WALNUT CANYON GEOLOGICAL REPORT

By Vincent W. Vandiver, Regional Geologist

INTRODUCTION

Walnut Canyon National Monument was reserved by the Government with the idea of the preservation of the numerous cliff dwellings which occur in this area. The geological features of the area are most interesting, however, and for those who will take the time to consider the various processes which contributed to the formation of this canyon, they will find that in miniature much the same factors are involved as those which resulted in the formation of the Grand Canyon of the Colorado River. I shall endeavor to relate in this report how these geological processes have played such an important part in the carving of the landscape in Walnut Canyon which resulted in an ideal location for the establishment of the homes of the Pueblo cliff-dwellers.

LOCATION

Walnut Canyon National Monument is located about 10 miles southeast of Flagstaff, Arizona, on a loop road connecting with U. S. Highway 66. The presence of walnut trees along the floor of the canyon has supplied its name. The reserve was created as a National Monument in 1915 although it is understood that the area was under the supervision of the Forest Service from 1906. It contains an area of 960 acres. There are of course many ruins in the Southwest of ancient pueblo peoples however there are relatively few cliff dwellings of this type. They are most accessible to large numbers of tourists due to the proximity to one of the main routes of transcontinental travel through this region.

ARCHEOLOGY

Dr. Harold S. Colton (1), of the Museum of Northern Arizona, states that the cliff dwellings in Walnut Canyon have been dated by the tree ring method indicating that they were occupied by pueblo Indians from around 900 to 1300 A.D. There may be some significance to the fact that these dwellings were being occupied shortly after the last eruption of Sunset Crater, situated some twelve miles to north, and whose last activity has also been estimated by the tree ring method as having taken place around 875 A. D. There are present ruins of some 300 rooms scattered along both sides of Walnut Canyon and it is easy to conceive of upwards to 1000 people living in this settlement. The area was visited by James Stevenson of the Smithsonian Institution in 1883 and he made the following statement: "The doors are large and extend from the ground up to a sufficient height to admit a man without stooping. The rooms are large and the walls are two to four feet thick. The fireplaces are in one corner of the room on an

elevated rock, and the smoke can only escape through the door. The masonry compares favorably with the construction of the best villages in Canyon de Chelly. Many objects of interest were found in the debris around and in these houses. Matting, sandals, spindle whorls, and stone implements of various kinds abound." During the interval from the time of Mr. Stevenson's visit and the taking over the area by the Forest Service there was much vandalism. Practically all of the objects left by the pueblos were removed and in searching for these materials many of the cliff dwellings were broken down and more or less destroyed. As the result of this vandalism it is doubtful if the detailed story of the peoples of Walnut Canyon will ever be known.

Dr. Colton considers that the people who built these cliff dwellings were probably the ancestors of those who constructed Elden Pueblo and many other sites near Flagstaff. This supposition is arrived at from the similarity of the potsherds and flattened skulls which have been recovered from the various ruins.

The dwellings in Walnut Canyon were constructed under overhanging ledges of limestone two hundred feet or more above the stream bed. Not only were their homes built along the recesses in the side of the canyon wall but retreats were also made on at least five "islands" of promontories in the canyon which served as fortresses as a means of protection against invaders. A trail is in evidence to the right of the present entrance trail to the monument which is believed to have been the route taken to obtain water from the stream or pools in the canyon. Little water now reaches the stream channel to fill the pools due to the recent construction of the Lake Mary dam. During dry periods it is also conceived that water may have been obtained by digging pits in the sand along the floor of the canyon. The remains of broken stone hoes, etc., have been discovered along the flats of the rim areas, northeast of the village, and it is here that the pueblos probably cultivated their meager crops. Another factor which no doubt influenced these peoples to select Walnut Canyon as a desirable place to live is the presence of ledges and recesses especially in the walls along the north side of the canyon which formed a means of protection against the climatic conditions of the severe winters. The presence of water supply nearby and satisfactory soil for cultivation along the rim as well as the "islands" in the canyon which were used as forts were likewise desirable features.

GEOLOGY

The oldest rocks of the general vicinity of Walnut Canyon belong to the Redwall limestone formation of the Mississippian, along the northeast flanks of Elden Mountain, where uplifted portions of the sedimentary section are exposed by this great laccolith. Above the Redwall is the river flood plain deposit, consisting of sandstones and shales, and containing tracks of land animals and impressions of fern-like plants, which has been termed the Supai formation of Permian age. Next above the Supai is the

cross-bedded Coconino sandstone and followed in order by the Kaibab limestone, both of Permian age. It is the two latter formations with which we are most concerned since they make up the sedimentary section of rocks exposed in Walnut Canyon.

