30 September 1955, Volume 122, Number 3170 SCIENCE

Recent Geology of Cane Wash, Monument Valley, Arizona

Charles B. Hunt

Among the major problems in the Colorado River drainage basin are soil erosion, arroyo cutting, and sediment load of the streams. In order to appraise in quantitative terms the effects of these several processes as they are operating today and have operated since about 1880, when most of the present arroyo cutting began (*1*), it is necessary to reconstruct the late Pleistocene and Recent history of the region. If this history were understood, it would be possible to evaluate the changes that have occurred in climate, vegetative cover, water supply, prehistoric land use, and other environmental conditions and appraise these changes as factors that must be considered in attempts to meet the present-day problems.

Natural history, like political and economic history, repeats itself. The arroyo cutting, dune migration, gully development on hillsides, other soil erosion, and the sediment-loaded streams that characterize the Colorado Plateau have occurred repeatedly during the Recent epoch. In order to estimate intelligently the damage done by erosion that has occurred since 1880 and the damage being done today, it is necessary to separate the effects of each of the different periods of erosion. An easily made mistake would be to attribute all the arroyo cutting to erosion since 1880; actually, many of the arroyos were well formed prior to 1880 and have merely been overdeepened or widened by the present-day cutting (Fig. 1). Another easily made mistake would be to overestimate the degree of present-day wind erosion; most of the loose sand that forms the present-day active dunes is being reworked from ancient dunes that originally formed during the very dry period or periods at the beginning of the Recent.

We cannot hope to map and study the late Pleistocene and Recent deposits of an entire river basin in time to solve the problems we face today, but a number of representative areas could be studied in order to measure the volumes of materials involved during each of the alternating periods of erosion and deposition. If we knew how much material was involved in the present and past periods of erosion, we could reasonably hope for better understanding of the processes involved.

Cane Wash, in Monument Valley in northeastern Arizona (Fig. 2), is one of the localities that promises to yield much useful information when the opportunity arises to study the valley in detail. This report, based on about a week of reconnaissance observations during May 1951, attempts only to present the possible bearing of Recent history on these problems of erosion and sedimentation.

Summary of Recent History

Pleistocene time in the Navajo country closed with deposition of an extensive alluvial deposit bearing mammoth remains and known as the Jeddito formation (*2*, p. 60). The climate evidently was cool and moist compared with that of the present.

The early part of the Recent was a time of great aridity, commonly referred to as the thermal maximum, the climatic optimum, or altithermal. During this time there was extensive erosion on the Colorado Plateau; the arroyos that were formed in general were deeper and wider than those formed in subsequent periods of aridity. Thick and extensive sand dunes also were formed at this time.

Moister conditions seem to have prevailed during the first and second millenia B.C. and during the earliest centuries of the Christian era. At this time alluvium, the Tsegi formation of Hack (*2*, p. 62), was deposited in the Navajo country. While the valleys were being aggraded, they were occupied by a prepottery people whose stone tools and hearths are common in the alluvium (*3*, p. 21).

During the Christian era especially severe drouths, lasting two or three decades, occurred near A.D. 715, 1100, 1290 and 1585 (*4*, p. 214). The latter part of the 19th century seems to have been another such period of drouth.

At the end of the 13th century, during the dry period known as the Great Drouth, the Anasazi people, who had built homes and had irrigated farms on the Tsegi alluvium, moved away from the Navajo country. Sometime between A.D. 1300 and 1700 another alluvial deposit formed in the Navajo country; Hack (*2*, pp. 62, 67) has referred to it as the Naha formation. The present arroyo cutting began in the last two decades of the 19th century (*1*).

Setting of Cane Wash

Cane Wash (Fig. 2) drains northeastward in a treeless valley cut in Triassic formations lying along the north base of Comb Ridge, which is a hogback formed by the Glen Canyon group of sandstones (Triassic and Jurassic) (*5*). In the vicinity of Chaistla Butte, and for about 3½ miles to the east, Cane Wash is in an arroyo 12 to 15 feet deep cut in an alluvial deposit that apparently is prepottery and no younger than the Tsegi formation. About 3½ miles east of Chaistla Butte the wash emerges from its arroyo and from there east is on top of the alluvium and is aggrading the valley floor. About 9 miles east of the butte the drainage enters an old, dried lake bed, which evidently formed as a result of the valley being dammed by some ancient dunes that lie north and east of the lake.

There is no perennial surface water along the present Cane Wash. There are, however, extensive ruins of prehistoric Anasazi villages along the Wash, and

Mr. Hunt is on the staff of the U.S. Geological Survey, Federal Center, Denver, Colo.

evidently there was surface water available at the time of occupation (roughly A.D. 500–1200).

