U.S. DEPARTMENT OF ENERGY | Legacy Management

Uranium Ore Deposit Formation in the Tuba City, Arizona, Area

Fact Sheet

What is the history of uranium on the Navajo Nation?

1930s–1945 Nations develop nuclear weapons technology for defense programs

1942 Carnotite, a mineral containing uranium and vanadium, was first discovered on the Navajo Nation in the Monument Valley area

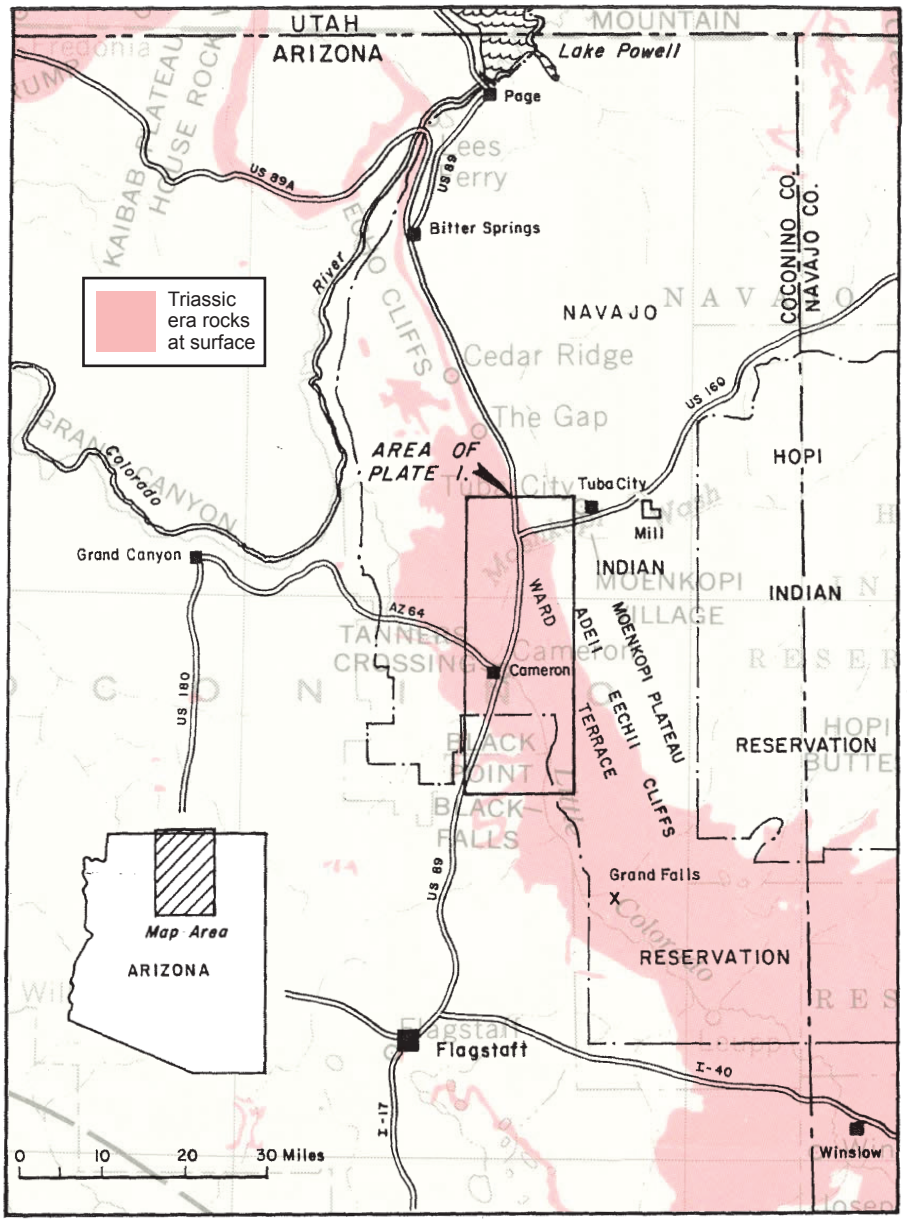
1940s–1950s Private companies mine and mill uranium for national defense purposes