Briefly the geologic history of the area may be described by stating that following the deposition of the Kaibab limestone the sea retreated as the region uplifted slightly with the sedimentary rock remaining practically horizontal apparently subjecting the formation to erosion long enough to produce a youthful topography. Upon this surface was deposited the shales and sandstones of the Moenkopi. A great thickness of varicolored shales and sandstones were then deposited in a large basin by rivers and shallow water lakes. These continental deposits make up the Chinle formation. They contain a land fauna and the remarkable deposits of silicified wood at the Petrified Forest. They supply most of the beautiful coloring to the Painted Desert area and are classed as the uppermost Triassic formation in this region. While these beds form the last record of sedimentation in this territory it is known from a study of the stratigraphy of the surrounding country that great thicknesses of Jurassic, Cretaceous and perhaps Eocene rocks were once present but have all now been removed by erosion.

COCONINO SANDSTONE

Below the Kaibab limestone which forms the rim rock at Walnut Canyon, there is the light colored, highly cross bedded sandstone, which has been designated as the Coconino sandstone from its type locality at the Grand Canyon. The contact between the two formations is readily observed along the canyon walls. Located between formations of Permian age, as determined by fossil remains, the Coconino is likewise referred to the Permian Epoch. A closer determination of the age of the Coconino is made as Middle Permian, in view of the grading contact with the underlying Hermit shale in the Grand Canyon, whose age has been found to be upper Lower Permian from the fossil flora secured.

The Coconino sandstone occupies a large area in northern Arizona, north of the southern limits of the Colorado Plateau. While much of this region is capped by the Kaibab limestone, the presence of the Coconino is certain from the many exposures in the canyon walls throughout the province. From a thickness of 1000 feet at Pine the formation thins out to zero along the Utah boundary. It also thins in a northwest direction towards the Nevada boundary where it is only a few feet thick whereas there is over 600 feet of section in the vicinity of Holbrook. From samples taken by Mr. Edwin McKee (2) the sand grains are predominantly medium coarse grained along the southern limits of the formation and grade into much finer materials to the north. The source of the material is therefore concluded to be from the south, in a barrier believed to have existed during most of earlier Paleozoic time, which extended through central Arizona and is known as Mazatzal land. Geologists generally consider that there is

sufficient evidence to conclude that the sand grains comprising the Coconino formation were in the main transported by the winds and deposited in the form of sand dunes. The lack of pebbles seems to point towards the wind as the major agent of transportation. The wedge-shaped cross bedded units of this formation are inclined in many directions, a feature not widely produced by the action of water. The only definite fossils thus far discovered in these sandstones are the footprints of amphibians or reptiles and trails made by annelid worms. The fossil evidence available also tends to support the theory of eolian origin of the formation.

The Coconino has supplied its portion of the natural features necessary in the making of Walnut Canyon an ideal site for the cliff dweller. In the valley south of Elden Mountain there are some large sink holes, known as the Bottomless Pits. They form the entrance to caves in the Kaibab limestone, which have been dissolved out by the action of ground waters on the limestone, as they flowed underground along joints and fissures to outlets in the lower levels of Walnut Canyon. The more or less porous Coconino sandstone was favorable to the seepage of this additional water into the canyon. The normal weathering of the Coconino caused much sand to be deposited in the canyon. This condition may in some instances have caused the formation of pools of water just beneath the surface and permitted the pueblo Indians to dig for water during periods of dryness. Then, too, as the canyon was being carved the Coconino was susceptible to certain straightening of the channel and during this process the old meanders of the stream were abandoned and "cut-offs" were formed. These "islands" permitted the Indians to build homes in fortress fashion in the central portions of the canyon and gave them an excellent means of protection.

KAIBAB LIMESTONE

Overlying the Coconino Sandstone throughout large sections of northern Arizona, except in the east near Holbrook, is the Kaibab limestone. It forms the upper portions of the walls of Walnut Canyon and Grand Canyon as well and caps most of the high plateau of the north-central part of the state. It is composed of grey, sandy limestone, with many horizons filled with chert, also massive layers of limestone interspersed with less resistant beds of shaly sandstone. The lithology of the Kaibab limestone with the constant variation of hard and soft members, the soft weathering away leaving the more competent beds to form overhanging ledges, has resulted in a natural habitat for the cliff dweller in this canyon.

