

The Sequoyah Corporation Fuels Release and the Church Rock Spill: Unpublicized Nuclear Releases in American Indian Communities

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The Three Mile Island nuclear release exemplifies why there is public and policy interest in the high-technology, highly visible end of the nuclear cycle. The environmental and health consequences of the early steps in the cycle—mining, milling, and processing of uranium ore—may be less appreciated.

We examined 2 large unintended acute releases of uranium—at Kerr McGee’s Sequoyah Fuels Corporation in Oklahoma and United Nuclear Corporation’s Church Rock uranium mill in New Mexico, which were incidents with comparable magnitude to the Three Mile Island release.

We urge exploration of whether there is limited national interest and concern for the primarily rural, low-income, and American Indian communities affected by these releases.

More attention should be given to the early stages of the nuclear cycle and their impacts on health and the environment. (*Am J Public Health*. 2007;97:1595–1600. doi:10.2105/AJPH.2006.103044)

WHEN ONE CONSIDERS THE risks of nuclear power, the incidents at Three Mile Island and Chernobyl (Table 1) come to mind for several reasons. These events have been broadly publicized by the media, studied extensively in the scientific literature, and in the case of Chernobyl, there is clear evidence that the release resulted in substantial health consequences.^{1–7}

Nuclear weapons and nuclear power would not be possible without the working-class jobs at the early stages of the nuclear cycle. The occupational toll from uranium mining—many thousands dead worldwide—is well documented in the scientific literature⁸ and includes hundreds of American Indian miners.⁹ Despite this, the dangers of uranium mining, milling, and processing are not well known in the public and policy arenas.

Uranium has been mined worldwide, including in the former Soviet Union, China, Australia, Canada, India, and many countries in Africa, Eastern Europe, and elsewhere. The bulk of uranium mining in the United

States has been in the Colorado Plateau in the southwestern part of the country. It has been estimated that 10 000 people worked in uranium mining in the United States from the late 1940s into the 1980s, with a disproportionate percentage of the workers being American Indians because of the location of the mining areas.^{10,11} The environmental impact of uranium mining is still being felt as a result of thousands of abandoned mines and dozens of former mill sites.^{10,12}

The main impact of uranium mining on the health of underground miners is caused primarily by inhalation of silica dust of the radioactive decay products of radon. United States Public Health Service studies of uranium miners were deemed unethical.¹³ A long and protracted campaign by former miners and their families resulted in a (still contested) federal compensation program.¹⁴ The issue of environmental harm caused by uranium mining and the mining’s possible impact on the health of community residents is still unresolved and pressing.¹⁵

We explored 2 acute incidents that occurred in the early stages of the nuclear cycle within the United States. The nuclear incidents at Kerr McGee’s Sequoyah Fuels Corporation (named for the Cherokee man who invented the Cherokee syllabary in 1812) in Oklahoma and at United Nuclear Corporation’s Church Rock uranium mill in New Mexico, although reported in the gray literature (reports not found in traditional, peer-reviewed publications), have not, with few exceptions,¹⁶ been presented in the peer-reviewed literature. In a search of MEDLINE (August 31, 2006) there were no citations for Sequoyah Fuels Corporation or Church Rock. This is in contrast to Three Mile Island (125 MEDLINE citations) and Chernobyl (3396 MEDLINE citations). We present brief case studies of these 2 unintended releases of uranium to raise interest in these and other effects from the early stages of the nuclear cycle. We also discuss the possible role of how the occurrence of these events in low-income and rural American Indian communities

TABLE 1—Comparison of the Three Mile Island, Chernobyl, Sequoyah Fuels Corporation, and Church Rock Releases

Event	Location	Year	Source	Released Material	Radiation Released
Chernobyl	Chechnya, USSR	1986	Nuclear power plant	Nuclear fission by-products	270 million curies
Three Mile Island	Pennsylvania, US	1979	Nuclear power plant	Nuclear fission by-products	13 curies
Sequoyah Fuels Corporation	Oklahoma, US	1986	Uranium conversion plant	Uranium hexafluoride gas	3 curies ^a
Church Rock Mill	New Mexico, US	1979	Uranium mill	Transuranic isotopes and heavy metals	46 curies ^b

^aCalculation based on 29 500 pounds of uranium hexafluoride released.

^bCalculation based on report of gross alpha levels and total volume of water released.



Source. Photograph courtesy of Southwest Research and Information Center.

