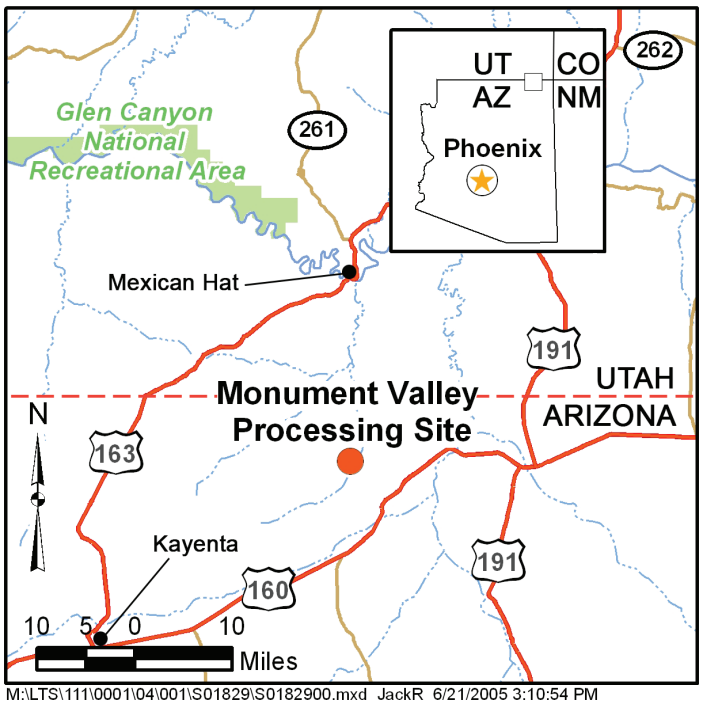
U.S. DEPARTMENT OF ENERGY | Legacy Management

View northeast from Monument Valley Processing Site across Cane Valley to Comb Ridge

FACT SHEET

Formation of Uranium Ore Deposits near Monument Valley, Arizona, Processing Site



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History and Key Facts

Navajo Nation resident, Luke Yazzie, first discovered carnotite (a mineral that contains vanadium and uranium) in the Monument Valley area in 1942. During World War II, nations were developing nuclear technology for warfare. In the late 1940s and early 1950s, private companies rushed to the area to mine and mill uranium. Vanadium Corporation of America (VCA) acquired mining rights for the Monument Valley deposit from the Bureau of Indian Affairs in 1943. VCA mined ore, first for vanadium and later for uranium, in the Monument No. 2 Mine from 1943 to 1968. Total ore production was 767,166 tons, which contained an average of 0.34 percent uranium; the mine produced more uranium than any other mine in Arizona.

How do geologists classify sedimentary rock formations?

Geologists identify formations based on the following:

1. Mineral composition
2. Color
3. Grain size, thickness, and geometry
4. Characteristics of organic remains

Distinctive appearances of the rock makes a formation recognizable. For example, the Shinarump Member of the Chinle Formation is composed of layers of sandstone, conglomerate, siltstone, and mudstone and contains abundant fragments of carbonized wood and petrified wood. Ideally, formations and members are named for their area's features or surroundings where they are normally displayed in a well-exposed type section.

Rock vs. mineral: A **mineral** is a naturally occurring inorganic substance that has a characteristic chemical composition and specific physical properties.

A **rock** is a solid aggregate of one or more minerals that are tightly compacted or held together by a cement-like mineral matrix.

Key facts about uranium:

- Uranium is a naturally occurring element that is widely distributed in groundwater, lakes, rivers, sea water, and every rock type. It usually occurs in small quantities.
- The element can also be found in larger quantities that make it cost effective to mine—known as economic quantities. Geologists classify this as ore. Uranium in economic quantities exist within the Monument No. 2 Mine at the Monument Valley processing site.
- Uranium combines with other elements to form various minerals.
- The Monument Valley areas of concentrated uranium deposits occur as elongated, flattened deposits that range in length from a few feet to a few hundred feet, and from less than 1 foot to 12 feet in thickness. The length to width ratio is commonly 5 to 1, but may reach up to 50 to 1 (typical of petrified wood/organic debris).