1950s–1980s Mill site operations contaminate the surface and groundwater at multiple sites nationwide; four sites are located on the Navajo Nation

1956–1966 Rare Metals Corporation and its successor, El Paso Natural Gas Company, operated a uranium mill in Tuba City

1978 U.S. Congress passes the Uranium Mill Tailings Radiation Control Act to address uranium contamination

1978–Today The U.S. Department of Energy (DOE) Office of Legacy Management (LM) addresses contamination at former uranium mill sites by working to meet groundwater quality standards set by the U.S. Environmental Protection Agency through long-term surveillance and maintenance



Index map of north central Arizona showing the location of the Cameron Uranium mining area

Where did the uranium come from?

The Rare Metals Uranium Mill Site's uranium ore came from Cameron, Arizona, located 52 miles north of Flagstaff, Arizona. The mill extracted uranium from ore that was mined at various locations near Cameron. LM is responsible for long-term water-quality monitoring at former uranium mills to ensure that any groundwater that moves offsite meets federal water-quality standards.

What are some key facts?

- Uranium is a naturally occurring element that is widely distributed in groundwater, lakes, rivers, and sea water but usually occurs in small quantities. The primary sources of uranium are lava, magma, and volcanic ash.
- Uranium is soluble (will dissolve) in water. If oxygen is removed from the water, uranium will precipitate out of solution and form solid uranium minerals.
- Uranium can be found in larger—or economic—quantities that make mining it possible. Geologists classify this as ore. Uranium ore exists naturally in the Tuba City area.
- Tuba City and the surrounding areas have numerous uranium ore deposits from the Upper Triassic Chinle Formation. The Petrified Forest Member of the Chinle Formation contained most of the uranium deposits in the Cameron area (see inset).

R. Steinberg
DMC 1-12

Geologic Time Scale

Eon	Era	Period	Epoch	Boundary Dates (Ma)
Phanerozoic	Cenozoic	Quaternary	Holocene	0.012
			Pleistocene	2.6
		Tertiary: Neogene	Pliocene	5.3
			Miocene	23.0
		Tertiary: Paleogene	Oligocene	33.9
			Eocene	55.8
			Paleocene	66
	Mesozoic	Cretaceous		146
		Jurassic		200
		Triassic		251
	Paleozoic	Permian		299
		Carboniferous: Pennsylvanian		318
		Carboniferous: Mississippian		359
		Devonian		416
		Silurian		444
		Ordovician		488
		Cambrian		542
PRECAMBRIAN	Neo-	Ediacaran		~635
Proterozoic	Meso-			2500
	Paleo-			
Archean				4000
Hadean		*No Rock Record on Earth*		~4600
		ORIGIN OF EARTH		

Note #1: Vertical timeline of boundary dates *is not* drawn with a uniform scale.
Note #2: Boundary dates from the International Commission on Stratigraphy 2010 Geologic Time Scale
Note #3: Carboniferous, Paleogene, and Neogene are more commonly used outside of the U.S.
Note #4: Epochs for the Mesozoic and Paleozoic are too numerous to be shown.
Note #5: The Hadean Eon is not formally recognized.

Upper Triassic	Wingate Sandstone		200–350	Reddish-brown to buff massive crossbedded fine-grained well-sorted sandstone.
	Chinle Formation	Church Rock Member	50–350	Reddish- to light-brown thin-to thick-bedded sandy siltstone.
		Owl Rock Member	150–450	Pale-red to reddish-brown thin- to thick-bedded siltstone and thin local reddish to greenish-gray limestone beds.
		Petrified Forest Member	0–700	Variegated red, purple, green, and yellow bentonitic claystone and clayey sandstone; intertongues with Owl Rock Member to the north.
		Moss Back Member	0–150	Yellowish- to greenish-gray fine- to medium-grained sandstone, conglomeratic sandstone, and conglomerate.
		Monitor Butte Member	0–200	Greenish-gray and minor amounts of pale-reddish-brown bentonitic mudstone and clayey sandstone; contorted and slumped bedding common.
		Shinarump Member	0–200	Yellowish-gray fine- to coarse-grained sandstone, conglomeratic sandstone, and conglomerate; contains abundant green mudstone lenses, carbonaceous material, and silicified wood in places.
		Mottled unit	0–250	Purplish-red siltstone to coarse gray- to pinkish-white arkosic grit and conglomeratic sandstone; frequently characterized by mottled purple, red, white, yellow, and brown coloration.
	Unconformity			
Middle(?) and Lower Triassic	Moenkopi		0–940	Reddish-brown evenly bedded ripple-marked cross-laminated siltstone and fine-grained sandstone.

