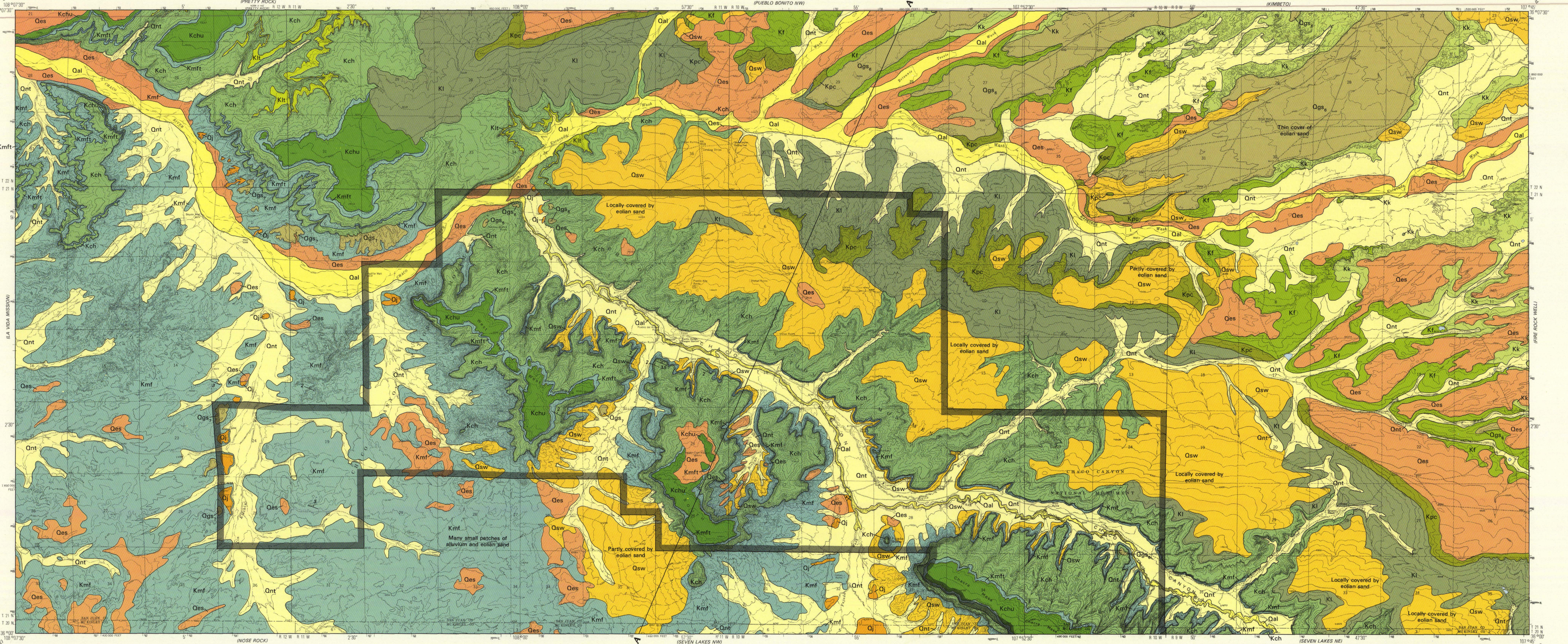
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

PREPARED IN COOPERATION WITH THE
NATIONAL PARK SERVICE

MISCELLANEOUS INVESTIGATIONS SERIES
MAP I-1571



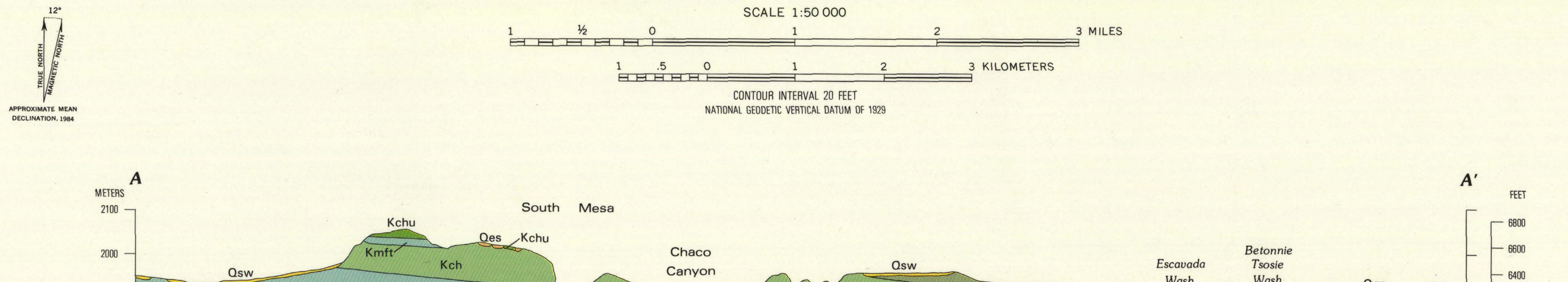
Base from U.S. Geological Survey Kin Klizhin Ruins, Pueblo Bonito, and Sargent Ranch, 1:24,000, 1966
10,000-foot grid based on New Mexico coordinate system, west zone
1000-meter Universal Transverse Mercator grid ticks, zones 12 and 13

APPROXIMATE MEAN DECLINATION, 1984

SCALE 1:50 000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Geology mapped in 1958, 1977 and 1981 by reconnaissance methods. High-level gravel deposits along Chaco Wash are from David W. Love (written commun., 1980)



NOTE

The surficial geology of the area and the bedrock of the eastern part were mapped in 1977 as part of a program designed to assess the impact on the environment of strip mining of coal-bearing strata in the western and southern San Juan Basin. The bedrock geology of the western part of the area was mapped in 1958 for the Shiprock 1° x 2° quadrangle (O'Sullivan and Beikman, 1963). The Chaco Culture National Historical Park lies within three 7-1/2 minute quadrangles—Kin Klizhin Ruins, Pueblo Bonito, and Sargent Ranch. The geology of these individual quadrangles was published separately in 1979 as Miscellaneous Field Studies Map MF-1094 (O'Sullivan and others, 1979), MF-1119 (Weide and others, 1979a) and MF-1120 (Weide and others, 1979b). The geology shown on these previously published maps, slightly modified, has been brought together on the geologic map included in this report. Lithologic descriptions of the various stratigraphic units are only summarized here. Reports describing the bedrock stratigraphy and economic geology of nearby areas, many of which concern the rocks of the Park, are by Bauer and Reeside (1921), Reeside (1924), Dane (1936), Fassett and Hinds (1971), Shomaker and others (1971), and O'Sullivan and others (1972). The stratigraphy and paleofauna of the Cliff House Sandstone in the park area are discussed by Siemers and King (1974). Subsurface correlations of rocks exposed in this area were studied by Fassett (1977) in the region from Pagosa Springs, Colorado, southward almost to the Park. More complete details on the lithology and regional aspects of the surficial deposits are in reports by Hack (1942), Richmond (1965), Love (1977), and Hall (1977).