Geologic Time-Scale Information

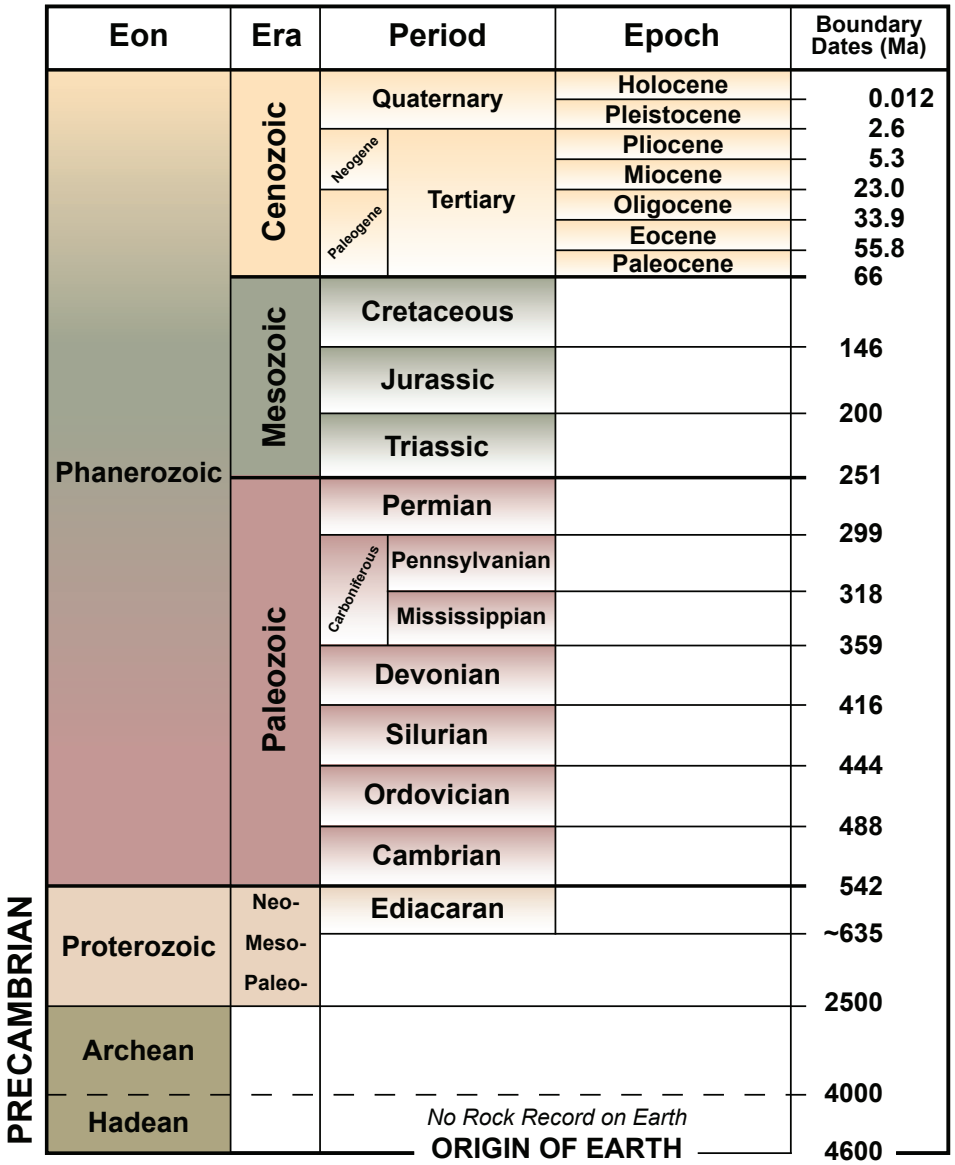
Beginning in the Triassic Period and continuing into the Quaternary Period, a series of geologic events and processes unique to the Monument Valley area produced large quantities of uranium ore at the Monument No. 2 Mine.

Triassic Period

- Volcanic activity in the headwaters of streams that formed the Shinarump Member caused sediment such as ash, eroded soil, trees, branches, twigs, and other organic matter to be deposited into the ancient stream channels. These stream channels cut down into the Moenkopi Formation.
- Over time, the organic-rich sediments became buried by more sediments; groundwater infiltrated the buried sediments.
- A chemical change occurred when the organic matter reacted with the groundwater. This process created a favorable environment for uranium dissolved in groundwater to be deposited as a solid.

Jurassic Period

- Sediments were deposited in the Monument Valley region that became the rock formations overlying the Chinle Formation.



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.

Steinberg, R. (2010) *Visualizing the Precambrian: Geologic Time Scale.* Retrieved March 14, 2016, from http://serc.carleton.edu/NAGTWorkshops/time/visualizations_teachtips/60786.html

Tertiary Period

- The first period of the Cenozoic era was the Tertiary, which included the Paleocene to Pliocene epochs: 66- to 2.6-million years ago.
- Magma containing uranium intruded the rock in the Four Corners area. Again, uranium dissolved in the groundwater infiltrated the sediments and reacted with organic matter to form large quantities of uranium in areas where organic matter was concentrated such as in bends of stream channels.
- Movement of the Earth's crust deformed the rocks in the Monument Valley area and produced the Comb Ridge monocline, resulting in the eastward dip of the bedrock on the Monument Valley site.

Quaternary Period

- The Quaternary Period is divided into two epochs: the Pleistocene (2.6-million years ago to 11,700 years ago) and the Holocene (11.7-thousand years ago to today).
- The wetter climate in the early part of this period and an ancient stream, tributary to the present-day Cane Wash, eroded geologic layers covering the concentrated-uranium areas in the Shinarump Member. This erosion exposed what is now known as the Monument No. 2 Mine.
- Wind-blown sand continued to be deposited throughout the Monument Valley area, and stream erosion continued during heavy rainfall events.

Monument Valley Today

- The uranium deposits are primarily found in ancient stream channels within 50 feet of the base of the Shinarump Member.
- Ancient stream channels are old water ways that formed deeper cuts into the underlying material. These ancient stream channels eroded the underlying sediments (now the Moenkopi Formation); were filled with sand, gravel, and organic matter; and were later cemented into conglomerates that are currently found at the base of the Shinarump Member.
- Uranium ore is associated with the organic matter found in these ancient stream channel conglomerates.
- No uranium ore in the area has been found outside of the ancient stream channels.
- Ore deposits range in size from a few tons to about 800,000 tons.
- Approximately 50 percent of the deposits are smaller than 1,000 tons and all but two are smaller than 50,000 tons.
- These uranium deposits are generally buried below the ground surface, but can be exposed at or near the surface due to geologic uplift and subsequent erosion.
- Geologists discovered many small to medium deposits in ancient stream channels because they were exposed along canyon rims.