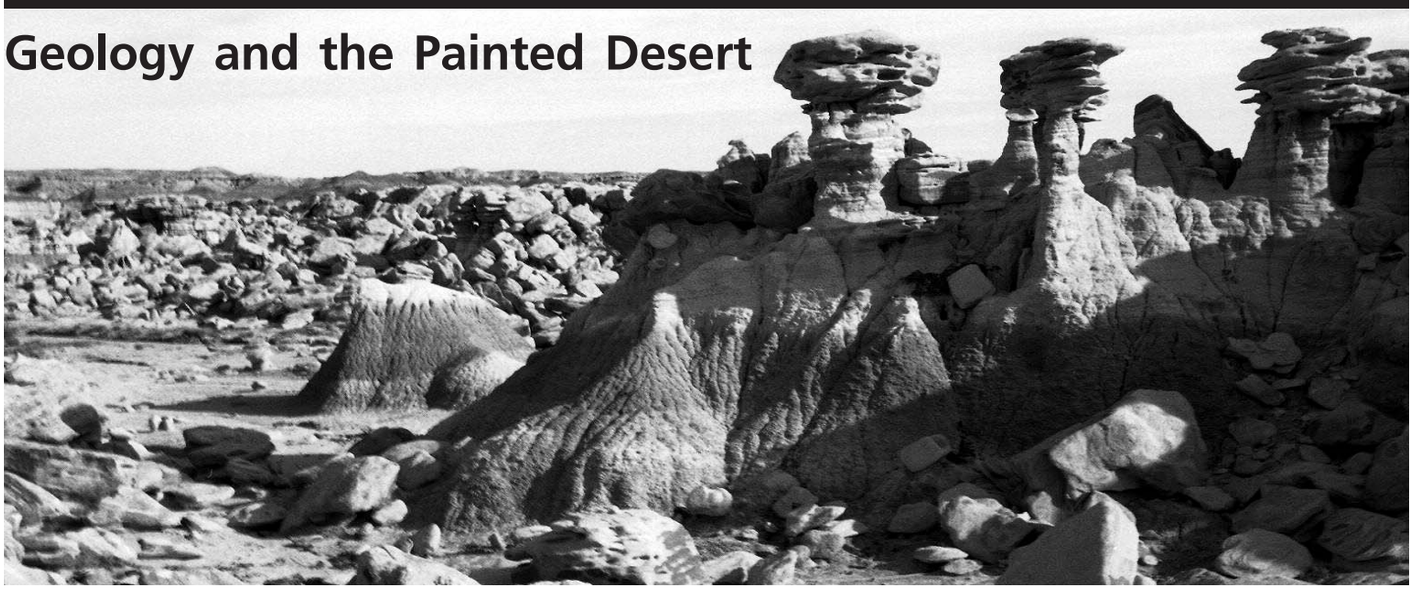
Petrified Forest

National Park Service
U.S. Department of the Interior

Petrified Forest National Park
Petrified Forest, Arizona

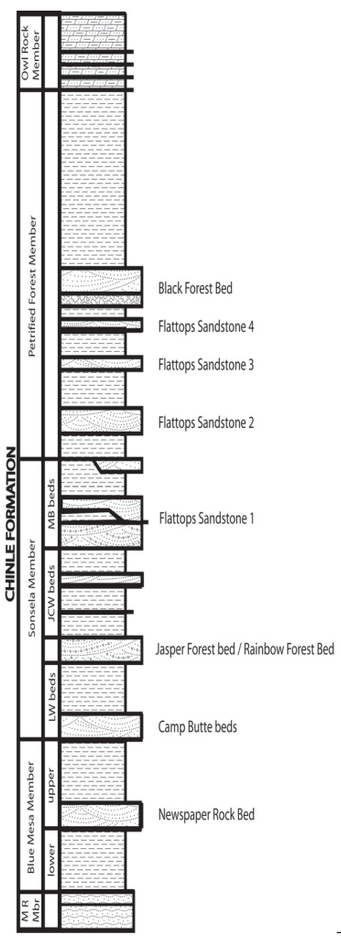
Geology and the Painted Desert



Part of the Painted Desert, Petrified Forest National Park features a strangely beautiful landscape. Erosion has sculpted and shaped intriguing landforms, revealing a treasure trove of fossils within multi-colored layers. The rocks reveal an enthralling chronicle of time that is unfolding and ever-changing.