A BRIEF OUTLINE OF THE GEOLOGY OF CHACO CULTURE NATIONAL HISTORICAL PARK

SETTING

Chaco Culture National Historical Park is near the middle of the downfolded San Juan Basin, a broad bowl-shaped intermountain basin 100-150 miles (160-240 km) wide, lying at an elevation of about 6,000 feet (2000 m) in northwestern New Mexico. The basin is bordered by the high San Juan and La Plata Mountains on the north, the Chuska and Carrizo Mountains on the west, the Sierra Nacimiento and Tusas Mountains on the east, and the Zuni Mountains on the south. The San Juan Basin is but a part of the Colorado Plateau, an elevated block of relatively flat-lying beds, which covers large parts of Arizona, Colorado, New Mexico, and Utah. The map area is drained by the Chaco River which joins the San Juan River, a tributary of the Colorado River, near Shiprock. Access to the Park is by graded New Mexico State Highways 57 and 197. These routes traverse drab, nearly flat-lying rocks of Late Cretaceous and early Tertiary age that surround and form Chaco Canyon. The Cretaceous rocks contain extensive energy resources including coal, natural gas, and oil. The formations that underlie Chaco Canyon are also found in the surrounding mountains and include Precambrian rocks and rocks of the Mississippian, Pennsylvanian, Permian, Triassic, and Jurassic Systems. The economic geology of the San Juan Basin as well as a discussion of the strata that overlie and underlie the rocks of the Chaco Canyon area is summarized in a report by Peterson and others (1965).

THE GEOLOGIC STORY

The oldest rocks seen at Chaco Canyon make up the Menefee Formation and are exposed at the edges of the valley floor along the Chaco River and Chaco Wash. This formation is also very widespread south and southwest of the park. These rocks are approximately 80 million years old and were laid down as sand, mud, and plant debris in coastal swamps and on alluvial plains that lay landward from a marine shoreline to the northeast. These ancient deposits are now preserved as coal, black carbonaceous shale, shale, and sandstone. During deposition, the geography of the coastline changed constantly as the shoreline retreated inland to the southwest in response to the encroachment of the ocean on the land, then moved northeast as sea level dropped. The evidence for this periodic oscillation is seen in the nonmarine coaly layers that interfinger with marine rocks. These interfingering sequences represent periodic transgressions and regressions of the sea. The buff-colored Cliff House Sandstone that overlies the Menefee Formation represents beach sand deposited at or very near the shoreline of this shallow Cretaceous sea. The Cliff House Sandstone forms the high cliffs of the Park and once served as a major source of building stone for the construction of the pueblos.

The Cliff House Sandstone interfingers with and is overlain by the Lewis Shale, a relatively deep water deposit that marks the most extensive transgression of the sea. Abundant fossils found in the beds of the Lewis Shale indicate that marine mollusks with lustrous pearly shells were plentiful. During both the beginning and the ending of the marine interval that produced the Lewis Shale, sea level changed. This resulted in the interlayering of relatively deep and shallow-water sediments. In addition to an ocean environment, volcanoes were active throughout the western United States during Late Cretaceous time. Ash from these eruptions was blown for great distances, and when it fell into the sea, was altered to bentonite, a sticky, expandable clay. The Lewis Shale contains many thin beds of bentonite.

As the sea withdrew for the last time from northwestern New Mexico, it moved gradually toward the northeast, followed by a shoreline that deposited sand on top of the Lewis Shale. This beach sand deposit is now called the Pictured Cliffs Sandstone. Final retreat of the sea must have required a considerable amount of time, for in places the Pictured Cliffs Sandstone is over 300 feet (90 m) thick. After the deposition of the buff-colored Pictured Cliffs Sandstone, the San Juan Basin, in response to great regional pressure on the earth's crust, began to sag, and bordering areas began to rise. As marginal lands increased in elevation, rivers brought fine sediments and plant material into the basin. Coastal and floodplain sediments, deposited on top of the Pictured Cliffs Sandstone, became consolidated and formed the easily eroded beds now called the Fruitland Formation and the Kirtland Shale. Both formations contain local concentrations of bones of dinosaurs, turtles, crocodiles, and fish, which reflect this deposition in a low, swampy coastal environment.

At the beginning of the Tertiary, about 65 million years ago, increasing uplift caused increasing erosion of the region surrounding the San Juan Basin. One of the earliest signs of this erosion is a conglomerate containing abundant quartzite pebbles that makes up the Ojo Alamo Sandstone of Tertiary (Paleocene) age. The Ojo Alamo Sandstone formerly covered the Chaco Canyon area but was stripped off along with younger beds of the Paleocene Nacimiento Formation and the Eocene San Jose Formation.

Even younger deposits of Oligocene age (about 37 to 24 million years old) apparently once covered the basin. With the exception of the Chuska Sandstone in the Chuska Mountains, these terrestrial sediments have been stripped from the landscape by erosion and removed from the San Juan Basin by the ancestral Chaco, San Juan, and Puerco Rivers. Miocene and Pliocene deposits probably also were present in the San Juan Basin. Today, however, only the Bidahochi Formation of Miocene and Pliocene age, west of Gallup, and a few high terrace deposits of Pliocene age remain.

The deep, widespread stripping of these younger sediments took place in Pliocene and Quaternary time, for during that interval, erosion was greater in the San Juan Basin than in most intermountain basins in the Rocky Mountains. For example, the Animas River south of Durango, Colorado, has cut a canyon more than 500 feet (610 m) deep in the last 600,000 years. This is double the rate of erosion of some other Colorado streams such as the South Platte River near Denver.

