Uranium mines: lung disease and mistrust among Native Americans

In a decision announced Feb 6, 2014, the New Mexico Supreme Court, USA, ruled that the state's designation of 400 000 acres near Mount Taylor as "traditional cultural property" for Native American tribes in the area does not violate state law. Some believe the ruling will strengthen Native Americans' position in opposition to plans for new uranium mines.

Mount Taylor is a sacred peak for five of the state's Native American tribes. It also harbours one of the largest deposits of uranium ore in North America.

Plans to open new mines there have rekindled mistrust among Native Americans, who recall the US Government's and uranium industry's failure to warn miners of lung cancer risks, and are concerned about persisting mine waste contamination of soil and water.

The primary hazard for underground miners was not uranium per se, but radon gas, agree experts contacted by *The Lancet Respiratory Medicine*. "The role of radon daughters (radioactive decay products) that accumulate in underground uranium mines in causing lung cancer is well established", explains Doug Brugge (Tufts University, Boston, MA, USA). Most Native American uranium miners were non-smokers, and yet researchers found they represented more than 70% of the lung cancers diagnosed among Navajo people. "In fact, the causal link was pretty clear by the early 1950s", Brugge says. But policies to improve ventilation in mines took more than a decade longer to implement, "causing more lung cancer", says Brugge.

Radium, thorium, and uranium are comingled in buried ores. Radium decays into radon, which yields "a whole series of radioactive isotopes", some of which release alpha particles, Brugge says. But during the 1950s, nobody informed uranium workers of the dangers. Some took ore and radioactive fossil wood home. Waste ore was used as building material for homes.

Early cohorts of miners were "really heavily exposed", says Jonathan Samet (Keck School of Medicine, Institute of Global Health, University of Southern California, Los Angeles, CA, USA), a pioneer in the study of uranium miners' lung cancer risks. "Federal documents from trips to these mines in the early 1950s describe miners whose tongues were covered with green ore dust, and a lack of washroom facilities." Such conditions were seen at larger corporate mines, he notes—not just small "dog-hole" operations.

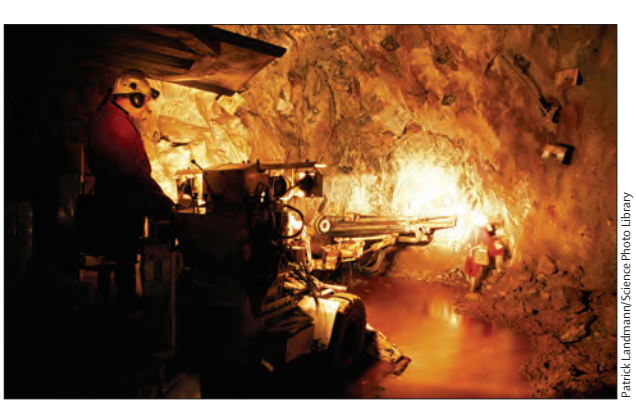
"Past episodes of lung cancer in miners were preventable with adequate ventilation in the mines," says Frank Gilliland (University of Southern California, Los Angeles, CA, USA), who investigated Navajo miners' lung cancers in the 1980s and early 1990s. Uranium miners brought contamination home on clothing, exposing family members including women and girls doing laundry, notes toxicologist Johnnye Lewis (University of New Mexico, Albuquerque, NM, USA). "There weren't showers or protective clothing", she says.

Another major concern was that Native American children grew up in mining camps, Lewis adds. "Children spent critical periods of organ development exposed in the camps and playing on waste piles." Following Navajo miners' lawsuits over lung cancer and silicosis, the 1990 US Radiation Exposure Compensation Act (RECA) was made law, offering uranium miners with cancer or lung disease, one-time payments of US$100 000. In 2000, the law was amended to include uranium mill workers and ore truck drivers. But miners exposed after 1971 are excluded from RECA payments, notes Manuel Pino (Scottsdale Community College, Scottsdale, AZ, USA). Before the 1970s, the federal government was the sole purchaser of uranium from the region.

Efforts are now underway to update earlier studies, report Samet and New Mexico Cancer Registry Director Charles Wiggins. "We're presently working on a study that will characterise the contribution of uranium mining to the burden of lung cancer among the Navajo in the decades after the uranium boom" (after the 1980s), Wiggins says. That study will be released later this year. Lung cancer rates "really seem to have been stable over time, but we've no tribe-specific analyses", he cautions.

A separate update of the Uranium Epidemiology Study of miners is also underway. "This study will represent one of the longest follow-ups of any study of uranium miners, and the results will be of great interest", Wiggins predicts. The cohort data include smoking histories, mine working histories, and respiratory function test results—a "rich data set last updated more than a decade ago," he says.

