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American Antiquity, Vol. 3, No. 3 (Jan., 1938), 224-227.

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Tue Nov 25 19:40:08 2003

THE COMPARISON OF FIBER PROPERTIES OF
ARIZONA CLIFF-DWELLER AND
HOPI COTTON

EMIL W. HAURY¹⁸⁴ AND CARL M. CONRAD¹⁸⁵

THE COTTON sample used in the following fiber study was found in the summer of 1932, in the Canyon Creek ruin, Fort Apache Indian Reservation, in east-central Arizona. During the excavations¹⁸⁶ remnants of cotton fabrics were frequently found in the rubbish, indicating that the occupants of the pueblo evidently made considerable use of the fiber. A small quantity of raw cotton, in the process of being spun into yarn, was found with an adult female buried below the floor of a room. From this it may rightfully be inferred that spinning and weaving were locally practiced; but the absence of cotton seeds and plant parts in the refuse of the dwelling, and the nature of the immediate environment made it appear that at least the fiber, and probably some fabrics ready woven, were imported from neighboring and more favorable areas.

The raw cotton was contained in a perfectly preserved twilled basket (Plate 7, Figure 1) along with the fully equipped spinning shaft. Fortunately the unspun end of the yarn is still attached to the fiber supply, giving us a clear-cut picture of the process. Spun yarn was wound on the spinning shaft below the wooden whorl.¹⁸⁷ Spinning kits duplicating this may still be seen in those modern pueblos where the art of weaving has not died out.

Other objects placed with the woman at the time of burial were a skein of fiber yarn of *Apocynum* (dog bane), and vessels of pottery and gourds. On the body were found a cord skirt and sandals, and before burial it was wrapped in a plain cotton blanket. The grave was covered with a large twilled mat weighted down by rocks.

The cotton fibers examined herein were taken from the basket illustrated. The age of the sample is of importance both to botanists and archaeologists. The roof of the room in which the burial was found was

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¹⁸⁶ By Gila Pueblo, Globe, Arizona.

¹⁸⁷ This spinning assemblage was previously illustrated in a report on the work in the ruin: Haury, E. W., 1934, *The Canyon Creek Ruin and the Cliff Dwellings of the Sierra Ancha*, Medallion Papers XIV, Gila Pueblo, Globe, Arizona; and the results of a preliminary examination of the cotton by Dr. R. S. Hawkins, University of Arizona, Tucson, Arizona, were presented therein.

nearly intact, and thus there were available several beams for tree-ring dating. The date for one of these was determined as 1340. The range of construction dates from the various rooms of the ruin was from 1326 to 1348, demonstrating a rather short construction period for the sixty-room pueblo. It may be supposed, in the light of the above dates, that the burial was made some time after 1340, but probably not much after 1348 when building activity had ceased and the pueblo was probably abandoned. Basing our judgment on these dates and on the character of the objects with which the cotton was associated, it may be placed unequivocally in the 14th century, and must therefore be regarded as the product of native Americans.

The Canyon Creek ruin is one of many to be found in cliff recesses in the Mogollon Rim area, built by a southern branch of the Pueblo culture during the 13th and 14th centuries.

Since a knowledge of the origin of this cotton is of special interest not only from the standpoint of archaeology, but also from the botanical standpoint, a comparison between its properties and those of the so-called Hopi cotton, grown by the Hopi Indians in the same region at the present time, seemed especially desirable. A portion of the lint was sent¹⁸⁸ to the Cotton Fiber Laboratory of the Bureau of Agricultural Economics where fiber measurements had already been made on several Hopi samples. The results of the fiber measurements are shown in the accompanying table (p. 226), and were all carried out in the same manner, except as indicated at the bottom of the table.

As can be seen from the table, considerable variation occurred in the same properties for the several Hopi samples. Since only three of these have been tested and results from only the one Cliff-Dweller sample are available, the degree of natural or seasonal variation of the fiber properties is not known. The fibers of the Cliff-Dweller cotton are appreciably longer than the average of those from the three Hopi samples. The upper quartile length of the former is 0.14 inch (over $\frac{1}{8}$ inch) and the mean length 0.15 inch (nearly $\frac{5}{32}$ inch) longer than the corresponding measures of the latter. It is well known that fiber length is influenced by the moisture content of the soil during the period of boll development,¹⁸⁹

¹⁸⁸ Through cooperation of T. H. Kearney, principal physiologist, in charge, Egyptian Cotton Breeding Investigation, Bureau of Plant Industry, U. S. D. A.