In the area of Chaco Canyon, severe erosion has continued to the present. Nearly all of the Pliocene and early Quaternary, and most of the middle Quaternary stream deposits and stream-cut surfaces have been eroded away. Only a few middle and late Quaternary pediment-like surfaces covered by sandy gravel have been preserved (see, for instance, Qgs$_{5}$, $_{6}$, and $_{7}$). These remnants show that the size of these ancient stream networks and their direction of flow were about the same as they are today. The ancestral Chaco River and its tributaries were more powerful than modern streams for they transported gravel instead of only sand, silt, and clay. Judging from the heights of remnants of pediment-like surfaces above the present streams and correlating with an excellent sequence of terraces along the San Juan River at Farmington, New Mexico, we estimate that the 300-foot-deep (90 m) Chaco Canyon has been cut in several stages during the 300,000 years since middle Quaternary time.

SURFICIAL DEPOSITS

Surficial deposits consist of unconsolidated or slightly consolidated gravel, sand, silt, and clay of thin and patchy distribution. In the Park, these sediments have resulted from erosion and deposition by wind and running water, the same processes that shape the landscape today. Sheetwash alluvium accumulates when rain falls on a steep slope and moves fine sediments downslope where they grade into the alluvium deposited by running water. Wind-deposited (eolian) sand that now occurs in large sand sheets partially stabilized by vegetation and in long, thin linear dunes, was picked up partly from stream valleys and partly from the disintegration of bedrock units like the Cliff House and Pictured Cliffs Sandstone. The wind-blown sand was deposited on the upland surfaces by a strong prevailing wind blowing from southwest to northeast, the same direction taken by modern winds. Alluvium, a third form of widespread surficial deposit, is laid down by streams, even by the smallest ephemeral and intermittent streams that flow only after a severe rain storm.

During Pliocene and Quaternary time, pediments and terraces formed in and near Chaco Canyon as streams continuously cut downward. Each of these surface remnants is mantled by 10-20 feet (3-6 m) of alluvium composed of coarse gravel near the mountains and finer gravelly sand in the center of the basin near the Park. While as many as 10 of these surfaces are found in the San Juan Basin, and seven in the Chaco River basin, only the three youngest are preserved within the Park. No datable material has been found in the terraces to estimate their true age; we believe, however, that they precede the arrival of man in North America.

Throughout the southwestern United States in general, the earliest evidence of man is found in the late Quaternary to early Holocene alluvium correlated with the Jeddito Alluvium. In the park, this alluvium is composed of gravelly sand and its upper surface generally forms a terrace about 23-33 feet (7-10 m) above modern stream level. Jeddito Alluvium may be seen along the sides of Fajada Wash southwest of the Visitors Center. Recent erosion has removed most of the Jeddito Alluvium in the Park.

Younger Holocene alluvium is composed of fine-grained sediment including sand, silt, and clay. Erosion of the silty alluvium creates flat-floored arroyos with vertical walls often more than 30 feet (9 m) high. These rectangular arroyos are characteristic of a semiarid climate where torrential rainfall and flash floods are common. Chaco Canyon averages about 10-15 inches (25-38 cm) of rain per year, much of it falling from intense local thunderstorms during a wet season from July through September. Within the Park, erosion caused by summer thunder storms has exposed three different deposits of Holocene alluvium.

The earliest of the three deposits is correlated with the Tsegi Alluvium. This alluvium was deposited before pottery was in use but does contain a few stone tools from archaic cultures. An intermediate-age deposit of Holocene alluvium is correlated with the Naha Alluvium. This alluvium is critical to an interpretation of the archaeology of the Park because it forms the upper part of the main terrace along Chaco Canyon and relates directly to the period of most intense occupation of the canyon. Archaeological time in Chaco Canyon, as is common throughout North America, is defined in terms of named cultures. In Chaco Canyon intense occupation began with the Basketmaker III period (about A.D. 500) and ended at the close of the Pueblo III period (a little later than A.D. 1127). Pottery was extensively used throughout this period and sherds of plain and decorated ware are abundant in the Naha Alluvium.

In most valleys of the southwestern United States, where an arroyo was cut into the Tsegi Alluvium, the subsequently deposited Naha Alluvium only partly filled the arroyo; a later arroyo which cut into the Naha left two well-preserved terraces. In the Park, however, the Naha Alluvium first covered the Tsegi Alluvium as a sheet of alluvium; then, as arroyo cutting proceeded headward through the Park, the entire fill was trenched, especially near the center of Chaco Wash. According to Bryan (1954) and Hall (1977), the center of the wash was repeatedly cut and filled in latest Holocene time.

Within both the Tsegi and Naha times of alluviation, there were many episodes of cutting and filling. We find that these episodes did not produce mappable deposits. Therefore, we have mapped only the deposits of the gross events (complicated as they may be in detail), thus requiring the lumping of the Tsegi and Naha Alluviums into a single unit.

The modern alluvium that covers the floors of the Chaco arroyos has come from the very recent cutting of those arroyos. About 1850, an extensive cycle of arroyo trenching began in the southwest, reaching Chaco Canyon about 1860 (Bryan, 1954). Although arroyos make cross-country travel difficult and locally impossible, they do expose the internal composition, structure, and archaeological content of the Naha and Tsegi Alluviums; they are truly the geologists' and archaeologists' windows to the past.

MASS WASTING

Mass wasting is the downslope movement of bedrock or surficial material by the force of gravity. At Chaco Canyon numerous large rockfalls are the chief form of mass movement. Rockfalls, some involving blocks weighing thousands of tons, have been a major hazard along the sides of the canyon since at least Pueblo III time when the occupants of Pueblo Bonito placed stone supports under the cliff to prevent falling blocks from crushing the pueblo. This early engineering work was successful until January 22, 1941, when "Threatening Rock", weighing over 30,000 tons, fell and crushed a significant part of Pueblo Bonito (Schumm and Chorley, 1964). Abundant large blocks of the Cliff House Sandstone scattered along the bases of vertical cliffs show that rockfalls are a recurring hazard. In July 1977, a large block plunged into the Park housing area narrowly missing at least two structures. Such rockfalls create potential hazards for structures and roads built within the Park.

Similar hazardous mass wasting takes place along the walls of the arroyos cut into the valley floor. When the bases of the vertical walls of alluvium are undercut by running water or become saturated, the strength of the silty alluvium is decreased and large rectangular blocks bounded by broad, poorly defined joints fall suddenly into the arroyo. These "earth falls" range widely in size but some include several tons of alluvium. They are potentially extremely hazardous to anyone in the arroyos, especially during the wet season from July to September.

