The GEOLOGY of CHACO CANYON

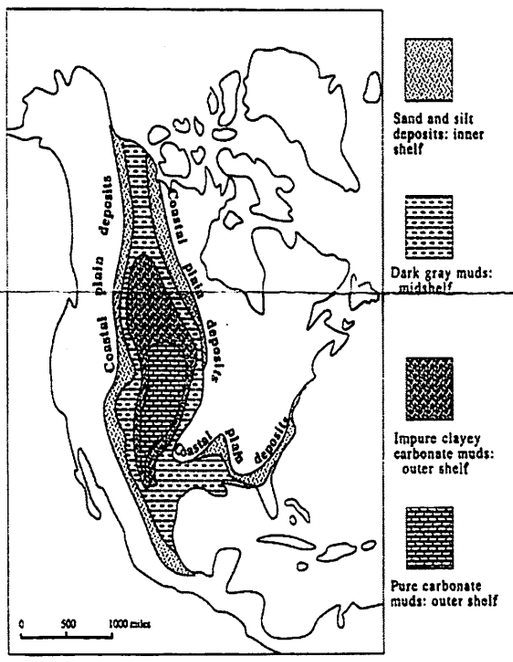
The Landscape

Chaco Canyon lies in the eastern San Juan Basin of New Mexico, near the southeastern edge of the Colorado Plateau. This region has broad exposures of horizontal sedimentary layers that have uplifted and eroded into plateaus, mesas, buttes, and canyons, creating the stunning landscape that exists today.

The Cretaceous Setting

The rocks exposed in Chaco Canyon record an interval in the Earth's history from approximately 75 to 80 million years ago during the Late Cretaceous Period. During this time, the region was situated at the edge of a shifting coastline of an ancient inland sea.

In the area of the Southern Rocky Mountains, mountain building activities produced a broad, low-lying area known as the Western Interior Basin, which flooded and created a vast sea known as the Western Interior Seaway. By Late Cretaceous time, the Western Interior Seaway was hundreds of miles wide and extended from the Arctic Sea to the Gulf of Mexico dividing North America into two separate land masses. The shorelines of this seaway were oriented generally north-south and repeatedly shifted position to the east or west in response to continuing changes in global sea level. This sea level change resulted in alternating marine and non-marine deposition of sediments as the sea increased and regressed (receded) over time.



Generalised Map of the Western Interior Seaway during the maximum transgression in the Late Cretaceous. (Kauffman 1977)

The climate of the Southern Rocky Mountain region during the Late Cretaceous was subtropical and supported lowland forests species thought to be similar to modern day conifer, eucalyptus, ebony, palm, cypress and magnolia. Upland areas supported hardwood forest species similar to oak, walnut, ash and birch. The landscape was much different than it is today, and resembled that of modern day coastal areas such as those found on the southeastern Atlantic and Gulf coasts of the United States. These mainland beach and barrier island environments consisted of river deltas, estuaries, marshes, swamps, and lagoons adjacent to beaches and relatively shallow coastal waters.

Stratigraphy of Chaco Canyon

"Stratigraphy" describes the layers of rock which compose sedimentary units. The majority of the exposed features in Chaco Canyon belong to a suite of rocks known as the Mesa Verde Group. The further subdivisions of the unit are, from oldest to youngest: the Crevasse Canyon Formation, the Point Lookout Sandstone, the Menefee Formation, the Cliff House Sandstone, the Lewis Shale, and the Picture Cliffs Sandstone. Of these formations, the Menefee and Cliff House Formations are visible within the main body of the canyon. Two younger units, the Lewis Shale and the Picture Cliffs Sandstone, are generally exposed only near the northern boundary of the park. The Crevasse Canyon Formation is only visible to the south in the Kin Ya'a unit of the park. The Point Lookout Sandstone is not visible within the park.

Menefee Formation

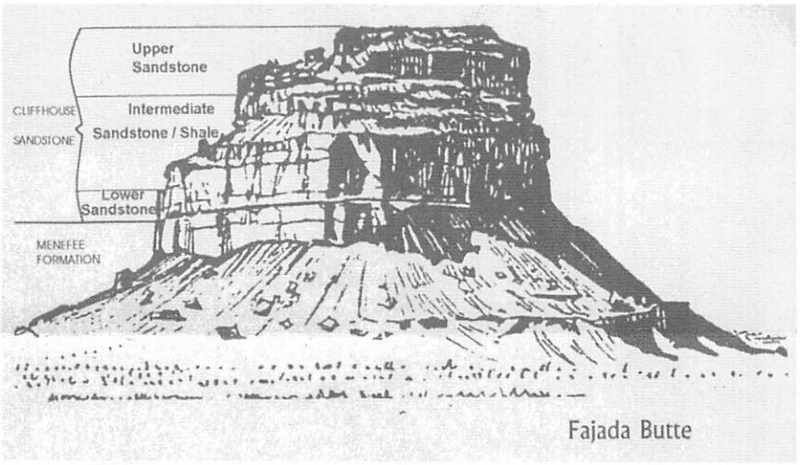
The Menefee Formation is the oldest exposed unit of the Mesa Verde Group within the main body of the canyon and is visible as a slope-forming unit that underlies the steep mesa walls of the more resistant Cliff House Sandstone. It is especially prominent on the south side of the canyon, with a number of excellent exposures at the base of Fajada Butte. Its layers show an upwards transition from fluvial sandstone and shale to carbonaceous shale, coal, and interbedded sandstones as it approaches the contact with the Cliff House Formation, telling the story of a very different climate from the one we experience at Chaco today.

