# The People, the Plateau, and uranium


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## Prelude

Uranium deposits abound in Triassic and Jurassic terrestrial sedimentary rocks of the Colorado Plateau [1], including Chinle and Morrison strata exposed in many places on *Diné bikéyah*, the Navajo Nation.

Left: Deposition of Late Jurassic uranium deposits by groundwater, from Ingebritsen & Sanford [2].
Above: Efflorescent uranium oxides in an outcrop of Late Triassic Chinle Group mudstones, Happy Jack, southeast Utah.

During the Cold War-era uranium boom, off-reservation firms large and small operated mines and mills on Navajo land and employed Diné miners and laborers.

Left: Shiprock, NM, uranium mill, 1954 or 1955 [3]. Above: Diné uranium miners at work near Cove, AZ [4].

In the rush to produce as much yellowcake ($U_3O_8$) as possible for weapons and reactors, mining firms and the U.S. Atomic Energy Commission paid little heed to worker health, waste management, or environmental protection although the hazards of the industry were already well-known [4, 5, 6].

After the collapse of the uranium market in the late 1970s, mines and mills were abruptly abandoned, leaving behind a generation of miners and millers ill and dying from radiation exposure and silicosis; hundreds of scattered, open shafts and adits; and exposed mill-tailings piles that gradually contaminated homes, businesses, and aquifers.

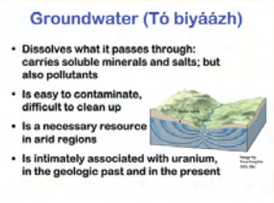
Much of the nation forgot about nuclear energy and uranium, but the Diné --the People-- could not.

A traditional story, holds that the first Diné were warned about the dangers of the yellow mineral *łeetso* by deities [5]. Diné students, teachers, and communities wanted to understand why the mining took place, how environmental damage could be remediated, and how to make informed decisions if uranium mining were to be proposed again.

***Rocks, Water, Metal: Łeetso*** is an environmental-geology curriculum module developed to be used adaptably in an introductory college geology course, for in-service teacher enhancement [7], or for community outreach. The module is place-based, situated in Diné bikéyah and integrating Diné and mainstream explanations for geological processes [8, 9, 10]. The four main ideas are:

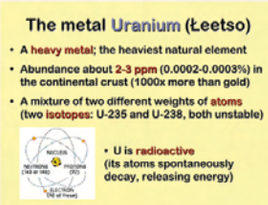
- Some processes that formed the sedimentary rocks underlying Diné bikéyah (involving interactions of **rock** and **water**) formed deposits of uranium (**łeetso**) minerals in some layers.
- Uranium is a naturally occurring radioactive **metal** mined for use as a source of nuclear energy.
- The process by which uranium is extracted from rocks is basically the reverse of the process that formed the ore.
- Careless mining and processing released radioactive and toxic elements into soil, water, and air and exposed many Diné to a serious health hazard.

The module integrates slides for interactive lecture with simple hands-on activities.




*Activity:*
Study groundwater flow and contamination using a groundwater model

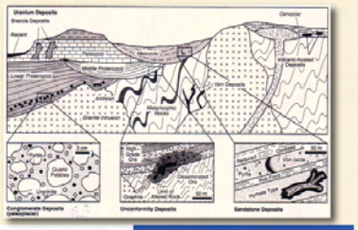
*Activity:*
Use a geiger counter to compare radioactivity of U ore (encapsulated in resin) and various Plateau rocks



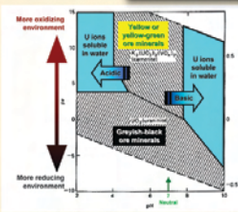
*Activities:*
(1) Conduct simple inquiry experiments on solubility with $CaCO_3$, vinegar, and water
(2) Examine and compare small specimens of different uranium minerals (encapsulated in resin)

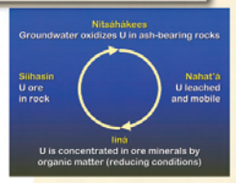
Bumpersticker reads: "Uranium Leave it in the ground"

***Niilyaai (the natural order)*** is an empirical Diné scientific model for cyclical natural processes that occur in the Earth system: analogous to Le Chatelier's Principle [8]. It is used in this place-based module to interpret and compare the processes of sedimentary uranium ore genesis and the milling process that extracts $U_3O_8$.



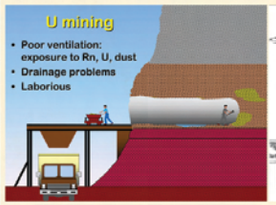
Right: Models of U ore deposit genesis, from [11].

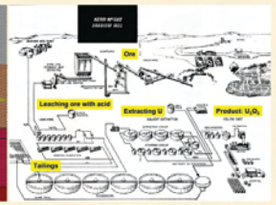



From Drever (1997)

Mining and milling essentially reverse the process; the students find that these can also be described in terms of the natural order:



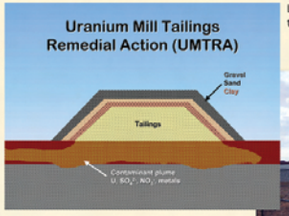
*Activities:*
Field trips to abandoned mine sites and mill sites in the region (following all established safety procedures)

Thus chemically released, U as $U_3O_8$ and radioactive daughter elements were not well contained within the operating and abandoned mines and mills on Navajo land.

Left: Scenes of environmental impacts of the uranium industry on the Navajo Nation, from Eichstaedt [5].

Right: Sign warns of water contamination at former Shiprock uranium mill site.

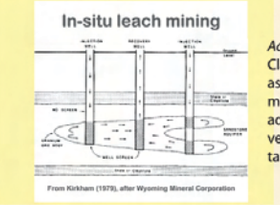
***Remediation activities*** conducted locally by the U.S. Department of Energy (successor to the AEC) are discussed, again in the context of process and the natural order.




Left: Cross-section of a uranium-mill tailings repository [3].

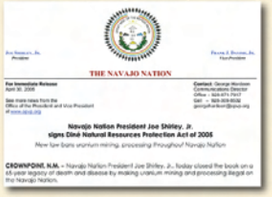
Right: Encapsulated uranium-mill tailings at former mill site in Mexican Hat, UT, near Monument Valley, Navajo Nation.

***The market for uranium*** has improved over the past several years, bringing renewed pressure to mine it on Navajo lands. An in-situ leach mining process is favored by mining companies:




*Activity:*
Class discussion and/or essay assignment, analyzing the environmental advantages and disadvantages of this proposed method versus the old (e.g., miner exposure, tailings, groundwater contamination...)

However, the regulatory setting has decidedly changed:




*Activity:*
Class discussion and/or essay assignment dealing with the Navajo Nation's 2005 ban on uranium mining and milling.
- A good idea?
- Will it withstand economic pressures?
- Should it be modified? etc.


**References**

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Some of these materials have been posted on the SERC website serc.carleton.edu/research_education/nativelands/navajo/index.html; an excellent resource for this topic:

*Acknowledgments: Perry Charley, Linda Garcia, Frank Morgan; Diné College Uranium Education Program; WERC - a consortium for environmental education; Doris Bahee; and Erin Klauk.*