FOLDS AND ARTESIAN WATER

The movement of underground water is controlled largely by the inclination of water-bearing beds or aquifers. The rocks forming the San Juan Basin dip toward the center of the basin about 45 miles (72 km) to the northeast of Chaco Canyon. The Park, therefore, lies on the northeastward-dipping southwestern flank of the basin. In the Park, the numerous layers of sedimentary rock are not flat but dip to the northeast at about two or three degrees. Thus, from south to north, younger rocks successively overlap older rocks (see cross section). Where dipping permeable rocks such as the Cliff House Sandstone are exposed at the surface, they absorb rain and melting snow and act as drains to carry the surface water underground. When the underground water meets an impervious barrier such as the Lewis Shale, it is forced along the contact and will finally emerge as natural springs where erosion and canyon cutting have exposed the contact between the sandstone and the shale. Such springs are common along the south side of Chaco Canyon and formed a significant part of the daily water supply of the Chacoan people. To the northeast of the Park, where the Cliff House Sandstone is overlain by the impervious Lewis Shale, the ground water is under pressure and wells drilled into the Cliff House Sandstone aquifer produce artesian water.

CONCLUSIONS

The geology and related landforms of Chaco Culture National Historical Park result from events that have taken place during the last 80 million years. Erosion and deposition, first in the ocean and later on the land, produced the sedimentary rocks and surficial deposits that characterize the Park area. Broad regional folding in Late Cretaceous and early Tertiary time tilted the sedimentary layers and exposed the rocks flanking the basin to erosion that partially filled the basin with additional sediment. Continued deep erosion in Pliocene and Quaternary time and deposition of that eroded material created the scenery of today. These geologic processes form an endless cycle that will slowly but persistently continue to change the Chaco Canyon landforms.

AN OVERVIEW OF THE ARCHAEOLOGY OF CHACO CANYON

Contribution No. 29, Chaco Center, National Park Service
and the University of New Mexico
By William B. Gillespie

Chaco Culture National Historical Park is best known for the large multistoried masonry pueblos contained within its boundaries. Pueblo Bonito and the other large ruins are some of the most spectacular prehistoric structures north of Mexico. The Park was created in 1907 specifically to protect and preserve these ruins after early explorers and archaeologists recognized both the aesthetic and scientific value of the sites. The Park has been the scene of considerable archaeological excavation over the past 80 years, including some of the earliest and largest projects in the southwest. The large amount of research, however, does not mean that the archaeological record is fully known; indeed, the more data recovered, the more numerous the unanswered questions.

While the impressive masonry pueblos have received the most attention from archaeologists as well as the visiting public, they are only a small part of the archaeology of Chaco Canyon. Altogether some 2,400 sites have been located and recorded in the Park and its immediate environs. Only about one third of these are habitation sites while the others are locations of more limited use such as stairways, water control devices, and rock art.

THE ARCHAIC PERIOD

The earliest inhabitants of Chaco Canyon were semi-nomadic hunters and gatherers who made use of the wild plants and animals available there. Man was present in Chaco as early as 5000 B.C. and may have been there even earlier. By the first century, domesticated corn, ultimately derived from Mexico, was added to the assemblage of utilized food plants. Corn was initially of only secondary, supplemental importance, but its use increased through time, and by about A.D. 500, was an integral part of the diet. In all, 70 sites, mostly small seasonal camps, have been identified in Chaco as representing a time of less intensive use before A.D. 500.

THE EARLY ANASAZI

Around A.D. 500, an important evolutionary transition led to a more sedentary life in small villages. Population was increasing; a concomitant increase in the reliance on agricultural production of corn, beans, and squash took place; pottery was used for the first time. Most people lived in small clusters of circular subterranean pithouses. The pattern of living in small villages of only a few families continued for several centuries, but by A.D. 900 another important transition had occurred: within the small villages, the locus of most domiciliary activities shifted from the pithouses to small contiguous masonry rooms built on the ground surface. At the same time, the pithouses evolved into structures known as kivas which were similar in size, location, and construction to pithouses, but limited in use primarily to ceremonial and socially integrative functions.

The same basic developments were occurring throughout most of the Anasazi region of the Colorado Plateau. As such, the early Pueblo archaeology of Chaco is not appreciably different from elsewhere in the Anasazi area. However, after A.D. 900 and particularly in the 1000's, developments took place in Chaco which set it apart from the other areas. The most conspicuous of these developments was the construction of the large communal houses or "towns" as they have frequently been called. Although most of the construction took place in the eleventh century, some of the towns were begun in the first half of the 900's. At three locations in the canyon—Pueblo Bonito, Peñasco Blanco, and Una Vida—long curving arcs of large habitation rooms backed by smaller multi-storied rooms were laid out and built. This basic pattern was similar to contemporary village architecture, but there was a remarkable difference in scale: the room blocks at the town sites were much more extensive and the individual rooms were substantially larger. At the three sites noted, these early room blocks formed the core for later additions.

BONITA PHASE ARCHITECTURE

The peak of the Chaco towns, the Bonito phase, occurred from about A.D. 1030 to 1125. The largest of the towns, Pueblo Bonito, grew to more than 600 rooms while 10 other sites had over 100 rooms. Altogether, there may have been as many as 5,000 people living in the canyon at this time.

Architecturally the towns have several characteristics which are rarely seen in other southwestern sites. Significantly, the basic units of construction and the patterns of growth are not the same as in other Anasazi or modern Pueblo structures. Rather than continuing to add one or more rooms to dwellings as they were needed, construction of the Chaco towns was planned beforehand and completed as a single unit. The towns, or major sections of the longer-lived sites, were evidently designed, foundations for walls laid out, and then the rooms built as one large construction project. Town layouts vary but most have regular symmetrical plans, typically C-, D-, E-, or L-shaped and oriented to the south with a large enclosed plaza.

The masonry workmanship of the towns was exceptionally good. Walls were built with a rubble core and veneer or facing of carefully fitted pieces of tabular sandstone, frequently laid in banded patterns. Room blocks were as many as five stories high with the walls necessarily thicker at the bottom to support the tremendous weight. Rooms were characteristically large with ceilings as high as 13 feet (4 m) and floor areas commonly greater than 82 square feet (25 m^2).