How do geologists classify sedimentary rocks and rock formations?

Geologists classify sedimentary rocks into formations based on:

1. Mineralogy (the study of minerals in rocks)
2. Color
3. Texture (size of the grains)
4. Thickness and geometry of the sediment's layers
5. Character of any organic remains

Ideally, formations are named for their area's features or surroundings where they are normally displayed in a well-exposed type section. Members, which are subdivisions of geologic formations, are named in a similar manner.

Geologic History

Beginning in the Triassic Period and continuing into the Quaternary Period, a series of events and processes occurred that produced large quantities of uranium ore.

Triassic Period

The sediments of the Painted Forest Member of the Chinle Formation were deposited in a lush tropical forest by streams that flowed from southeast to northwest across New Mexico, Colorado, Arizona, Utah, and Nevada to the sea that was, at that time, present in western Nevada.

Volcanic activity in the stream's headwaters caused sediment such as volcanic ash that included uranium, soil, trees, and other vegetation to be deposited into the ancient stream channels.

The streams and groundwater underlying the Painted Forest Member dissolved the uranium contained in the ash.

Triassic, Jurassic, and Cretaceous Periods

Over time, as sediments in the upper Chinle and various other formations buried the Painted Forest Member sediments, groundwater in the Painted Forest Member sediments became reducing (lacking dissolved oxygen) resulting from reaction of dissolved oxygen in groundwater with the organic matter introduced into the stream channels by the volcanism that occurred while the Painted Forest Member sediments were being deposited.

As a result of the lack of dissolved oxygen, the uranium precipitated from solution and became concentrated as uranium ore in these reducing areas.

Tertiary and Quaternary Periods

Beginning 60 million years ago in the Tertiary Period, uplift of the Colorado Plateau initiated the erosion of the Painted Forest Member and sediments above it by streams and exposed the uranium ore contained in the Painted Forest member at the surface.

Navajo Nation Today

The Petrified Forest Member of the Chinle Formation is composed of multicolored claystone and siltstone with some light-gray, fine- to coarse-grained sandstone, especially in the lower part of the member. The Painted Forest Member erodes into badlands and has brilliant, multicolored rocks typical of the Painted Desert. In the Cameron area, the member is up to 900 feet thick.

Example of the Petrified Forest Member of the Chinle Formation

These rocks are exposed at the surface immediately west of Tuba City and Cameron.

The Petrified Forest Member uranium ores are contained within ancient stream channels that are filled with fine- to medium-grained sandstones, carbonaceous matter, and silicified-carbonized fossil logs occasionally reaching lengths of 50 feet or more.

Ore consists chiefly of secondary uranium-vanadium minerals filling pore spaces in the sandstones and in fossil logs. Within the stream channels, the ore tends to occur in the bottom of stream channels or at meander bends, and tends to associate with carbonaceous layers.

Uranium ore mining in the Cameron area began in 1951, peaked in 1957, and ended in 1963. Most of the mining was in open pits that ranged in size from shallow trenches to pits as deep as 130 feet. During the mining period, 289,300 tons of ore were produced from 98 locations. This resulted in approximately 1,211,800 pounds of uranium.

During the mining process, approximately 0.21 percent of the mined material contained uranium minerals. The remaining 99.79 of rock contained various other minerals including quartz and feldspar.

Contacts

More information about the Tuba City site is available on the DOE Office of Legacy Management website at https://www.lm.doe.gov/tuba/Sites.aspx.

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