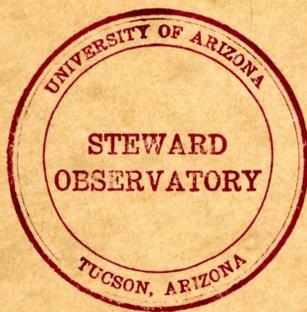


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Photograph by O. C. Havens

CEILING POLES IN ONE OF THE ROOMS OF PUEBLO DEL ARROYO, CHACO CANYON

By the recovery and study of such timbers, the seemingly unsolvable riddle of the Southwest has been solved—How old are the pre-Columbian pueblo ruins? The original inhabitants had no written language; they left no calendars; yet science has found a way to read their secrets, not in stones, but in wood and charcoal.

THE SECRET OF THE SOUTHWEST SOLVED BY TALKATIVE TREE RINGS

Horizons of American History Are Carried Back to
A. D. 700 and a Calendar for 1,200 Years
Established by National Geographic
Society Expeditions

TWO series of National Geographic Society expeditions, one which explored the now famous Pueblo Bonito ruins in Chaco Canyon, New Mexico, and the other which sought to ascertain the actual age of those ruins, have culminated in findings of prime importance to the history of pre-Columbian America.

They have pushed back the historic horizons of the southwestern United States to a period nearly eight centuries before Columbus crossed the Atlantic.

They have discovered not only the age of the great communal dwelling of Pueblo Bonito, metropolis of our aboriginal Southwest, but also have dated some 40 other ruins whose time of occupancy hitherto had been unknown.

Moreover, they have developed a tree-ring calendar which can be applied to all early ruins in which datable timbers exist.

A collateral finding of great interest, yet to be developed, is the possible relation between the weather cycles clearly revealed in this tree-ring calendar of the southwestern United States and similar cyclic variations being recorded by a third National Geographic Society Expedition

(in conjunction with the Smithsonian Institution), an expedition which still is in the field, at Mount Brukkaros, South West Africa, making daily observations of solar radiation.

Members of The Society have received reports in the NATIONAL GEOGRAPHIC MAGAZINE from time to time of the marvelous finds of the Pueblo Bonito Expeditions. One major question remained to be answered: "How old is Pueblo Bonito?"

Primarily to solve that problem, The Society invited Dr. A. E. Douglass to undertake the investigations which gave the answer, and far more—a chronology that includes many major ruins of the Southwest and thus dates the hitherto untimed annals of pre-Columbian history.

In the following summary of his work, Dr. Douglass relates the fascinating story of how he, an astronomer, was led from the study of sun spots to cutting tree and timber sections, which, when codified and joined together, yielded this priceless secret of North America's remote past.

The members of the National Geographic Society can obtain much satisfaction in having supported such important and successful explorations.

THE EDITOR.

BY ANDREW ELLICOTT DOUGLASS, SC. D.

Leader of the National Geographic Society Tree-Ring Expeditions and Director of Steward Observatory, University of Arizona

BY TRANSLATING the story told by tree rings, we have pushed back the horizons of history in the United States for nearly eight centuries before Columbus reached the shores of the New World, and we have established in our Southwest a chronology for that period more accurate than if human hands had written down the major events as they occurred.

We are now able definitely to announce the important dates in the history of Pueblo Bonito, oldest and largest of the great Indian communities, in Chaco Canyon, New Mexico, the exploration of which has been carried to completion by eight National Geographic Society expeditions.

Furthermore, we can now date nearly



Photograph by Neil M. Judd

EARLY SPANIARDS CARVED THIS OLD BEAM FOUND AT ORAIBI, ARIZONA

From such supporting timbers The Society's expedition could not cut full cross-sections. In these cases cores were drilled which showed the tree-ring sequences. The Indians consented when given small fees and bits of turquoise were deposited in the holes to "ward off the spirit of decay" (see text, page 753, and illustrations, pages 760 and 762).

forty prehistoric ruins in the Southwest and reconstruct there a succession of major events through which Indian settlements rose, passed their heyday, and disappeared.

Just as the far-famed Rosetta Stone provided the key to the written mysteries of ancient Egypt, so the collection of an unbroken series of tree rings has made clear the chronology of the Southwest.