FIGURE 1—The breach of the dam at Church Rock, NM, in 1979.

might have affected the attention given to these incidents. We suggest that early nuclear cycle events need to be better studied and brought to greater awareness of the public and policymakers at a time when uranium mining and production is in resurgence.¹⁷

We reviewed written documentation, largely from the gray literature, about Sequoyah Fuels Corporation and Church Rock. We supplemented the literature review with experiential knowledge that D.B. gained during 12 years working with the Navajo uranium mining communities and about 5 years working with communities near Sequoyah Fuels Corporation. Another author (J.D.) has studied uranium transport in the Church Rock area. We assembled the available information into a narrative description of events and drew lessons based on both the documented history of the events

and our personal and professional knowledge and experience.

THE SEQUOYAH FUELS CORPORATION RELEASE

On April 20, 1970, after 2 years under construction, and 2 days before the first Earth Day celebration, Kerr McGee Corporation opened the \$25 million Sequoyah Fuels Corporation facility near the towns of Gore, Vian, and Webber's Falls, in eastern Oklahoma.¹⁸ Sequoyah Fuels Corporation is located near a major interstate highway (I-40), at the confluence of the Illinois and Arkansas Rivers and upstream from the Robert Kerr Reservoir in countryside that is within the jurisdiction of the Cherokee Nation. Census tracts adjacent to the plant were between 10% and 30% American Indian in the 1990 census.

Sequoyah Fuels Corporation was licensed as a fuel cycle facility regulated by the Nuclear Regulatory Commission to convert yellowcake (concentrated uranium ore) into gaseous uranium hexafluoride (UF_6). Sequoyah Fuels Corporation was the second facility of its kind to open in the United States and was 1 of 4 nuclear industry plants in Oklahoma. At Sequoyah Fuels Corporation, yellowcake was treated with nitric acid for purification and extraction of uranium. The uranium was then treated with hydrogen fluoride to produce UF_6 , which was stored and transported in compressed gas cylinders.¹⁹

On January 4, 1986, just 4 months before the Chernobyl release, Sequoyah Fuels Corporation experienced a rupture in an overfilled UF_6 cylinder that contained an estimated 29 500

pounds of gaseous UF_6 (an event that is described in Nuclear Regulatory Commission reports^{20,21} and an academic article¹⁶; Table 1). The incident led to the death of a 26-year-old worker, James Harrison, of African American and Cherokee heritage, and the hospitalization of 37 of the 42 onsite workers. Health care providers examined up to 100 people, many from the community, for health effects, and 21 were hospitalized for short periods.

Reconstruction of events indicated that at 2:15 AM, the cylinder, with a capacity to hold 27 500 pounds of UF_6 , had been overfilled. Apparently, the scale read only 26 400 pounds because it was not calibrated properly. Once it was determined that the cylinder was overfilled, the shift supervisor directed workers to remove the excess UF_6 . By 8:45 AM much of the UF_6 had solidified and no more could be removed. Workers were then instructed to liquefy the UF_6 by heating it in a steam chest, a direct violation of company policy. At 11:30 AM, 2 hours and 15 minutes after heating began, the cylinder ruptured. The UF_6 vaporized and combined with the moisture in the steam chest, which released a highly acidic gas. Half of the UF_6 was reported to have washed into the on-site emergency pond and half formed a white plume containing uranyl fluoride and hydrofluoric acid.

The facility ventilation system carried the plume of uranyl fluoride and hydrofluoric acid toward the scrubber building 15 m away where Harrison inhaled the hydrofluoric acid, which caused acute respiratory injuries that led to his death. The plume left the plant and traveled 29 km (the

wind was registered at 40 km per hour) south of the plant, past I-40, and over several sparsely populated residential areas.

On the day of the rupture, Sequoyah Fuels Corporation lacked a systematic procedure to deal with the emergency. The Gore Police Department was called, and they notified the Sequoyah County Sheriff's Department and Oklahoma Highway Patrol to close down I-40 and Highway 10, the side road that passed directly in front of the plant. The general public was notified through the local radio, by workers calling home, and by Sequoyah Fuels Corporation's Manager of Personnel and a representative of Gore Civil Defense going home-to-home prior to the media being informed. A hotline at Sequoyah County Department of Health also was established.