What can the rocks tell us? Think of the colorful layers of the Petrified Forest as pages in a massive book. As the pages are turned, we discover that the words are a language we don't completely understand. The pictures help, but we must put together the story of this ancient book with fragmented clues. The first chapter of this geological text is the Chinle Formation.

Chinle Formation



The colorful badland hills, flat-topped mesas, and sculptured buttes of the Painted Desert are primarily made up of the Chinle Formation, mainly *fluvial* (river related) deposits. Within Petrified Forest National Park, the layers of the Chinle Formation include the Blue Mesa Member, the Sonsela Member, the Petrified Forest Member, and the Owl Rock Member.

The Mesa Redondo Member consists mainly of reddish sandstones with some minor mudstones. This layer represents the lowest (and thus oldest) member of the Chinle Formation found in the park. Unfortunately, it is restricted only to a small area in the Tepees section of the park.

The Blue Mesa Member consists of thick deposits of grey, blue, purple, and green mudstones and minor sandstone beds, the most prominent of which is the Newspaper Rock Sandstone. This unit is best exposed in the Tepees area of the park. The Blue Mesa Member is approximately 219 million years ago based on fossil pollen, vertebrates, and dates from radioactive minerals.

The Sonsela Member consists of five parts: 1) the lower Camp Butte beds consisting of white sandstone and conglomerates; 2) the Lots Wife beds consisting of purple mudstones and gray sandstones; 3) the Jasper Forest bed (at Crystal and Jasper Forests, Blue Mesa) and the Rainbow Forest Bed (at Rainbow Forest), consists of thick gravelly sandstones and conglomerates which contain the majority of the colorful petrified wood; 4) the Jim Camp Wash beds, another unit of mudstone and sandstone with numerous calcareous lenses; and 5) the Martha's Butte beds, purple mudstones and massive brown colored sandstones termed the Flattops One Sandstones. The Sonsela Member was deposited about 216 million years ago.

The Petrified Forest Member consists of thick sequences of reddish mudstones and brown sandstone layers. This member is exposed in the Flattops and the red part of the Painted Desert. The Black Forest Bed, part of the Petrified Forest Member north of Kachina Point, has been determined to be 214 million years old.

The Owl Rock Member consists of pinkish-orange mudstones mixed with hard, thin layers of limestone. This member is exposed on Chinde Mesa at the northernmost border of the park. The Owl Rock Member is 205 million years old.

During the Late Triassic, this region was located on the southwestern edge of the supercontinent Pangaea and just north of the equator. Evidence from ancient soils as well as fossil plants and animals indicates that the climate was humid and sub-tropical during the Late Triassic. The sedimentary layers of the Chinle Formation consist of sandstone, mudstone, and conglomerate deposited by a large river system that had cycles of droughts and floods, similar to those affecting many modern river systems. The colorful stripes in the Chinle Formation, which give the Painted Desert its name, represent ancient soil horizons. The coloration is due to the presence of various minerals. While the red and green layers generally contain the same amount of iron and manganese, differences in color depend on the position of the groundwater table when the ancient soils were formed. In soils where the water table was high, a *reducing* environment existed due to a lack of oxygen in the sediments, giving the iron minerals in the soil a greenish or bluish hue. The reddish soils were formed where the water table fluctuated, allowing the iron minerals to oxidize (rust).

Colorado Plateau

The supercontinent Pangaea began to break up about 200 million years ago due to tectonic movement of the earth's crust, eventually forming the continents of today. About 60 million years ago this region began to rise. The uplift process raised some areas as much as 10,000 feet above sea level. Over millions of years, erosion stripped away many layers of rock. It is thought that erosion stripped away the rocks of the Jurassic and Cretaceous Periods before the Chinle rocks were covered by younger rocks of the Bidahochi Formation, creating a break in the rock record—an *unconformity*. The unconformity between the Late Triassic Chinle Formation and the Miocene-Pliocene Bidahochi Formation can be seen from Whipple Point. In Petrified Forest, this gap represents about 200 million years of missing geological history! Geologists study other areas in the region to learn about the layers absent in the park.