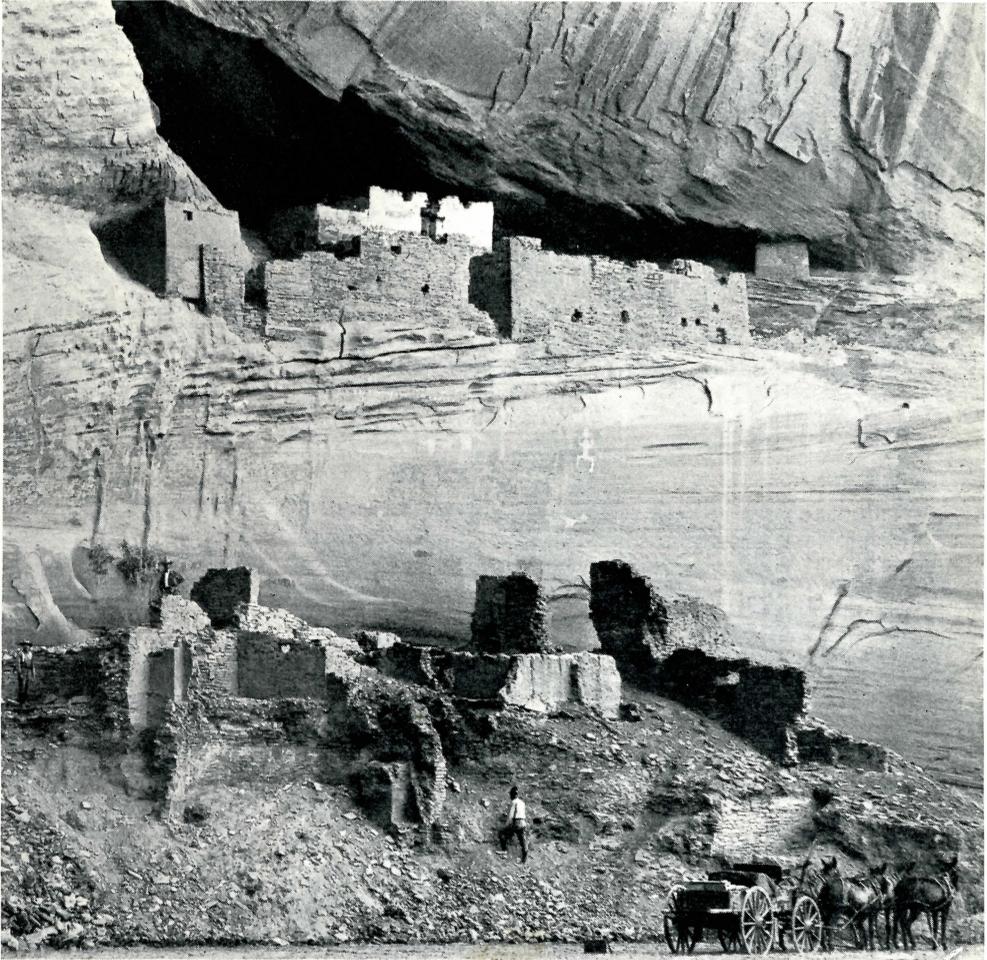
Through this work we have learned of some outstanding events in America which were contemporaneous with the conquest of Spain by the Moors, and we know that certain Pueblo Indian settlements were en-

joying their golden ages when William the Conqueror faced Harold the Saxon at the Battle of Hastings.

These researches have carried the calendar back to A. D. 700 in the Southwest, and they have provided the beginnings of a continuous weather chart for 1,200 years.

PRICELESS TREE TRUNKS HAVE BEEN BURNED

Many a prehistoric jewel has been given to the flames unwittingly because no one knew the importance of tree rings in recording the passage of years. Where fuel was scarce, fragments of precious timbers



Photograph by Charles Martin

WHITE HOUSE RUIN CLINGS TO THE CLIFFS OF CANYON DE CHELLY IN
ARIZONA

Ancient house timbers found and studied here prove that this picturesque communal dwelling was built and occupied as early as 1060—a quarter of a century before the Domesday Book of medieval English history fame was compiled.

at many an ancient ruin in the American Southwest have been used as firewood by sheep-herder, prospector, and even archeologist. They were scraps of wood, nothing more. The Bible story of the stone which the builders rejected, but which became the head stone of the corner, has found a counterpart in the wood that the modern searcher overlooked, for it has become a key to prehistoric chronology.