Sequoyah Fuels Corporation had not arranged in advance with Sequoyah Memorial Hospital to treat workers in such an emergency. After Harrison inhaled hydrofluoric acid, he was driven 13 km to a nursing home for a canister of oxygen before he was taken to Sequoyah Memorial Hospital, which was 18 km away. However, Memorial Hospital was unequipped to treat Harrison and sent him to a larger hospital, Sparks Regional Medical Center in Fort Smith, Arkansas, another 34 km away. Harrison died at 3:00 PM, soon after arriving at the emergency room at Sparks Regional Medical Center.²²

Although Sequoyah Fuels Corporation was able to reopen after the incident, the company never fully recovered. In 1988, Kerr McGee sold the facility to General Atomics. Another acute release occurred at Sequoyah Fuels Corporation in 1992. In 1993, the plant shut down for good

and began a long decommissioning process to address on-site contamination, most of which arose from routine operation.²³ Chronic on-site releases, some of which were substantial, cumulatively contributed far more contaminants—both radioactive and chemical—to the environment than did the acute incident in 1986, with leakage from storage ponds contributing to the bulk of the contamination.^{24,25}

It is tempting to compare the Sequoyah Fuels Corporation release of UF₆ to Three Mile Island. Although the 2 events have innumerable distinctions, the overall size of the releases and health impact of both may be similar (Table 1). The health impact of the Three Mile Island release is subject to some controversy; however, most sources cite no acute health effects, and there is debate about possible long-term effects. The acute health impact at Sequoyah Fuels Corporation was 100 people going to the hospital with 21 hospitalized and 1 death. Long-term effects are also not clear in the Sequoyah Fuels Corporation release. Despite the similarity in scale and impact, Three Mile Island is far better known.

A striking difference is that the Three Mile Island release happened in a highly populated area near major media outlets and in the aftermath of a major motion picture about a nuclear accident, whereas the Sequoyah Fuels Corporation release was in a sparsely populated, low-income, heavily American Indian countryside. The Sequoyah Fuels Corporation release involved highly acidic uranium, which has a very low specific activity (i.e., is not very radioactive), so the cause of acute injuries was chemical corrosion rather than radiation

poisoning, possibly lessening the drama of the event.

In the 1980s and into the 1990s, the grassroots community-based organization Native Americans for a Clean Environment was a critic of Sequoyah Fuels Corporation. The group's impact remained local, and any effect that they had on the eventual closing of Sequoyah Fuels Corporation is difficult to disentangle from the general decline in the US uranium market by the 1980s.²⁶ In the 1990s, other initiatives by the Cherokee Nation (who have maintained a long-term interest and involvement in the Sequoyah Fuels Corporation site), namely a National Institute of Environmental Health Sciences-funded environmental justice project and periodic federally mandated public hearings about the decommissioning plans maintained a moderate level of community involvement but never generated national attention (D.B., unpublished data—personal observations based on 5 years working with community groups near Sequoyah Fuels Corporation).

Interestingly, another incident that involved death, radiation, Kerr McGee, and Oklahoma is well known. Karen Silkwood was a Kerr McGee worker whose death was taken up by the antinuclear movement as a symbol of their concerns about nuclear power. Silkwood's concerns about health and safety practices at Kerr McGee's plutonium facility near Crescent, Oklahoma, and her subsequent death in an automobile crash has been told in books²⁷ and made into a major motion picture. It is likely that the interest in the Silkwood story resulted from her participation in a union and being picked up as a cause by the US environmental movement.

Notably, the Silkwood case arose near a major city (Oklahoma City) rather than a rural American Indian community and involved higher order nuclear production (plutonium).

THE CHURCH ROCK SPILL

In 1968, 27 km northeast of the city of Gallup in the town of Church Rock, NM (a rural chapter, as the towns of the Navajo Nation are known), United Nuclear Corporation began mining the largest underground uranium mine in the United States.²⁸ Residents in proximity to the mine site area were almost entirely Navajo and relied on the nearby Puerco River as a watering source for their livestock.²⁹ In addition, local medicine men derived remedies from the native plants that grew along the riverbank, and children played in the river during hot summer months.³⁰

Less than 10 years after the initiation of mining, United Nuclear Corporation was licensed by the New Mexico Environmental Improvement Division to operate the Church Rock Mill, which enabled the company to produce more than 2 million pounds of uranium oxide (U₃O₈) annually—enough to supply annual reload fuel to approximately 5 nuclear power plants. The mill and disposal complex were in an area used primarily for livestock grazing and employed more than 200 Navajo workers.²⁸