Stratigraphy of the Recent Deposits

The oldest deposits recognized antedate the Anasazi occupation and are of three kinds: alluvial fans, sand dunes, and alluvium. Also recognized are postoccupation eolian sand, alluvium, and lake beds.

The alluvial fan deposits (fg) shown in Fig. 2 are along the north base of Comb Ridge and slope to the alluvial valley bottom. It may be that the fan deposits are very thin and mantle pediments. Presumably they intertongue with the alluvium (al_1) to the north, but this possible relationship was not established. In any case, this ground is stony and slopes toward Cane Wash. The surfaces of the fans seem to be fairly stable; no conspicuous signs of degradation or aggradation were observed.

Preoccupation sand dunes (s_1) are widespread along the north side of Cane Wash. The dunes are clustered barchans 10 to 15 feet high. Today they are being reworked actively by wind action. The unconformity between this reworked sand and the older sand from which it was derived is the Anasazi occupation layer. Abundant remains of vegetation along this layer include juniper and shrubs that today grow only on the valley walls a few hundred feet higher than these dunes. The older sand is pre-Anasazi in age and probably dates from the thermal maximum at the beginning of the Recent.

Preoccupation alluvium, probably Tsegi (al_1), is at least 15 feet thick along Cane Wash for about 3½ miles east of Chaistla Butte. This alluvium presumably extends beneath the younger alluvium (al_2) to the east and beneath the younger sand (s_2) to the north. It may intertongue with, or overlap onto, the fan deposits along the south side of the wash. The stratigraphic relationship between this alluvium and the preoccupation sand dunes has not been determined, but the ages inferred for the two deposits imply that the alluvium overlaps the older sand (s_1).

Cane Wash is incised as deeply as 15 feet into the alluvium. Tributary to the main arroyo are deep gullies. Between these gullies and northward for several hundred feet from the main arroyo, the alluvial surface has been lowered by deflation as much as 2 feet since the Anasazi occupation. The deposit, therefore, is being eroded actively by Cane Wash and its tributaries, and the surface of the deposit is being eroded by wind action.

The postoccupation eolian sand (s_2) is extensive but rarely deep. It occurs as a thin hummocky sheet on the preoccupation alluvium north of sites *A*, and this deposit apparently was derived largely from deflation of the alluvial surface along the wash. It is present also in the area of older sand dunes north of the segment of valley that is being aggraded (between the two groups of sites *B*). In these areas active dunes are 10 to 15 feet high.

Postoccupation alluvium (al_2) forms an inner fill terrace 5 or 6 feet high within the arroyo of Cane Wash. This deposit is too small to show on the map. East of the arroyo of Cane Wash, however, this postoccupation alluvium covers the flood plain and the eastern part of the preoccupation alluvium.

The lake beds at the eastern edge of the area no doubt include deposits as old as the preoccupation dunes that dammed the wash, but the surface layers are postoccupation in age.

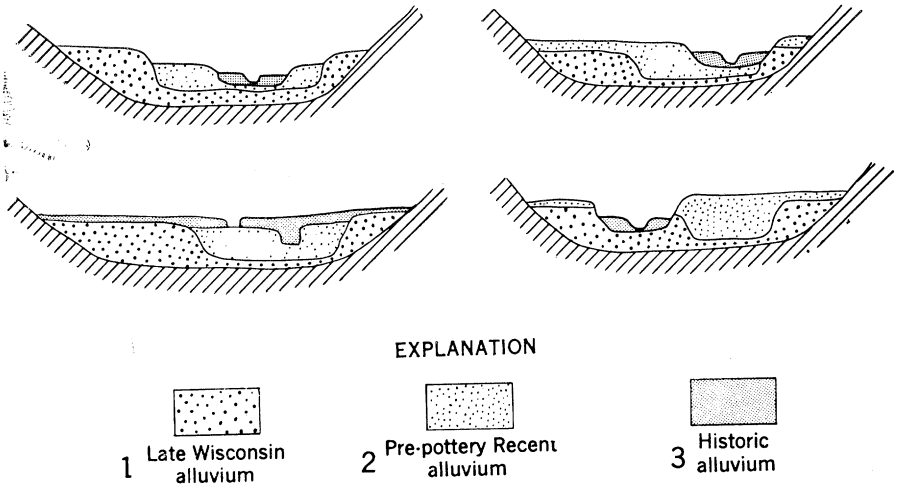

Fig. 1. Diagrammatic sections illustrating some common stratigraphic relationships in the alluvial deposits on the Colorado Plateau. A cross section of Cane Wash at sites *A* (Fig. 2) might look like the top right section. At the most westerly of sites *B* the cross section would resemble the bottom left section. In general in the Southwest the width and depth of the modern arroyos are less than the width and depth of the arroyos that were eroded after deposition of alluvium No. 2. And those arroyos generally are not as wide or deep as the arroyos cut in the late Wisconsin alluvium.