Through long-past ages and with unbroken regularity, trees have jotted down a record at the close of each fading year—a memorandum as to how they passed the time; whether enriched by added rainfall

or injured by lightning and fire. By learning how to read these records—specifically those of the pines—we have discovered a magic key to open mysterious books and interpret the meaning of their writings.

In favorable regions, rings in trees may be identified, each one in its appropriate year, and traced back till we get to the utmost reach of living trees, and then beams from ancient ruins and buried logs carry the story back for many more centuries.

Thus these tree records have provided us with an American calendar reaching



Photograph by Neil M. Judd

A NAVAJO MAN OF JADITO VALLEY

In this arid Southwest, man and tree alike cry always for water and more water. Tree rings reveal when rain fell or failed, and the Indian's most common invocation is his prayer for rain.

beyond the rise of Charles Martel or the Mohammedan invasion of India. Some of these trees were cut a thousand years ago. From them we have learned the exact building dates of major ruins of the southwestern United States as definitely as we have been able to fix the dates of Old World monuments of the ancients whose records are inscribed on stone.

A CHAPTER IN THE BOOK OF WEATHER FORECASTING

For the last six years this detective story of science has been evolving out in Arizona. Seen from one angle, it pushes back the bounds of history in our South-

west and gives us human activities—even tragedies—among the native inhabitants for hundreds of years. From another angle this history in trees tells us the climatic story of the Southwest with amazing accuracy.

When a real theory of climate has been developed and we can predict drought and flood over a period of years, this Arizona story in tree rings will have played a creditable part in developing that climatic foresight which is perhaps the most valuable economic advantage yet lying beyond our reach.

From this combination of climatic facts and human movements we have unearthed evidence of a human cycle, the time during which village Indians of the Southwest could live in one place till they depleted its resources and were compelled to move to new localities.

Success in ascertaining the age of Pueblo Bonito and many other prehistoric ruins throughout the Southwest is to be attributed primarily to the National Geographic Society, whose Committee on Research has sent various expeditions under the direction of Mr. Neil M. Judd to collect the vast number of specimens required in these investigations.* The University of Arizona has

* See, in the NATIONAL GEOGRAPHIC MAGAZINE, "A New National Geographic Society Expedition," June, 1921; "The Pueblo Bonito Expedition of the National Geographic Society," March, 1922; "Pueblo Bonito, the Ancient," July, 1923; "Everyday Life in Pueblo Bonito," September, 1925; and "Exploring in the Canyon of Death," September, 1925.

generously permitted me to devote much of my time to this objective for several years, and the interest of the Carnegie Institution of Washington in the climatic phases of this study really paved the way along which we advanced to our present, independent goal.

READING THE DIARIES OF TREES

The method which we have used in extending the historical calendar of the Southwest is the outcome of a long attempt to read the diaries of trees. Every year the trees in our forests show the swing of Time's pendulum and put down a mark. They are chronographs, recording clocks, by which the succeeding seasons are set down through definite imprints. Every year each pine adds a layer of new wood over its entire living surface of trunk and branches.

If every year were exactly the same, growth rings would tell the age of the tree and little more. Only in rare cases would they record exceptional events of any interest to us. But a tree is not a mechanical *robot*; it is a living thing, and its food supply and adventures through life all enter into its diary. A flash of lightning, a forest fire, insect pests or a falling neighbor may make strong impressions on its life and go into its diary.

But in the arid regions of our Southwest, where trees are few and other vegetation scarce, the most important thing to man and trees is rainfall. So, in the rings of the talkative pines we find lean



Photograph by Frederick I. Monsen

SCION OF ONE OF THE FIRST FAMILIES OF NEW MEXICO

This smiling Indian girl never heard of the tragic eras of drought through which her ancestors passed more than two centuries before Columbus discovered America; but the old, lifeless beams over which she has romped plainly record the dates and duration of such dry periods.

years and fat years recorded. The same succession of drought and plenty appears throughout the forest. This fact has helped vastly in our dating work, for certain sequences of years become easily recognized from tree to tree, county to county, even from State to State.

LIVING TREE RINGS MATCHED WITH DEAD TIMBERS

No living, diary-keeping tree in the semi-arid region inhabited by the Pueblo Indians goes back more than a few hundred years; and the giant sequoias of Cali-



Photograph from Dr. A. E. Douglass

NAMPEYO REVIVES A LOST ART

Hopi pottery flourished in the early Spanish era in the Southwest; then became decadent (see text, page 759). Thirty years ago this Hopi woman artist undertook to revive it and with notable success. Hopi pottery is of a rich cream color, of fine grain, hard texture, and rich ornamentation.

fornia register in a different way those seasonal fluctuations that control the pines of northern Arizona. So when we reached the earliest date which the oldest living weather-recording Arizona tree could tell us about, it became necessary to search for beams that had been cut and used by man before the now living trees took up the story. Here and there we found beams the latter years of which were contemporaneous with the early life of trees still living.