Kivas are present in the towns, but they are larger and fewer, relative to the number of rooms, than in contemporary village sites. However, the very large great kivas, rare throughout most of the Anasazi region, are comparatively abundant in or near the Chaco towns. A more unusual circular structure, the elevated or tower kiva is virtually unique to Chaco sites.

Several aspects of Chaco town architecture are suggestive of a more complex system of social organization than is characteristic of the Anasazi or the modern Pueblos. The evidence of planning, organized construction projects involving a large directed labor force, and craft specialization in the detailed masonry work all suggest a non-egalitarian division of labor and authority. In other words, the implication is of a "ranked" society headed by a social elite with enough authority to dictate some of the activities of the larger group. Evidence of such an elite may be present in the few burials from Pueblo Bonito where abundant and elaborate material accompaniments apparently indicate the high status of the individuals.

OTHER BONITO PHASE CHARACTERISTICS

Additional indications of a non-egalitarian social system are seen in some of the other developments in Chaco. Organized construction activities were not restricted to the large buildings. Throughout the canyon, small but well-made irrigation systems involving diversion dams, canals, headgates, and gridded fields were built in an effort to increase agricultural production. The principal water source was not the main wash of the canyon, but rather the small ephemeral lateral channels draining the sides of the canyon. A substantial amount of labor was also expended in connecting many of the towns with broad, straight pathways or "roads" up to 29.5 feet (9 m) wide and featuring ramps and stairways where cliffs were encountered. Traces of prehistoric roads also extend outside the canyon to the north and south.

During the peak of the Bonito phase, Chaco appears to have been the focus of a large, regional, socio-economic system. Other large sites showing many of the attributes of the Chaco Canyon towns began to appear in the surrounding areas. Some of these are virtually indistinguishable from the Chaco towns and illustrate the same sophistication in planning and construction. The best known examples of these outlier communities are the Aztec and Salmon Ruins located about 62 miles (100 km) north of Chaco along the Animas and San Juan Rivers.

Many items were probably exchanged through this regional network, but two which are illustrative of the extent to which materials were transported are pottery and turquoise. Technological analysis has shown that much, if not most, of the pottery found in Chaco was not manufactured there, but was instead made in areas around the edges of the San Juan Basin. A reason for manufacturing ceramics in the higher peripheral areas may have been the greater availability of wood required for firing the vessels. On the other hand, Chaco evidently was a major center for the manufacture of turquoise ornaments (especially beads) yet turquoise does not occur naturally within the San Juan Basin. It had to be imported to the canyon in raw form from distant mines, most of which were probably in the Cerillos Hills south of Santa Fe, about 110 miles (175 km) to the east.

Long-distance trade with the advanced Toltec civilization of Mexico is also in evidence. Excavated Chaco sites, particularly Pueblo Bonito, have revealed some items which could only have come from Mexico. While they may seem few in number, there are far more in Chaco than in other contemporary sites in the northern southwest. Best known are the remains of brightly feathered scarlet macaws and small copper bells. Connections with Mexico are also seen in some of the architectural features such as masonry colonnades and broad steps ascending to small raised platforms.

The significance of these Mexican features in Chaco is a controversial topic among archaeologists today. Some suggest that the southern traits are simply high value items imported to Chaco through extensive trade connections. Others argue that these features are the physical evidence of the presence of traders from Mexico who came north to Chaco and established it as a regional center to serve as a northern outpost of the larger Mexican system. By either interpretation, turquoise is viewed as perhaps the main commodity transported south from Chaco.

At the time that the large towns were built and used, many inhabitants of the canyon continued to live in small villages, most of which are scattered along the south side of the canyon. Archaeologists have long contemplated the relationship between the occupants of the two site types and the debate continues. Other than the obvious architectural differences, and the presence of more exotic items found in the towns, the material remains of the two are quite similar. In the past, researchers have viewed the two as separate cultural groups; the town dwellers were "better off" and presumably dominated the villagers. Alternatively, the canyon could have been occupied by a single group and the towns organized as "public work projects." A controlling social elite may have been present in the towns, but this does not imply that all of the town dwellers were of a privileged group.

ABANDONMENT AND NAVAJO OCCUPATION

Sometime during the first half of the 1100's, Chaco lost its position as a major regional center and people began to leave the canyon. Major construction activities ceased and distinctive Chaco features indicative of an organized non-egalitarian society disappeared. Limited occupation in both towns and villages continued into the 1200's, but by 1300, Chaco, as with most of the Four Corners region dwellings, was abandoned. Reasons for the depopulation are still not firmly established, but in Chaco, the imbalance between a large population and inadequate resources may have been an integral factor.

The canyon was visited only sporadically until the Navajo began farming and herding sheep there in the early 1700's. Over 700 Navajo hogans, or one room dwellings, are located in the Park and adjacent areas with the greatest number dating from near the turn of the last century. An early trading post, operated by Richard Wetherill from 1897 until his death in 1910, helped to make Chaco a regional economic center once again. Development of the Park led to displacement of the local Navajos, but presence of the ruins continues to make the canyon a major attraction of northwestern New Mexico.

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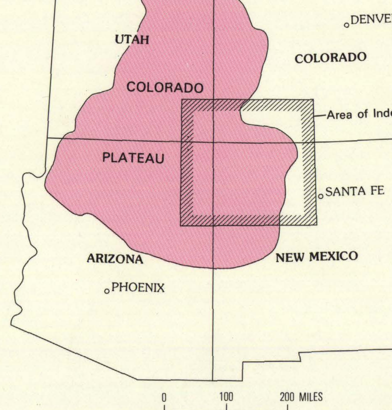
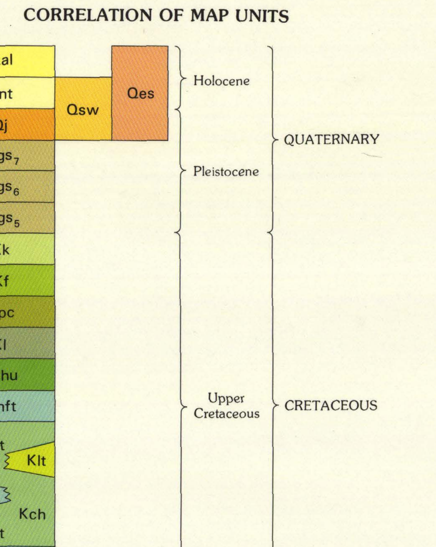