Probable Environment of the Ruins at the Time of Occupation

The Anasazi occupation is represented by the ruins of numerous one-room dwellings, foundations of ovens or cists, and a scattering of potsherds and stonework. The ruins can be described in three groups, designated in Fig. 2 as sites *A*, *B*, and *C*. A surface sample of sherds and stonework from each of the groups was collected, and tentative identifications were made by Arnold Withers, of the University of Denver, and by Frank H. H. Roberts, of the Bureau of American Ethnology. The collection, which has been deposited in the Bureau of American Ethnology, includes types of materials characteristic of the Basketmaker III through Pueblo III cultures, and the occupation, therefore, may be dated roughly as A.D. 500 to 1200 or 1300. The collection also suggests that the eastern sites contain a higher proportion of materials from the earlier cultures than do the western sites. To confirm this impression would require studies by archeologists, but it might be an important fact bearing on attempts to evaluate erosion and sedimentation if the center of population actually did shift upstream during the period of occupation.

All the ruins obviously represent open valley sites. The sites designated *C* are on old dunes surrounding the lake bed at the eastern edge of the area. Only two sites were observed here, but presumably others are concealed by the young sand that has been derived by reworking the old dunes. According to a letter from Roberts ". . . the material from sites *C* appears to be pretty much straight Pueblo I. There are one or two sherds that might be considered Basketmaker III, but the bottoms of the culinary vessels from Pueblo I frequently are hard to distinguish from some of the Basketmaker III fragments. Certainly the over-all impression given by the lot of sherds is a straight Pueblo I horizon."

Abundant tree stumps and logs were observed among the dunes in the vicinity of sites *C*, at the unconformity represented by the occupation zone. Apparently this part of the valley was woodland at the time of occupation. Some of the buried trees are cottonwood, others are juniper and piñon. It seems likely that the now dry lake bed contained water at least part of the time during the period of occupation.

Upstream from the lake beds (Fig. 2) Cane Wash for about 3½ miles east of Along this stretch of valley the ruins