Wastes from the ore extraction process, consisting of wet sand and mill liquids, were disposed of in 3 lined lagoons.^{30,31} Earthen dikes separated each cell and a 50- to 75-foot-high earthen impoundment surrounded the complex. This earthen dam had been identified by United Nuclear

Corporation's own consultant, in addition to state and federal agencies, as being built on geologically unsound land. According to these groups, the soil under the dam was susceptible to extreme settling that was likely to cause cracking and structure failure. In fact, large cracks were observed on the dam in 1977, but were not reported to the appropriate authorities.²⁸

In the early morning hours of July 16, 1979, less than 4 months after the highly publicized release at Three Mile Island,³² the earthen dam at Church Rock Mill failed (Table 1). The amount of radiation released at United Nuclear Corporation was *larger* than the release at Three Mile Island. The 6-m-wide dam breach sent approximately 1100 tons of radioactive mill waste and 95 million gallons of mine process effluent down Pipeline Arroyo and into the North Fork of the Puerco River.³³ This tremendous flow of water backed up sewers, affected 2 nearby aquifers, left pools along the river, and transported contaminants 130 km downstream to a point near Navajo, Arizona.³⁴

A United Nuclear Corporation employee identified the dam breach around 6:00 AM, at which time discharge to the disposal complex was suspended. A temporary dike was constructed in front of the breach, which stopped the flow of residual tailings by 8:00 AM. United Nuclear Corporation contacted the New Mexico Environmental Improvement Division, the Nuclear Regulatory Commission, and the Mine Safety and Health Administration. Gallup city officials were contacted, and news of the spill was broadcast on local radio stations. In accordance with a state contingency plan, Navajo

employees of United Nuclear Corporation were dispatched to personally notify Navajo-speaking residents downstream.²⁸

Within weeks, signs were posted in New Mexico and Arizona that warned against the use of water for human or livestock consumption. Water, soil, and air samples were taken and revealed a spike in radioactivity immediately following the spill, followed by a rapid decline attributed to evaporation of spill liquids and heavy precipitation in August and October of 1979.^{28,30} Some contaminated water wells were closed by the New Mexico Environmental Improvement Division, which prompted United Nuclear Corporation to supply bottled water and to dig new wells for livestock watering. Local veterinarians and the Centers for Disease Control and Prevention confirmed that sheep and goats that ingested water from the Puerco had elevated levels of radiation in their tissues.²⁹ Six Navajo individuals were sent to Los Alamos Scientific Laboratory in attempts to address human exposure to radionuclides from the spill. Test results demonstrated no acute effects in these individuals, and it was reported 7 months later in a local newspaper that there was no significant danger to human health from the spill.³⁰

In August 1979, the chairman of the Navajo Tribal Council's Emergency Services Coordinating Committee sent a telegram to the Governor of New Mexico requesting that he declare a state of emergency and that McKinley County be declared a disaster area. The request was denied.³⁰ It was the first of many denials for assistance, which resulted in significant downplay of a nuclear release.

United Nuclear Corporation manually removed 3500 tons of sediment from the Puerco River to a distance of 16 km downstream, estimated as only 1% of the spill material.²⁸ It was projected that the company was losing more than \$200 000 per day in yellowcake production while milling was suspended. In his testimony to Congress on October 22, 1979, David J. Hann, the executive vice president and chief operating officer of United Nuclear Corporation, expressed his concern about the denial of permission to reopen the Church Rock Mill facility and stated that continued delay "will force us to reduce our workforce substantially, resulting in severe hardship to the local community."²⁸ Less than 2 weeks later, on November 2, 1979, the Nuclear Regulatory Commission permitted United Nuclear Corporation to resume operation with discharge allowed into the central tailings cell and burrow pits (unlined ponds),²⁹ a process that led to widespread groundwater contamination and placed the United Nuclear Corporation Church Rock Mill on the Environmental Protection Agency's National Priorities List in 1983.³¹ In 1982, United Nuclear Corporation announced temporary closure of the mill because of depressed uranium market conditions, and it never reopened.³²