MAP SHOWING LOCATION OF COLORADO PLATEAU AND AREA OF INDEX MAP

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

(In general, surficial deposits are mapped only where they are more than 5 ft (1.5 m) thick)

Qal ALLUVIUM (UPPER HOLOCENE)—Alluvium in lowest channels cut into floodplains of larger ephemeral streams throughout the area. Composed primarily of dark-gray silt and white, fine to coarse sand derived from shale or sandstone bedrock, or reworked from deposits of older alluvium. Contains clasts of sandstone and sideritic ironstone from local bedrock. Thickness ranges from less than 10 ft (3 m) to more than 50 ft (15 m) in the bed of Escavada Wash

Qnt NAHA AND TSEGI ALLUVIUMS (FORMATIONS OF HACK, 1941) UNDIFFERENTIATED (UPPER HOLOCENE)—Each formation is identifiable in many places, but the units were not differentiated for this report

Naha Alluvium—Grayish-brown, friable to slightly hard, thinly laminated and cross-stratified sand and silt in discontinuous layers. Fills washes of ephemeral streams. Forms entire alluvial column near center of Chaco Wash. Forms upper 4 ft (1.2 m) of alluvial column where it overlies Tsegi Alluvium near sides of Chaco Wash. Lacks zonal soil in the upper part, but thicker deposits may contain buried clay or humus-rich horizons. In vertical banks along centers of deep washes, commonly shows a complex sequence of cut-and-fill channels (Bryan, 1954, and Hall, 1977). As mapped includes some sheetwash alluvium and alluvial fans along valley walls. Top of terrace lies as much as 33 ft (10 m) above arroyo floors. Locally contains abundant sherds of prehistoric pottery in upper 20 ft (6 m) or less along Chaco Wash (Bryan, 1954). Thickness ranges from 10 ft (3 m) to more than 20 ft (6 m). Naha Alluvium overlies Tsegi Alluvium along deep arroyos of Chaco Wash

Tsegi Alluvium—Yellowish-gray or grayish-brown, firmly consolidated, fine to coarse sand, silt, and clay containing several clay and humus-rich layers. In the upper part is weakly developed soil with a yellowish-brown B horizon 6-24 in. (15-61 cm) thick and an underlying moderately firm C_{ca} horizon 15-30 in. (38-76 cm) thick. B horizon contains large well-developed columnar peds as much as 8 in. (20 cm) wide and 24 in. (61 cm) high. Where the soil was removed by erosion, Tsegi Alluvium cannot easily be differentiated from overlying Naha Alluvium. Tsegi Alluvium either makes up the whole terrace or lies beneath the Naha in the deep arroyo along Chaco Wash and probably is widespread beneath Naha Alluvium in the valley fills. Thickness about 10 ft (3 m)

Qsw SHEETWASH ALLUVIUM (UPPER HOLOCENE TO UPPER PLEISTOCENE)—Consists of poorly consolidated clay, silt, and coarse to medium sand containing rock fragments ranging from pebbles to large sandstone slabs. Chiefly sheetwash material derived from shale and sandstone bedrock on gently sloping tops of mesas and gently to steeply sloping valley walls. In part derived from older surficial deposits. Includes small unmapped rock falls and talus cones derived from bedrock on steep valley walls, and colluvium subjected to creep on steep slopes. Locally covered by unmapped eolian sand. Locally well-cemented on south side of Chaco Canyon between Wijiji and Pueblo del Arroyo Ruins. Small areas of gravelly sheetwash alluvium along Fajada Wash are considered to be equivalent to gravelly Jeddito Alluvium (**Qj**) in the gravel pit one-half mile southwest of the Park headquarters. Zonal soil in upper part contains a B horizon 6-24 in. (15-61 cm) thick having weakly developed coarse columnar structure, clayey texture, and yellowish-brown color. Underlying C_{ca} horizon is 15-30 in. (38-76 cm) thick, and contains weakly developed floury or spotty accumulation of calcium carbonate. Thickness of unit is as much as 20 ft (6 m)

Qes EOLIAN SAND (UPPER HOLOCENE TO UPPER PLEISTOCENE)—Includes both young and old deposits. Younger eolian sand is white, well-sorted, cross-stratified loose quartz sand in active barchan and climbing dunes. Sand was blown from channels of major washes and from sandy bedrock by winds that still trend N. 60° to 70° E. Older eolian deposits consist of light-brown, slightly consolidated, fine to medium sand containing subrounded to rounded, frosted quartz grains in stabilized linear dunes and sand sheets on the uplands. Discontinuous soil in upper part of older sand is marked by a reddish-brown oxidized B horizon up to 10 in. (25 cm) thick underlain by a firmly consolidated, light-brown C_{ca} horizon up to 18 in. (46 cm) thick containing scattered carbonate nodules. This soil probably formed during the Altithermal middle part of Holocene time and shows that part of the sand has been stable for more than 4,000 years. Thicknesses of eolian sand are more than 40 ft (12 m) in active dune fields along the Chaco River and Chaco Wash and more than 7 ft (2 m) in the older sand deposits

Qj JEDDITO ALLUVIUM (FORMATION OF HACK, 1941) (LOWER HOLOCENE TO UPPER PLEISTOCENE)—Dark-yellowish-brown sand containing moderate yellowish-brown, angular, pebble- to cobble-sized clasts of sandstone and very dark brown to black, pebble-sized clasts of ironstone. Along Kin Klizhin and Fajada Washes, most clasts are from the underlying Menefee Formation (**Kmf**). Along the Chaco River, the Jeddito contains clasts of quartzite, petrified wood, quartz, and chert as large as 12 in. (30.5 cm) in diameter derived from Ojo Alamo Sandstone of Paleocene age, and other sources. (Some clasts were a source of flaking material for the manufacture of prehistoric stone tools.) Some Jeddito Alluvium along Fajada Wash is of sheetwash origin. Along Fajada Wash, a reddish-brown, well-developed, Altithermal soil formed in the upper part of the alluvium. It contains in descending order: a sandy humic A horizon about 2.7 in. (7 cm) thick, a reddish-brown clayey firm B horizon 12 in. (30.5 cm) thick, and a nodular to densely concentrated C_{ca} horizon more than 27 in. (70 cm) thick. In terraces along Kin Klizhin Wash and the Chaco River, the B horizons of original soils generally were removed by erosion, but part of the calcium carbonate of the C_{ca} horizon remains as coatings on the undersides of pebbles. Altithermal soil is exposed locally in the lower parts of arroyo walls along Chaco Wash, which suggests that, near the center of the wash the Jeddito Alluvium forms a deep and seldom-exposed fill. Emplacement of Tsegi Alluvium was shallower, but still deeper than Naha Alluvium. Jeddito Alluvium forms a terrace about 23 ft (7 m) above the Chaco River, Fajada Wash, and Kin Klizhin Wash. Maximum thickness along Fajada Wash is about 33 ft (10 m)