After the Three Mile Island nuclear accident in 1979, many planned nuclear power plants were cancelled and the uranium mining industry declined, Samet says. Mining companies "just left and let the mines flood in the



Patrick Landmann/Science Photo Library

Lancet Respir Med 2014

Published **Online**
February 19, 2014
http://dx.doi.org/10.1016/S2213-2600(14)70005-0

To read more about the **New Mexico Supreme Court's ruling** see http://nmindepth.com/2014/02/07/states-high-court-aids-mt-taylor-preservation-efforts/

For **Brugge's coauthored history of uranium mining and the Navajo people** see http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3222290/

For more on the **health legacies of uranium mining on the Navajo Nation** see *Environ Health Perspect*; http://ehp.niehs.nih.gov/122-a44/

For **Samet and colleagues' work on uranium mining and lung cancer among Navajo men** see *N Engl J Med* 1984; **310:** 1481–84

For **Gilliland and colleagues' work on uranium mining and lung cancer among Navajo men between 1969 and 1993** see *J Occup Environ Med* 2000; **42:** 278–83

For more on the **Navajo Birth Cohort Study** see http://www.epa.gov/region9/superfund/navajo-nation/pdf/stakeholders/2013/dr-lewis-birth-cohort-study-update2013.pdf

1980s." The Navajo Nation alone has 521 abandoned uranium mines and at least 1100 abandoned so-called features such as waste piles. The western USA has more than 4000 abandoned uranium mines.

"Uranium issues on tribal lands are huge", Lewis says. "That's part of a much larger problem, which is about a half-million hard rock mine waste sites. The most recent figure I've seen on remediation costs was US$21 million per site. That was in 2001 dollars. Half a million sites are not going away any time soon."

Environmental release of heavy metals and radioisotopes from waste-rock piles and tailings are "the prime environmental concerns in abandoned uranium mining and processing sites", says mine water chemist Martin Mkandawire (Cape Breton University, Sydney, NS, Canada). Major hazards are posed by atmospheric dispersion of radioactive aerosol particles by wind, contamination of water, and radon gas emanation into air, he says.

For decades, the world's largest open-pit uranium mine—the Jackpile—operated just 2000 feet from Paguate Village on the Laguna Pueblo Indian Reservation in New Mexico, says Pino, a member of the neighbouring Acoma tribe. The Jackpile "was a massive site, nestled up against Paguate," says Samet. "There's no doubt that dust traveled from the mine. Elsewhere, animals grazed on unstabilised tailings." Mining there was active from the 1950s to 1982, and reclamation efforts occurred in the 1990s. In December, 2013, Jackpile was designated a federal National Priorities List "Superfund" hazardous waste site. Before reclamation efforts to revegetate the mine, blowing dust from the mine was a frequent issue, Pino recalls. "During the rainy season in July, August, and September, our dry arroyos became raging rivers, and we began to ask about the migration of contaminants from the mine."

Massimo Borchi/Science Photo Library

In the 1980s, cases of lung cancer, leukaemia, lymphoma, and gall bladder cancer were diagnosed in Paguate villagers, recalls Ron Lujan, a retired surgeon who worked with Native populations in the area. Those malignancies were rarely seen among people living in other villages, he tells *The Lancet Respiratory Medicine*. "There was some maxillary sinus cancer there too, which was rare, and I wonder if that wasn't from inhalation of carcinogens", he says, adding that these represent his clinical experience but not a formal epidemiological study.

On the Navajo Nation, Lewis, Chris Shuey (Southwest Research and Information Center, Albuquerque, NM, USA), and others involved in the DiNEH (Diné Network for Environmental Health) Project found that residential proximity to abandoned mines and waste sites was an independent predictor of hypertension, kidney disease, and autoimmune disease risk. Direct contact with waste sites—such as herding animals over mine waste or using mine water to drink, bathe, or water livestock—further increased health risks, they say. Kidney disease was associated more with the active mining era, whereas hypertension and autoimmune disease were more associated with an "environmental latency period" after mining had largely ceased, Shuey noted. These added risks are troubling for Native populations beset with high rates of obesity and diabetes.

Responding to concerns among Native Americans about the effects of mine waste exposures on children, Lewis, Shuey, and others have teamed up to do a prospective biomonitoring study of pregnancy outcomes on the Navajo Nation, with the US Centers for Disease Control (CDC/ATSDR), Navajo Division of Health, the Indian Health Service and others. The Navajo Birth Cohort Study will document uranium mine waste exposures among mothers, fathers, and newborns, and "follow them forward", Lewis says. "We're looking at blood and urine samples for current exposures (to uranium and heavy metals), ongoing levels of exposure, and collecting data to help us go back and see where the exposures are coming from", Lewis says. "The DiNEH study found a relationship to uranium waste piles, but not necessarily the uranium. We don't know exactly what was in the waste material—a lot of arsenic, copper, vanadium, nickel, and heavy metals; you might expect multiple metals working together" in toxic synergy. Lewis and her colleagues are collaborating with geochemists to characterise the waste materials. "There's still a lot we don't know."

Because of a longstanding Navajo Nation prohibition on genetic research involving its members, the study will not include genomic, epigenetic or gene mutation analyses. "There's a lot of mistrust of research in Native communities", Lewis notes. Her team includes Navajos. Recruitment efforts include YouTube interviews with participants.

Meanwhile, the lessons from past mining in the US must be applied to "the expansion of uranium mining in developing countries, especially in Africa", urges Brugge. "So far there is little evidence that new mining in these countries will be much better than historical mining in the USA. It would be a tragic shame to subject another wave of miners to the same illnesses and suffering."

Bryant Furlow