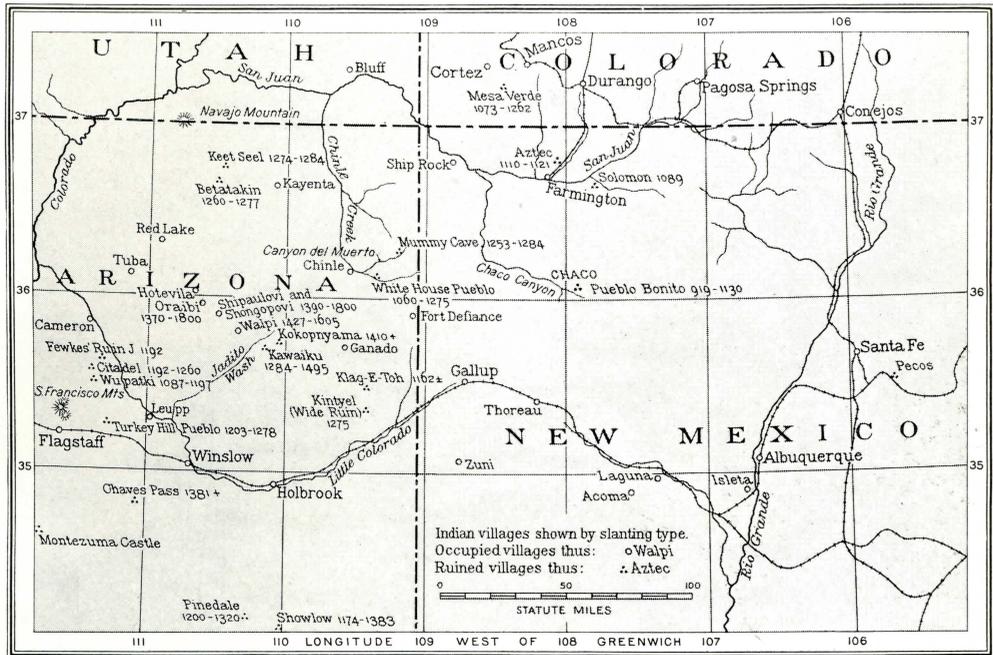
WHY STUDY TREE RINGS?

By arranging these beams in their proper sequence, so that the inner diary entries of each one dovetailed into and matched the outer entries of its predecessor (see illus-

trations, pages 760 and 769), we knew that we had an unbroken succession of beams and trees.

In this way, step by step, we pushed historical dates back further and further until we found a beam whose earliest ring was formed A. D. 1260 (see illustration, page 760), less than half a century after the Children's Crusade.

The development of this tree-ring study presents an example of how a scientific research starting with a definite idea may lead into unforeseen channels. Originally my work was a study of sun spots. It is known that there is a periodicity in their occurrence; they are most numerous at intervals of eleven years. As an aid in that astronomical investigation, I studied



Drawn by A. H. Bumstead

TREE RINGS HAVE GIVEN DEFINITE DATES TO THESE INDIAN RUINS

In many instances one group name is applied to several ruins. For example, in the Chaco group, various portions of Pueblo Bonito were under construction at different times—919, 1017, 1033-92, 1102, and 1130; Pueblo del Arroyo was being built in 1052-1103. In the Mesa Verde group, Cliff Palace is dated 1073; Oak Tree House, 1112; Spring House, 1115; Balcony House, 1190-1206; Square Tower House, 1204, and Spruce Tree House, 1216 and 1262. Mr. Earl H. Morris, in collaboration with the author, supplied beams from which the dates 1110-21 for Aztec Ruin and 1133-1135 for cliff dwellings in Grand Gulch, Utah, were ascertained. In the Chinle district Mr. Morris aided in fixing the years 936-57 for Sliding Ruin, 1253-84 for Mummy Cave, and 1060-96, 1219, and 1275 for White House Pueblo.

trees, for solar changes affect our weather, and weather in turn affects the trees in Arizona's dry climate, as elsewhere.