Loss of jobs to the Navajo people would be only 1 of many consequences. It is still unclear how many individuals suffered adverse health effects from the Church Rock spill. With the exception of the 6-person human exposure assessment carried out by the Centers for Disease Control and Prevention,³³ the various exposure pathways and related human

health outcomes associated with this spill have yet to be characterized. The Centers for Disease Control study addressed only inhalation of suspended tailings and ingestion of livestock, ruling out other exposure pathways such as consumption of vegetables, ingestion of river water or groundwater, and inadvertent ingestion of contaminated sediment. This assessment failed to incorporate not only all potential exposures but also radiation types.³⁴ A number of subsequent studies carried out in the Puerco River basin have identified contaminated groundwater from the spill as well as downstream transport and deposition of radionuclides from the Pipeline Arroyo areas, suggesting that exposure will continue to occur through these pathways in the future.³⁵⁻³⁷

Like Sequoyah Fuels Corporation, the Church Rock spill occurred in a low-income, rural, American Indian area, albeit closer to a substantial secondary city, Gallup, NM, which has large Hispanic and White populations. Because the spill happened in the immediate aftermath of nationwide coverage of the Three Mile Island release, the muted coverage and response is particularly striking. It is not clear that there was acute harm from the Church Rock spill, so like Three Mile Island, the main concern is the development of disease over time after exposure. Compared with Sequoyah Fuels Corporation, the Church Rock spill contained more radioactivity because the tailings included radium, thorium, and other uranium decay products that have relatively high specific activities. In contrast to Three Mile Island, the population near Church Rock was already chronically exposed to uranium mine and mill waste

through both occupational and environmental routes and continues to be exposed today.³⁸

A series of local struggles and public health studies have refocused local attention on the Church Rock area as well as the entire Eastern Navajo area. The struggles revolve around proposals to restart uranium mining with in situ leach methods. In response, the Navajo Nation voted to ban all uranium mining, a resolution that is currently being challenged by mining companies.³⁹ The studies are community based and involve a collaboration among Eastern Navajo communities, the Southwest Research and Information Center, the University of New Mexico, and others. The focus of research is the health impact of environmental uranium exposure (oral communication, J. Lewis, PhD, University of New Mexico, and C. Shuey, MPH, Southwest Research and Information Center, March–June 2006).

CONCLUSIONS

When *National Geographic* released an issue in 2006 that featured nuclear power,^{40,41} the examples were, again, Chernobyl and Three Mile Island. To us it seems that incidents in low-income, rural, American Indian communities have not attracted the same attention as have incidents in communities with people of higher socioeconomic status such as Three Mile Island or incidents that affected White victims such as Karen Silkwood. Of course, Chernobyl was much larger and had a greater health impact than the Sequoyah Fuels Corporation or Church Rock events, but that should not preclude study of these other incidents. We cannot prove the underlying cause or causes of the

low profile of Sequoyah Fuels Corporation and Church Rock events but hope that presenting them here raises interest in these and other early nuclear cycle issues.

There is a need to expand the examples of incidents that are studied to better understand the whole range of experiences and impacts of nuclear weapons and power development. By looking at the first few stages of the nuclear cycle—mining, milling, and processing of uranium ore—it is possible to make a case that this low-tech part of the cycle that requires working-class labor entails some significant exposures and health impacts, but it is precisely this part of the cycle that is least well known and least thoroughly examined.

Finally, it is worth asking whether these cases have informed policy in such a way that workers and communities are now better protected. Both events happened well after the basic federal regulation of workplaces and the environment was in place in the United States. They also occurred before federal government enforcement of occupational and environmental standards began to decline and before the demise of the uranium mining industry in the 1980s. Taken together, it is our opinion that the events at Sequoyah Fuels Corporation and Church Rock had little or no effect on the regulation of similar activities beyond fairly localized responses, such as the as yet incomplete decommissioning clean-up processes.

It is unfortunate that these cases have not led to greater introspection and examination of the impact of uranium mining and needed regulation. Perhaps if they had, there would be less concern about a new uranium

boom that appears to be in its early stages in the southwestern United States prompted by the rising price of uranium on the world market, rebirth of interest in nuclear power, increasing cost of fossil fuel, and concerns about global warming.^{42,43} There is a rich set of historical impacts of uranium mining, milling, and processing, including but not limited to the cases we presented, that deserve academic and policy attention. ■

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Contributions

D. Brugge took the lead on assembling and editing the article. J.L. deLemos wrote the Church Rock case example and contributed to editing the article. C. Bui wrote the first draft of the Sequoyah Fuels Corporation example and read and approved the article.

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This article did not involve the collection of data from human participants, but it was approved by the Navajo institutional review board.

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