The Kaibab limestone is quite variable in thickness, ranging from upwards to 1000 feet in the Virgin River valley to 600 feet on the Rim of Grand Canyon, and from 300 feet in the vicinity of Flagstaff to zero just east of Holbrook. Mr. Edwin McKee, Park Naturalist at Grand Canyon National Park, has developed some new and interesting details concerning this formation and the resultsof his study will be published in the near future. At Walnut Canyon the Kaibab is quite fossiliferous. Many marine fossils of brachiopods such as Productus and Spirifers may be observed. In some in-

stances the silica nodules and concretions enclose fossils sponges. The various types of fossils collected of which there are some 80 species indicate that the limestone is of shallow water marine origin. Since the limestone was deposited below sea level and now has an elevation of approximately 7,000 feet above sea level there is every reason to believe that the region has been uplifted on a large scale. It will be noted along the walls of the canyon that the contact of the limestone with the underlying Coconino is practically horizontal and it is therefore assumed that the Kaibab sea advanced rapidly at the close of Coconino time since there is no evidence of erosion of importance along this line of contact.

An important point to consider with respect to the Kaibab formation and the cliff dwellers in this canyon is the presence of softer members of sandy limestone interspersed in the section with the more resistant or massive limestone beds. This condition during the process of the carving of the canyon and the normal weathering processes gave rise to ragged, vertical cliffs, with recessed grooves in the walls which finally formed the homes of the pueblo Indians. The ledges may have been formed in part by the action of the stream on the softer beds when it was cutting away at much higher levels, but the process may be explained in most instances I believe, by the normal agencies of differential weathering.

STRUCTURE

Since the structural details would involve a rather lengthy report it may suffice to say briefly that they include upward movements at the close of the Permian and profound uplifting during the Tertiary. Generally speaking the uplifts have caused greater displacements of the rock strata than the faults, especially in the southern portion of the Colorado Plateau area. The exact time of the uplift which resulted in the canyon cycle of erosion to form the Grand Canyon, Walnut Canyon, and many other canyons in this region is still the subject of considerable difference of opinion.

As regards to Walnut Canyon in particular, during one of the later periods of uplift, the rock strata were broken forming what has been termed the Anderson Mesa fault. This fracture in the earth's surface represents a displacement of around 300 feet, strikes N 65° W, with the uplifted block on the northeast side. The fault no doubt partially dammed the stream but since the uplift was so slow the stream was able to maintain its channel and thereby with the additional gradient and power supplied the cutting tool gained sufficient force to carve Walnut Canyon. Dr. Colton has referred to these clefts as being actually sawed, with the body of the saw composed of the water, the teeth made up by the boulders, pebbles and sand grains, and the energy being supplied by gravity. Much the same factors were necessary in the cutting of the Grand Canyon of the Colorado River. Minor North-south faulting along Walnut creek has probably been responsible for some of the zig-zag courses which the stream followed. The stream followed these breaks or cross-faults as a line of least resistance in the softer broken rocks before returning to its normal course. As cut-offs

were formed and the old meanders abandoned the central "islands" were carved out.

SUMMARY

It is thought that the following points may prove of interest to the visitors without boring them with too much geological detail:

I. Walnut Canyon may be termed a Grand Canyon in miniature in which a broad regional uplift supplied the stream with the necessary power to carve the gorge.

II. The stream working through zones of weakness along minor north-south faults which cross the canyon, developed many meanders or goose necks, and when later these were carved through, cut-offs forming "islands" remained which the pueblos have utilized as fortresses.

III. Ledges in the Kaibab limestone were formed by the differential weathering of the hard and soft members. The massive resistant limestone beds for the ledge which served as the roof and floor and the weaker sandy limestones eroded more rapidly to form the recesses in which the cliff dwellings were constructed.

IV. The contact between the Kaibab and the Coconino seems a worth while feature to point out as well as the nature of the Coconino sandstone with typical characteristics of a wind blown dune deposit.

V. The marine fossils in the Kaibab limestone should prove of interest as they clearly demonstrate the uplift that has taken place in the general area. These beds are now some 7,000 feet above sea level.

INFORMATIONAL SIGNS

The following informational signs are recommended:

I: WALNUT CANYON
The Canyon was formed as the result of a gradual uplift of the region with the stream being able to maintain its course. The additional power supplied the stream enabled it to saw out the gorge that we now see.

II: KAIBAB LIMESTONE
A shallow water limestone deposited in the sea and containing many remains of marine fossils.

III: COCONINO SANDSTONE
A wind blown dune deposit containing footprints and trails of land animals.

IV: LEDGES AND GROOVES
The ledges make up the more massive and resistant members of the Kaibab limestone. The grooves or recesses consist of the weaker beds which contain more sand in the limestone and are more easily eroded. This is the result of normal differential weathering.

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