Our study of sun spots and their influence upon weather and the consequent effect upon vegetation as recorded by tree rings progressed most successfully. The first confirmation of our general interpretation of a relationship between tree rings and sun-spot periods came in a most dramatic way.

Evidence of the eleven-year sun-spot cycle had been easily found in Arizona pine trees. The regularly recurring periods had been recorded for 500 years by tree rings, *except for the interval from 1650 to 1725*. During that 75 years the tree rings gave no evidence of periodical changes in the weather such as were to be expected.

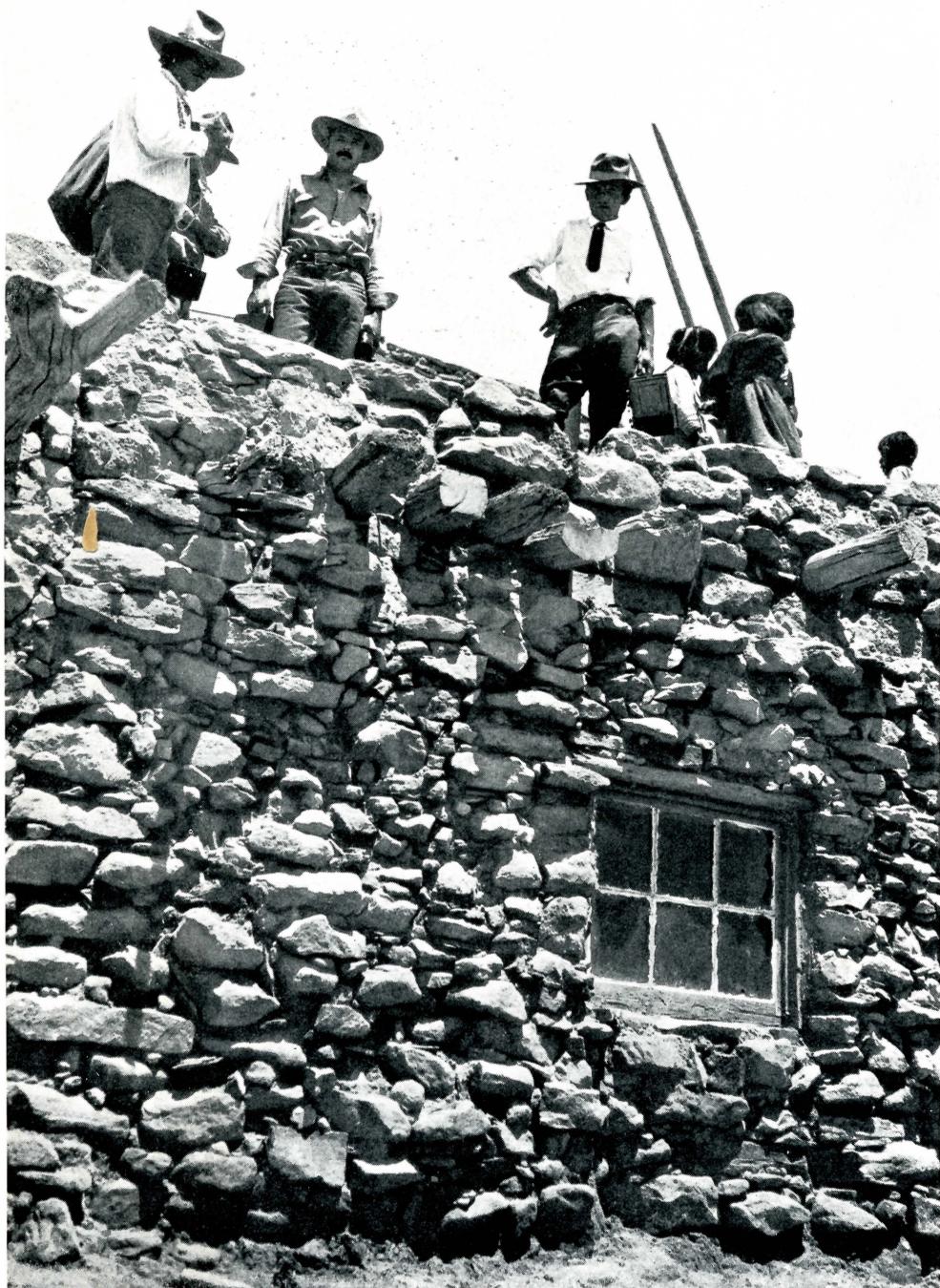
Several years after we had encountered

this puzzling fact the late Dr. E. Walter Maunder, an eminent English astronomer, unaware of my findings, wrote to me that he had discovered that *there were no sun spots between 1645 and 1715*, and that if my tree rings did not indicate some effect of this absence of sun spots, my work was being conducted on an erroneous hypothesis.