Qgs$_7$, Qgs$_6$, Qgs$_5$ GRAVELLY SAND (UPPER PLEISTOCENE)—Very pale brown, dark-yellowish-brown or grayish-orange, gravelly, medium to coarse sand containing pebbles averaging about 1 in. (2.5 cm) in diameter. Pebbles decrease in abundance upward. Size and composition of clasts varies with location and proximity of source. Quartzitic sandstone, quartz, and chert clasts are chiefly from Ojo Alamo Sandstone of Paleocene age, which crops out 7.4 miles (12 km) north of the Park; ironstone and clinker (baked shale) are chiefly from the Fruitland Formation (**Kf**). Sandstone and ironstone clasts found along the Chaco River are chiefly from the Cliff House Sandstone (**Kch**) and Menefee Formation (**Kmf**). A soil zone in the upper part of the alluvium contains an A horizon 14-20 in. (36-51 cm) thick, underlain by a dark brown hard clayey B horizon 12-24 in. (30.5-61 cm) thick and a white, very calcareous, friable, pebbly C_{ca} horizon 24-40 in. (61-102 cm) thick that locally contains nodules of calcium carbonate. Deposits occur as sheets overlying pediment-like surfaces that cut across nonresistant bedrock and slope toward the Chaco River or other local major valleys. At least seven erosion surfaces and their associated gravelly sand deposits are recognized in the drainage basin of the Chaco River. Each reflects an erosional episode related to changes in the grade of the Chaco River or the San Juan River. Various surfaces from highest and oldest (**Qgs$_1$**) to lowest and youngest (**Qgs$_7$**) are distinguished from each other by the height of the erosion surface above the Chaco River and its major tributaries. In addition, soils that developed on the higher and older deposits of gravelly sand are more strongly developed than those on the lower and younger deposits. The three youngest geomorphic levels of gravelly sand are present in the Park area, and range from 60-200 ft (18-60 m) above the local drainage. Thickness of each deposit ranges from 8-20 ft (2.5-6 m)

Kk KIRTLAND SHALE (UPPER CRETACEOUS)—Light-olive-gray to greenish-gray, silty and sandy mudstone and a few yellowish-gray, thin sandstone beds. Contains sparse black, carbonaceous mudstone beds that contain some swelling clay and commonly show a popcorn-like appearance on weathered exposures. The Kirtland Shale commonly forms badlands showing curious erosional forms such as pedestals, knobs, and spires. Contains some gray to white silicified wood. Probably more than 490 ft (150 m) thick, but only lower part of formation is present in report area

Kf FRUITLAND FORMATION (UPPER CRETACEOUS)—Highly variable sequence of intercalated lenticular sandstone, siltstone, mudstone, carbonaceous shale, and coal. Siltstone and mudstone are dusky yellow to moderate brown. Mudstone units generally are 5-20 ft (1.5-6 m) thick, but locally are as much as 50 ft (15 m) thick. Contains layers of swelling clay. White to yellowish-gray, medium-grained, friable sandstone beds of this unit are lenticular, and most are less than 10 ft (3 m) thick; locally they contain sideritic ironstone concretions as large as 4 ft (1.2 m) in maximum dimension. Forms picturesque badland topography. Local individual coal beds are more than 6.5 ft (2 m) thick. Red clinker beds mark the outcrops of burned coal beds. Total thickness of unit probably is less than 295 ft (90 m)

Kpc PICTURED CLIFFS SANDSTONE (UPPER CRETACEOUS)—Yellowish-gray to grayish-orange, thick-bedded and crossbedded, cliff-forming, well-sorted, friable, fine-grained sandstone comprises the upper part of the formation. Contains brown, hard, round, slabby, calcareous sandstone concretions that are parallel to bedding and as large as 4 ft (1.2 m) in diameter. Lower part consists of alternating thin beds of yellowish-gray to moderate-brown, fine-grained to very fine grained sandstone and light-gray to dark-gray, silty shale. Upper 6.5 ft (2 m) of shaly unit contains thin discontinuous layer of hard fine-grained ironstone. Contains fossil marine invertebrates and casts and impressions of burrows of *Ophiomorpha major*, which are indicative of near-shore marine environment. Forms low bluffs. Formation is about 60 ft (18 m) thick

Kl LEWIS SHALE (UPPER CRETACEOUS)—Upper part is calcareous, sandy shale that contains light-brown sandstone beds 1-5 ft (0.3-1.5 m) thick. It is transitional into the overlying Pictured Cliffs (**Kpc**). Middle part is light-gray to dark-olive or olive-gray claystone and siltstone that contains a few thin sandstone zones and scattered beds of sandy concretionary limestone. Lower part is sandy and transitional into underlying Cliff House Sandstone (**Kch**). Calcareous concretions in the formation contain marine invertebrate fossils equivalent in age to middle Pierre Shale (Campanian) of eastern Colorado. Formation is about 100-115 ft (30-35 m) thick

Klt TONGUE OF LEWIS SHALE (UPPER CRETACEOUS)—Greenish-gray, slope-forming, thin-bedded siltstone, sandy shale, and shale. Crops out near junction of Escavada and Chaco Wash and in Ah-shi-sle-pah Wash area. Thickens northward and joins main body of the Lewis Shale in the subsurface. Thickness 0-90 ft (0-27 m). Along north side of Chaco Canyon, a conspicuous broad bench in the Cliff House Sandstone separates two high sandstone cliffs. This broad bench is developed south of the pinchout and at the stratigraphic level of the tongue of Lewis Shale