¹⁸⁹ A Study of Some Factors Affecting Lint Development of Cotton, D. G. Sturkie, 42nd Ann. Report, Ala. Agr. Expt. Sta., 1931, p. 18; Some Observations on the Relation of Lint Length to Rainfall, R. E. Kelsick, West Ind. Bull., 17:79-82, 1920; The Effects of Fertilizers and Rainfall on the Length of Cotton Fiber, E. B. Reynolds and D. T. Killough, J. Amer. Soc. Agr., 25:756-764, 1933.

but the differences have generally been less than those here observed.

The other properties of the Cliff-Dweller sample deviate in their values relatively slightly and insignificantly from the corresponding averages of the Hopi samples, with the exception of percentage of immature fibers and bundle strength. The percentage of immature fibers

FIBER PROPERTIES OF THREE SAMPLES OF HOPI COTTON AND OF THE CLIFF-DWELLER SAMPLE

	Hopi samples				Cliff-Dweller sample	Deviations of Cliff-Dweller samples
	a 1934	b 1934	c 1935	Average		
Upper quartile length ¹⁰⁰ , ins.	0.90	0.94	0.94	0.93	1.07	- 0.14
Mean length, ins.	0.78	0.82	0.82	0.79	0.94	- 0.15
Coef. of length variation, pct.	24.8	20.0	22.3	22.4	21.3	- 1.1
Fiber fineness, 10 ⁻⁴ mgs. per in.	43.5	40.7	38.7	41.0	42.5	- 1.5
Fiber per cross section 22s yarn	156.8	167.6	176.2	166.9	160.4	- 6.5
Var. of fiber fineness with length, pct.	7.0	8.5	15.0	10.2	11.7	- 1.5
Immature fibers, pct.	22.5 ¹⁹¹	23.8 ¹⁹¹	26.3	24.2	44.9	-20.7
Var. immature fibers with length, pct.	25.7	29.3	27.0	27.3	18.2	- 9.1
Bundle strength, 10 ³ lbs. per sq. in.	192	94.0 ¹⁹³	91.0	92.5	72.6	-19.9

in the Cliff-Dweller sample is much above the average for the Hopi samples, but this is a property known to be materially affected by growth conditions, especially conditions of drought¹⁹⁴ during boll development. While the strength of the fiber is some 21 percent below the average for two of the Hopi samples, it is by no means certain that it might not have been equal in its original condition. It is still above what might be expected in American upland cotton of the same fiber fineness

¹⁰⁰ Length at the 25 percent point on the length-cumulative weight percent curve, reading from the longest fibers.

¹⁹¹ Data converted to common basis of technic by factor 1.8.

¹⁹² No breaks could be obtained due to shortness and strength of fibers.

¹⁹³ Only one break could be obtained due to shortness and strength of fibers.

¹⁹⁴ Methods of Estimating Cotton Fiber Maturity, R. S. Hawkins, J. Agr. Research, 43(8):733-742, 1931; Tests on Samples of Cottons Grown with Different Applications of Water, Nazir Ahmad, Ann. Report Indian Central Cotton Comm., 1932, p. 53.

and length.¹⁹⁵ In fact, it is most surprising that a sample nearly 600 years old has not lost nearly all of its strength, and exceptionally good conditions for preservation must be assumed to explain the remarkable degree of retention of this property.

Still another fact not immediately evident from the fiber data is that both the Cliff-Dweller and the Hopi fibers are much finer than has usually been observed in American upland cotton of the same fiber length. Based on a rather close relationship between fineness and upper quartile length in several hundred American upland samples, the Hopi fibers are on the average about 30 percent lighter per unit of length, while the Cliff-Dweller fibers are about 19 percent lighter per unit of length than the average for the American upland cottons. The high percentage of immature fibers in the Cliff-Dweller sample may be partly responsible for the relatively low weight per unit of length, but the difference, even after making allowance for this, is still considerable.

These data indicate that the Cliff-Dweller sample probably represents a variety of cotton closely related to the modern Hopi. The high percentages of immature fibers would indicate that the plants from which the Cliff-Dweller sample was obtained had developed under adverse weather conditions. Although considerable present evidence points to drought as a causal factor in the production of a high percentage of undeveloped or "immature" fibers, it is not impossible that an unusually wet season might also result in poor growing conditions and a high proportion of such fibers. The latter kind of season would best explain the appreciably greater fiber length in the Cliff-Dweller cotton as compared with the Hopi samples.

¹⁹⁵ Based on a theoretical equation relating the strength of over 125 American upland cottons to their fiber fineness and length.