TREES ARE NATURE'S RAIN-GAUGES

The coincidence between the failure of Arizona trees to register any sun-spot effect upon the weather during those years, and establishment of the fact, by entirely independent study, that the customary sun-spot cycle did not occur during approximately the same period of years helped confirm the relationship between the growth of trees and solar changes.

The remarkable dependence of rings in



Photograph by Dr. A. E. Douglass

OLD BEAMS IN A MODERN HOPI DWELLING AT WALPI (SEE, ALSO,
PAGES 745 AND 761)

Prehistoric pines trimmed with stone axes and saw-cut cottonwood logs may roof a Hopi house to-day. Windows and first-story doors are fairly recent innovations, for fifty years ago the Hopi were still fearful of Navajo and Apache depredations. The builders of Hano, inseparable from modern Walpi, were invited from the Rio Grande Valley about 1700 to help ward off successive enemy raids.

the Arizona pines on rainfall, and especially on winter precipitation, showed that trees are Nature's rain-gauges, and in them we now have the history of drought and plenty in this plateau country for 1,200 years. We can point to certain years, such as 1632, 1379, 1067, and 840, and say definitely that they were years of excessive drought in this region.

Having established such facts, the transition to archeology is easy, for if the rings in a prehistoric roof beam can be dated by these known drought years, then surely it is easy to tell when that tree was cut by the Indians for purposes of building, for such cutting date is the year of—or that next following—the outermost ring, if the tree section be complete.

In 1922 Mr. Judd, leader of The Society's expeditions into Chaco Canyon, after learning of my use of tree rings in ascertaining the comparative ages of Aztec Ruin and Pueblo Bonito, expressed the belief that extension of the method could definitely date Pueblo Bonito, provided enough beams of different ages could be found. With his active coöperation, three expeditions were sent into the field by the National Geographic Society to obtain the necessary beams.

THE FIRST EXPEDITION INVESTIGATES HOPI VILLAGES

In the early development of the chronology of the ruins of Arizona and New Mexico, the material brought in by Mr. J. A. Jeancon and Mr. O. G. Ricketson, Jr., of The Society's first expedition in



Photograph by Dr. A. E. Douglass

THE FIRST TREE-RING EXPEDITION IN THE PLAZA AT WALPI

The oldest timbers found at Walpi were cut 65 years before Columbus discovered America.

search of beams, was invaluable. The expedition started from Flagstaff in June, 1923, and first visited the Hopi villages, where I accompanied them as supercargo for ten days. It was my first experience in picking up old, dried-up pieces of wood, which had formed portions of Indian houses, and trying to assign exact dates to them.

The experience developed only slowly toward satisfactory results, for while the age of some of the pieces was promptly recognized by comparison with Flagstaff trees, others leaped over the centuries and the time when they flourished was still a mystery.

Jeancon and Ricketson proceeded to



Photograph by Neil M. Judd

FROM THIS OLD HOUSE AT ORAIBI CAME THE BEAM WHICH CARRIED HISTORIC CHRONOLOGY BACK TO 1260

The log which proved to be such an important link in the investigations of The Society had been cut in 1370, when it was 110 years old, and had rendered more than five centuries of service. It now is safely preserved in a tree-ring laboratory in Tucson, Arizona (see, also, text, page 754, and lower illustration, page 760).