Bidahochi Formation

During the Miocene and Pliocene of the Tertiary Period (4-8 million years ago) a large lake basin with ephemeral lakes covered much of Northeastern Arizona. Fine-grained fluvial and *lacustrine* (lake related) sediment such as silt, clay, and sand represent the lower part of the Bidahochi Formation. Volcanoes, both nearby and as far as the Southwestern Nevada Volcanic field, spewed ash and lava over the land and into the basin. Many of the volcanoes were *phreatomagmatic*, when ground or lake-water mingled with eruptive material (magma) to cause explosive eruptions. The resulting ash formed fine-grained deposits that were deposited within the lake sediments. After a few million years of erosion, most of the Bidahochi Formation has been removed from the park area, exposing the volcanic landforms known as scoria cones and *maars* (flat-bottom, roughly circular volcanic craters of explosive origin). The vent from one of these maars is exposed in the Painted Desert Rim across the park road to the east from Pintado Point. The Hopi Butte Volcanic Field, which can be seen from the northern overlooks of the park extending northwest, is considered one of the largest concentrations of maar landforms in the world, covering about 965 sq. miles (2,500 sq. km). The erosion-resistant lava flows, such as Pilot Rock and the Hopi Buttes, protect the softer lake-bed deposits beneath.

Quaternary Sediments

Quaternary Period (1.8 million years ago to present) deposits of windblown sand and *alluvium* (deposited by flowing water), now cover much of the older formations of the park. 500,000-year-old dunes are located at higher elevations in the northern part of the park. Younger dunes, around 10,000 years old, are found in drainage areas that contain sand such as Lithodendron Wash. The youngest dunes are found throughout the park, in all settings, deposited around a thousand years ago. These dune deposits are largely stabilized by vegetation, especially grasses. While not as numerous as the fossils of the Chinle Formation, fossils have been found even in the Quaternary sediments, including fragments of an ancestral *proboscidean* (elephants and their relatives, such as mammoths).

Present and Future

The Little Colorado River and its tributaries, including the Puerco River, have cut their own valleys into the soft Chinle and Bidahochi Formations of the Painted Desert. Water erosion is the major geologic process that removes the exposed bentonite and sandstone revealing more of the petrified wood and other fossils. While erosion can be relatively fast in the Painted Desert, the actual rate is variable due to the material, the slope, and the presence of vegetation and pebbles. Bentonite clay, one of the main components of Chinle Formation rocks, swells as it absorbs moisture, then shrinks and cracks as it dries, causing surface movement that discourages plant growth. This lack of plant cover renders the sediment susceptible to weathering. Heavy rains of the summer monsoons remove as much as ¼ inch of rock each year from the steep, barren slopes. In addition, water creates small tunnels (*pipes*) in the hills, which widen into large gullies through time. This gullying carves the canyons that exist between the mudstone hills, giving the badlands their dissected appearance.

Where capstones of harder sandstone or basalt protect the soft Chinle layers, *mesas* (broad flat-topped hills) and *buttes* (narrow flat-topped hills) form. These landforms can erode at a substantially decreased rate due to the protective capstones. Similarly, where vegetation grows, erosion is much slower. In some areas, strong winds carry away the dry, loose soil leaving only a covering of surface pebbles, called *desert pavement*, which act as a protective crust.

The ancient book of Petrified Forest's geology is far from over. Even as the first pages are turned and studied, new pages are being formed. The same natural processes of the past are ongoing in the present and will continue to shape the dramatic landforms of Petrified Forest National Park.

Preserved and protected for future generations, our national parks and their resources need everyone's care. Every year, up to a million people visit Petrified Forest National Park. Permanent damage to this area occurs quickly from such impact but is slow to mend. Please leave the park undisturbed—take only pictures and memories.