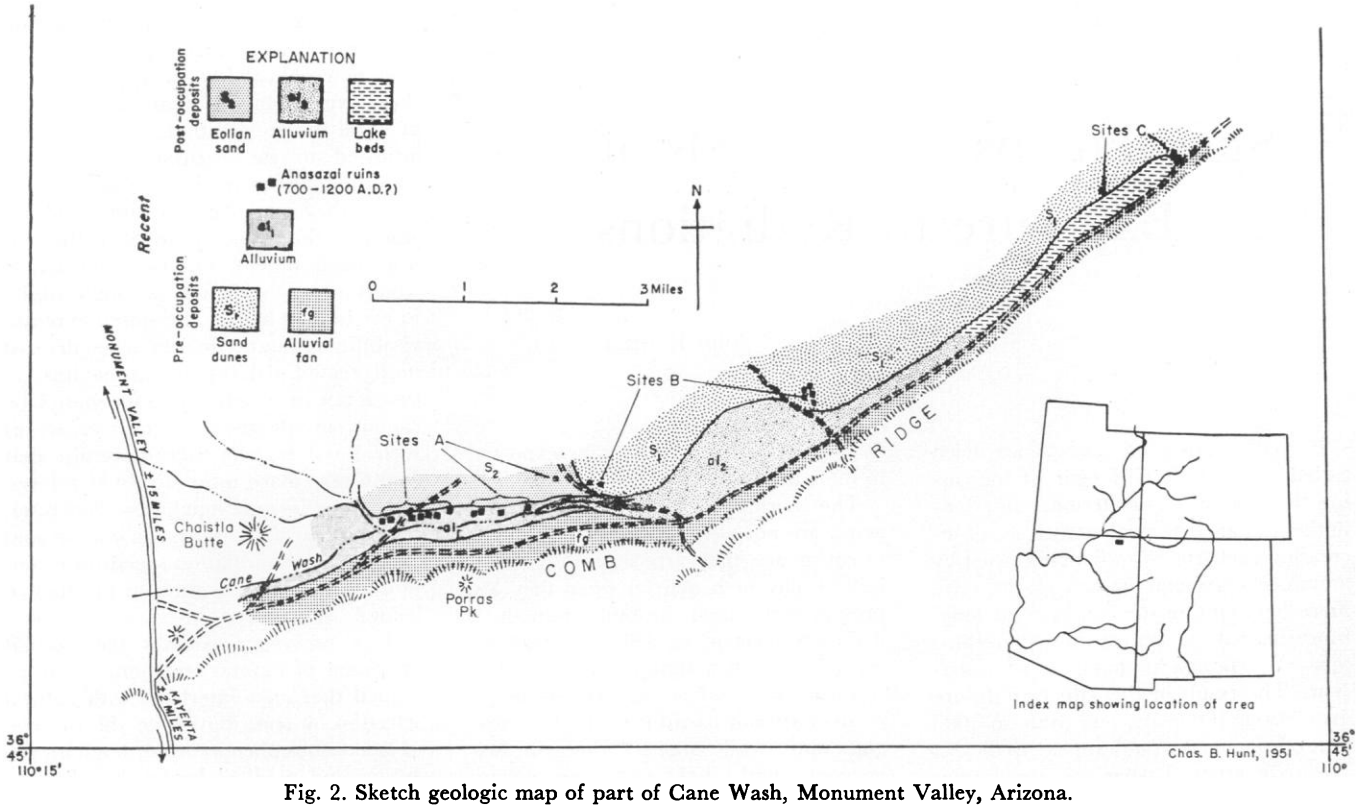

Fig. 2. Sketch geologic map of part of Cane Wash, Monument Valley, Arizona.

(sites *B*) are on the ancient dunes, which are higher than the valley floor. The ruins at *B* appear to be younger than those at *C*. The pottery collection from *B* was reported on by Roberts (in a personal letter) as follows.

"The material from sites *B* suggests about equal representation for Basketmaker III and Pueblo I, and in addition there are a few sherds that probably are Pueblo III, or possibly Pueblo II. I am wondering whether the proportions of Basketmaker III and Pueblo I would be approximately the same from both of the sites *B* or whether perhaps separate collections from the two might not show that a different relationship existed. By mixing the material from the two, the picture may be somewhat clouded. Because the material from sites *C* seems to be straight Pueblo I, I would be inclined to suspect that possibly the eastern *B* might be predominantly Pueblo I."

The valley in the vicinity of sites *B* no doubt was subject to flooding at the time of occupation, much as it is today. While this stretch of valley is being aggraded, winds transport sand from it to the north. The occurrence of preoccupation sand dunes immediately north of this stretch of the valley suggests that the regimen of this stretch is rather like it was prior to deposition of the preoccupation alluvium.

The sites at *A* are on the alluvium north of Cane Wash, and very likely others are buried beneath the younger sands (s_2) to the north. The collection from these sites indicates they are younger than those at *B*. Roberts reported on the collection as follows.

"The specimens from sites *A* indicate a predominant Pueblo III horizon. A few sherds are of older types, but the proportion is very small. I am not certain how the dendrochronological dates run in that area, but I would be inclined to guess that sites *A* probably fall in the A.D. 1100–1200 period. I would be surprised if they are as late as 1300."

No sites were observed on the fans or alluvium south of the wash. The occurrence of dwellings on the alluvial plain and their alinement along the north side of the present wash strongly suggest that the stream was at the same location then as now, that its bed was below the level of the alluvial surface, and that it discharged sufficient water to supply a considerable population. Moreover, in places the surface of the alluvium is marked by linear or curvilinear furrows that may be remnants of ancient irrigation works.

In any case, the evidence at hand suggests that the earliest Anasazi occupation was at the east end of the area shown on Fig. 2, and that the center of population shifted upstream during the period A.D. 500–1200. Such a shift in population could be interpreted, in part at least, as response to diminishing discharge in Cane Wash.

Conclusions

In numerous areas like Cane Wash there is need for detailed geologic mapping of the late Pleistocene and Recent deposits to determine the geologic stratigraphy and the successive changes in the physical geography and regimen of the valley and to measure the volumes of materials involved in the different kinds and different stages of erosion and sedimentation. Also there is need for studies by archeologists to provide the basis for determining the dates of occupation, estimating the population, and determining whether there were significant shifts in centers of population during the occupation periods. Further, these studies should be supplemented by studies of the botanical and ecological changes that have occurred. If such basic information from the historical and prehistorical record were available, we would be ever so much better prepared to deal with today's land-use problems in which erosion, sedimentation, and water supply are important factors.

References

1. K. Bryan, *Science* 62, 338 (1925).
2. J. T. Hack, *Papers of Peabody Mus., Arch. and Ethn., Harvard Univ.* 35, No. 1 (1942).
3. A. P. Hunt, *Univ. of Utah Anthrop. Papers*, No. 14 (1953).
4. E. Schulman, *Bull. Am. Meteorological Soc.* 19, 211 (1938).
5. I. Witkind, in preparation.