Photograph by Charles Martin

THE CLIFF PALACE, A REMARKABLE CENTER OF EARLY CIVILIZATION: MESA VERDE NATIONAL PARK, COLORADO

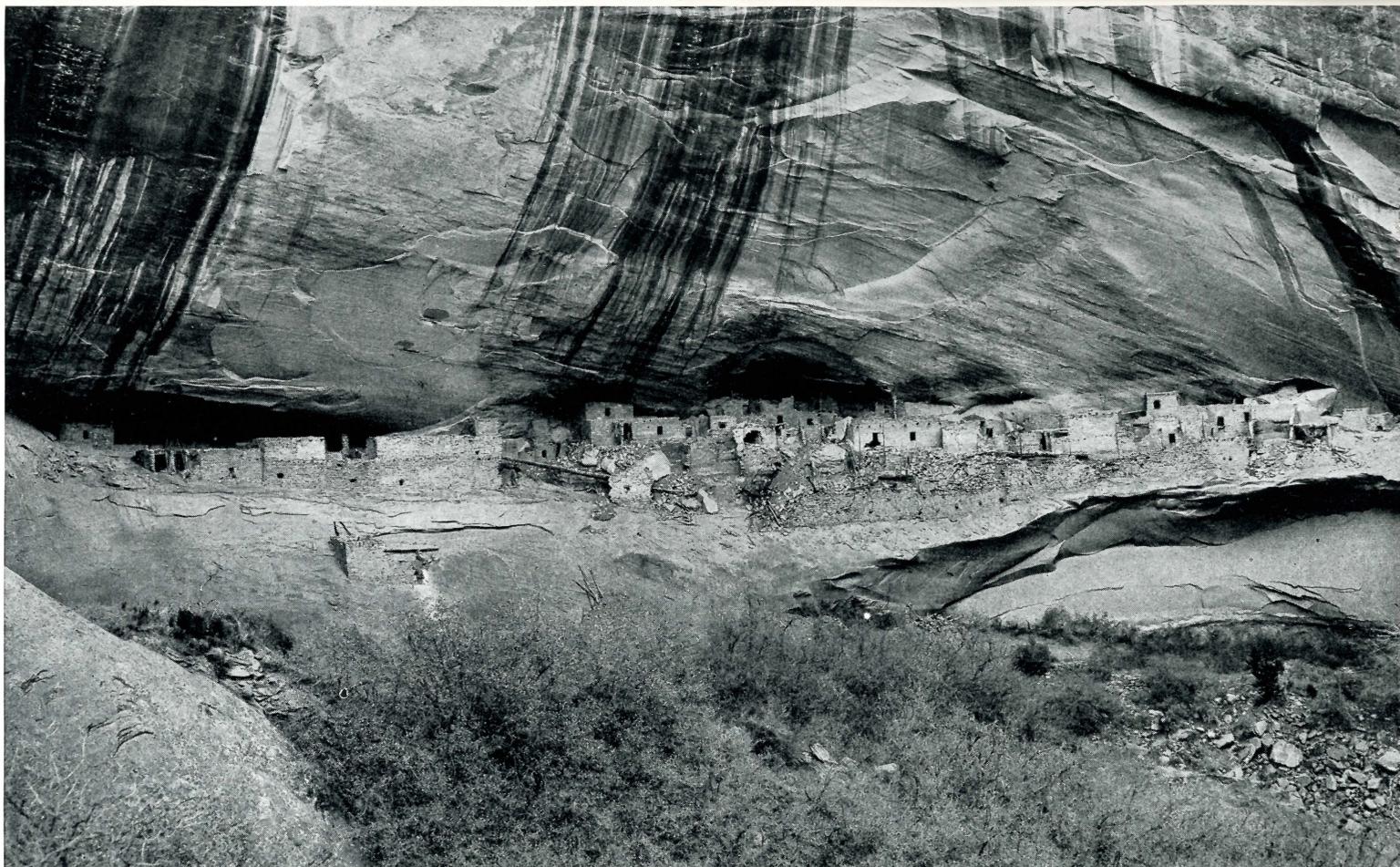
In this romantic ruin was found a log whose ring count showed that it was cut in 1073.



SHIPAULOVI, A HOPI TOWN, SEEN FROM AN AIRPLANE

© Scenic Airways, Inc.

Through such villages three expeditions of the National Geographic Society searched for timbers which might establish the chronology of our prehistoric Southwest. Gifts of velvet, old felt hats, and turtle shells won the confidence of many suspicious Indians (see text, pages 752 and 756).



Photograph by Edwin L. Wisherd

KEET SEEL, THE LARGEST KNOWN CLIFF RUIN IN ARIZONA

From the rings of some of its timbers it was learned that Keet Seel was inhabited as early as 1274. The ruin is a part of Navajo National Monument.



Photograph by O. C. Havens

CEILING POLES AND A HATCHWAY AT PUEBLO BONITO

The timbers at this metropolis of the once prehistoric Southwest are unimpeachable witnesses of the sequence of events through many centuries. One beam from Pueblo Bonito tells us that it began to grow in the year 700 and had attained the age of 219 years when the Bonitan builders, with their stone axes, cut it down for use in erecting their great communal center (see text, page 767).

examine certain old ruins on the mesa to the north of the Hopi villages—Fire House to the east; Wide Ruin, south of the latter; and the ruins of Chaco Canyon, Mesa Verde, and the Rio Grande Valley. As a result, 100 excellent timber specimens came to me for examination.