The Menefee Formation is thought to have been formed from sediments deposited on a deltaic coastal plain by rivers flowing north and east across New Mexico toward the retreating sea. At the edge of the sea, the streams meandered through a wide, flat, coastal plain with deltas, shallow swamps, and lagoons accumulating plant material which would eventually form thin beds of lignite, a type of coal.

Vertebrate fossils found regionally within the Menefee Formation include turtles, fish, and crocodiles as well as fragmentary evidence of larger creatures such as hadrosaur, ankylosaur, and ceratopsian dinosaurs, and giant marine lizards known as mosasaurs. At Chaco Canyon, remains of a Cretaceous side neck turtle (*Testudines pelomedusidae*), an unidentified hadrosaur dinosaur, and an unidentified theropod dinoasur have been recovered from the upper portions of the Menefee Formation.

Plant fossils found in the Menefee include leaf impressions of palm and conifer as well as specimens closely resembling modern laurel, witchhazel and camellia, suggesting a warm, moist, subtropical environment. At Chaco Canyon, plant fossil specimens are predominantly conifer with occasional broad leaf angiosperms (plants that produce flowers and encased seeds) and palm leaf impressions.

Cliff House Sandstone



Fajada Butte

The Cliff House Sandstone is a sequence of marine sandstones on top of the Menefee Formation. It formed at a time called a transgression, when sea level was rising. The three principle Cliff House units (Lower, Intermediate, and Upper) visible in Chaco Canyon represent the beach, near shore marine, and offshore marine deposits produced near a barrier island beachfront by repeated incursions of the Western Interior Seaway.

The Lower Sandstone unit, a massive marine sandstone, forms the 80 – 100 foot prominent cliffs visible throughout the canyon. This sandstone was deposited just off of a Late Cretaceous beach, in relatively shallow water still affected by wave and storm action. An abundance of ripple marks are visible in this unit. Fossils include shells and casts from clams, ammonites (including possible *Placenticeras*) snails, and shark's teeth. Iron-cemented, knobby casts of burrows known as *Ophiomorpha* ("serpent shape") *Nodosa* ("nodular") are particularly abundant. These casts are thought to be the fossilized remains of burrows left by a small shrimp-like crustacean known as *Callianasa*.

Immediately above the Lower Sandstone unit is the Intermediate unit. Although primarily a shallow water marine sandstone, it has locally interbedded shales which were deposited in deeper water. This unit is less resistant to erosion than the Lower Sandstone and forms gentle slopes rather than cliffs. Fossils found in this unit are generally similar to that of the Lower Sandstone but *Ophiomorpha* burrows are often less abundant and accumulations of the large clam *Inoceramus* are often more abundant.

The uppermost unit exposed in the main body of Chaco Canyon is the Upper Sandstone unit. It is similar in composition to the Lower Sandstone and also forms steep cliffs, but is generally only 30-60 feet in thickness. This unit represents a beach and barrier island environment and was deposited in shallower water than the Intermediate unit, reflecting a lowering of local sea level as the Western Interior Seaway receded for a period of time. Fossils found in this unit include abundant invertebrate shells and shark teeth, and bone debris probably from marine lizards.

Erosion & Cliff Formation

During the Late Cretaceous, sediments were deposited at sea level. Subsequent uplift due to mountain building processes brought a large region called the Colorado Plateau to present day elevations. Between 40,000 and 70,000 years ago, Chaco Canyon was eroded by ancient waterways to expose the Menefee Formation. Since that time, the canyon has re-filled with 38 meters (125 feet) of alluvium, which form the modern valley floor.

The Menefee Formation is less resistant to erosion than the Cliff House Formation and often completely erodes from beneath the younger sandstone. The unsupported sandstone will then break away in large slabs and boulders as the undercutting reaches local weaknesses and breaks in the sandstone called joints. This step-wise erosion is responsible for producing the prominent cliff faces in Chaco Canyon as well as the debris mounds, or talus slopes, piled against them. When this erosional process continues from several directions, it may actually "sever" a landform into separate segments and produce large, apparently free standing rock masses. Fajada Butte was "severed" from Chacra Mesa over the last 10,000 years by just such a process of gradual erosion.

One of the most dramatic examples of step-wise erosion and undercutting of the massive sandstone blocks is the immense slab of sandstone known as "Threatening Rock", located just behind Pueblo Bonito. When construction began at Pueblo Bonito, "Threatening Rock" stood in a precarious position just behind it. Aware of the danger it posed, the Chacoans built an earth, masonry, and log retaining wall beneath this massive rock slab. The slab was described by modern travelers in 1901, referred to as the "Elephant." The Navajos called it "Braced-up Cliff," and the Park Service staff named it "Threatening Rock". It fell on January 22, 1941, taking over thirty rooms in Pueblo Bonito with it.