Kch CLIFF HOUSE SANDSTONE (UPPER CRETACEOUS)—White to dark-yellowish-orange, thin- to thick-bedded, fine- to coarse-grained, lenticular and crossbedded or massive sandstone. Contains gray or brown carbonaceous shale lenses. Forms high bold cliffs and ridges. Mapped as Chacra Sandstone Member (name now abandoned) of Mesaverde Formation by Dane (1936). Intertongues with both Lewis Shale and Menefee Formation. Some tongues of Menefee Formation are mapped with the Cliff House; other tongues are mapped separately. Contains casts of the burrows of *Ophiomorpha major* indicative of a near-shore marine environment and marine fossil invertebrates. Cliff House Sandstone is as much as 430 ft (131 m) thick

Kchu UPPER BED OF CLIFF HOUSE SANDSTONE (UPPER CRETACEOUS)—Brown and yellowish-gray, massive sandstone. Commonly capped by a dark-brown sandstone about 2 ft (0.6 m) thick, which contains abundant broken bits of marine fossil invertebrates. Forms conspicuous ledge that is everywhere separated by a tongue of the Menefee Formation from underlying parts of the Cliff House Sandstone. As much as 55 ft (17 m) thick. Thin and grades northward into Lewis Shale at localities to the northwest of the report area

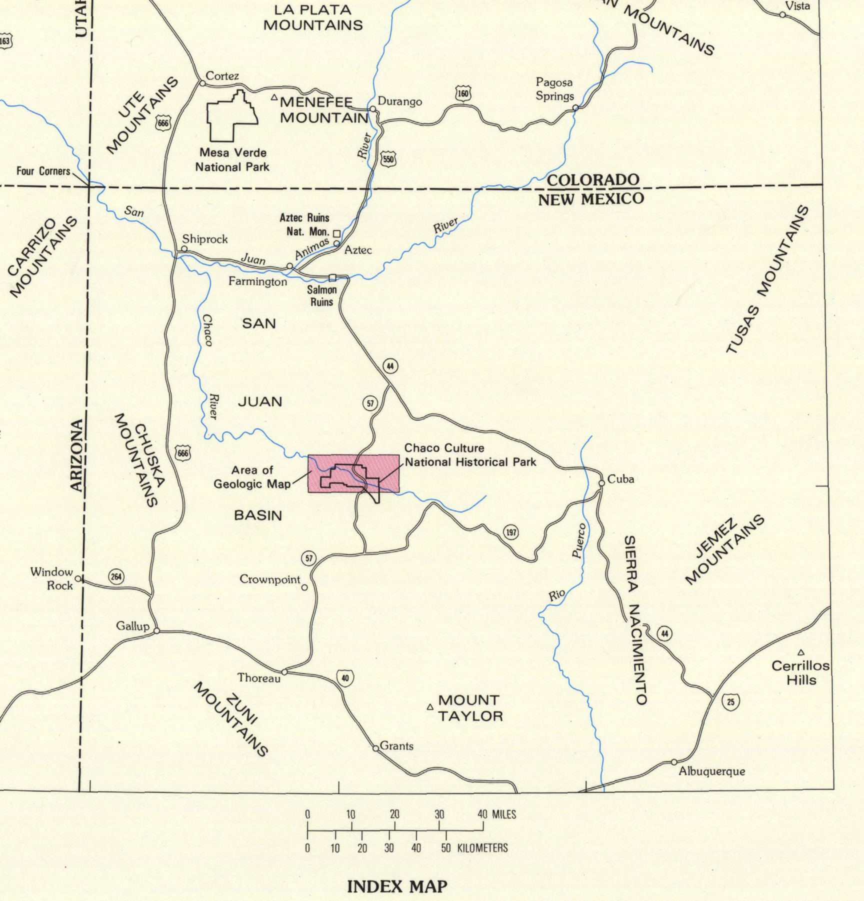
Kmf MENEFEE FORMATION (UPPER CRETACEOUS)—Heterogeneous sequence of thick, lenticular beds of grayish-yellow to brown, fine- to medium-grained, crossbedded sandstone and interbeds of dusky-yellow to olive-gray, sandy shale and mudstone, moderate-brown, sandy limestone; and lenticular beds of carbonaceous shale and shaly coal. Coal beds occur sporadically in the upper 246 ft (75 m) of Menefee Formation. The coal beds are commonly burned at the outcrop; red outcrops across from Casa Chiquita are result of burned coal. The Menefee Formation is widely exposed in southern San Juan Basin; base of the formation crops out 18.6 miles (30 km) south of the Park. Unit is 400 ft (122 m) thick at the type locality at Menefee Mountain in southwestern Colorado about 87 miles (140 km) north of Chaco Canyon; it thickens southward. In a drill hole 5.9 miles (9.6 km) north of the northern boundary of the map area, unit is about 1,500 ft (457 m) thick

Kmft TONGUES OF MENEFEE FORMATION (UPPER CRETACEOUS)—Gray and brown, lenticular sandstone interbedded with black, carbonaceous shale, gray claystone and siltstone, some thin beds of highly weathered coal. Occurs as beds within Cliff House Sandstone (**Kch**) that thin northward. Beds undoubtedly represent two or more separate tongues extending northward from main body of Menefee Formation (**Kmf**). Stratigraphic connection, however, has since been removed by erosion in map area. Thickness 0-80 feet (0-24 m)

CONTACT

DIP OF INCLINED BEDS

GRAVEL PIT



INDEX MAP

GEOLOGIC AGE			AGE IN MILLIONS OF YEARS (APPROXIMATE)
CENOZOIC ERA	QUATERNARY	Holocene	
			(10,000 YRS.)
		Pleistocene	
			1.8
	TERTIARY	Pliocene	
			5
		Miocene	
			24
		Oligocene	
			38
		Eocene	
			55
		Paleocene	
			65
MESOZOIC ERA		Cretaceous	
			138
		Jurassic	
			205
		Triassic	
			240
PALEOZOIC ERA		Permian	
			290
		Pennsylvanian	
			330
		Mississippian	
			360
		Devonian	
			410
		Silurian	
			435
		Ordovician	
			500
		Cambrian	
			570
		Precambrian	

GEOLOGIC TIME CHART

GEOLOGIC MAP OF THE CHACO CULTURE NATIONAL HISTORICAL PARK, NORTHWESTERN NEW MEXICO

By
Glenn R. Scott, Robert B. O'Sullivan and David L. Weide

1984

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