal damage, as well as radiologically hazardous, causing gastric and kidney cancers, as well as leukemias.[5] In addition, it has recently become apparent that it acts as an estrogen analogue (Raymond-Whish et al[6]) causing reproductive problems and potentially increasing the risk of gynaecologic cancers.

Radium was in the past used to render the faces of watches luminous in the dark, but was abandoned when it became apparent that the workers using this material were developing osteonecrosis of the mandible (death of the bone of the jaw bone) and leukemias. Indeed it was the cause of the death of its discoverer, Marie Curie. With the realisation of just how toxic it is, its use was abandoned as too dangerous.

Lead-210 preferentially deposits in bone, behaving like calcium in the body. While it decays with beta radiation with a half-life of 22 years, its main toxicity stems from this deposition in bone, followed by its decay into polonium-210.

Polonium-210 is one of the most highly toxic substances known. One <u>micro</u>gram delivers a radiation dose of approximately 0.1 GBq,(100,000 Becqerels), which may be expected to prove fatal[7], (and indeed was the estimated dose delivered to Alexandr Litvinenko) It is well absorbed from ingested food or liquids (absorption ranges between 10% to 90% of the ingested dose, depending on chemical form and whether it is in food), and acts primarily on soft tissues such as bone marrow, liver and kidneys, killing the cells, and causing the death of the organism within one month. Polonium is present in the tailings, will continue to be produced by decay of the precursors for the next 10,000 years, and with any spill, or seepage into the water table, will contaminate the water supply with potentially lethal consequences.

While the proponents of uranium mining are insistent that “modern engineering methods render uranium mining safe” the countless (largely aboriginal) populations who have been poisoned by uranium and the tailings, together with the shear impossibility of confining these products for the time scales required belie these assurances. By any rational standard, the population health risks attendant on uranium mining far outweigh the short-term economic benefits. I would strongly urge the government to enshrine in law the existing moratorium on uranium mining, as a permanent ban.

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