This material was examined as fast as time allowed. In July, 1927, it was evident that a new chronology had been discovered. Wupatki and Citadel ruins, near Flagstaff; Mummy Cave, in Canyon del Muerto, and Mesa Verde, in southwestern Colorado (see map, page 743), had first been developed, each by itself, into local chronologies covering 100 years or more. Subsequently it was found that all three joined into one continuous sequence 180 years in length.

Archeologists agreed, from study of the cultural remains, that these ruins were generally later than Pueblo Bonito. Therefore we had a second chronology partly filling the uncharted interval of time be-

tween the prehistoric timbers of Chaco Canyon and modern trees near Flagstaff and leaving two gaps shorter than before, but of unknown length. On a trip to Betatakin and Keet Seel, out in the northern Navajo country, in 1927, excellent timber specimens, which showed that they belong to the latter part of this second chronology, were obtained (see page 760).

THE PREHISTORIC GAP BETWEEN CITADEL AND PUEBLO BONITO IS BRIDGED

Thus the newly developed chronology showed that Citadel, Fewkes' Ruin J, Wupatki, Mesa Verde and Mummy Cave, Betatakin, Keet Seel, and other pre-Spanish pueblos belonged to the same general period. Between all of these and Pueblo Bonito, however, there was a gap which Mr. Judd believed to be short, but which bothered us a great deal. Finally, we checked over the records given us by a juniper and a pine and compared them with the latest rings from Pueblo Bonito,



Photograph by E. W. Haury

MODERN HOUSES STAND ON ANCIENT RUINS WHERE BEAM HH39 WAS FOUND
(SEE PAGE 770)

The Mormon town of Showlow derived its name from an early-day card game. The stakes were high. One cowboy bet his all that he held the lowest card—and lost. So the spot became “Show low.”

and, lo, what was a distressing gap yesterday to-day was filled in and two chronological periods were united into one (see text, page 767).

Thus, on February 3, 1928, I was able to write Mr. Judd that the gap between the Pueblo Bonito period and that of Citadel and associated ruins had been bridged, that we had more than 580 years in a continuous prehistoric sequence.

I now made an effort to discover very old trees in the hope that thereby we could link this united and extended prehistoric sequence with our modern chronology, and offered a reward for any pine 600 years old. We already had a section from a 640-year-old tree, but it had a serious injury near the center, which we did not understand then, but which we now know was caused by the great drought of 1276 to 1299. The next 100 years of that tree's life were very complacent and gave no configurations of rings that could readily be recognized.

An attempt was made to match our

prehistoric pine sequence with that of the long-lived sequoias of California. This failed to give any certainty in dating, for there was no point at which the correspondence between the two stood out in a striking manner. I was compelled to renew the search for beams.

BEAMS CUT BY STONE AXES SOUGHT IN
HOPI VILLAGES

As successive generations of Hopi Indians had dwelt among the mesas 100 miles north of where the Santa Fe Railroad crosses the Little Colorado River, near Winslow, we believed that here was a promising field for search. Oraibi, for instance, has long been regarded as the only one of the present Hopi villages that has been continuously occupied since a period antedating the advent of the Spaniards, in 1540. We knew that many of its logs were cut by stone axes. Some of these, we reasoned, must be very old.

Thirty years ago Oraibi, with its 900 inhabitants, was the largest of the Hopi



Photograph by Sumner W. Matteson

THE SNAKE DANCE LINE-UP AT SHONGOPOVI, HOPI RESERVATION, ARIZONA

Like the Bean Dance described on page 754, the Snake Dance is celebrated as a prayer for rain. It is based on the tradition that snakes are elder brothers of the Hopis and are more powerful than they in compelling the nature gods to bring rain.

villages; but when the rains began, after the great drought of 1880 to 1904, their farms were washed away, the underground water was lowered, and crops failed. Dissensions arose, and they felt that some of the inhabitants should leave to try their fortunes in new places. The actual division came in 1906 and was over the unrelated question of whether their children should be sent to school, as ordered from Washington.

The decision as to which party should leave was reached in a characteristically Hopi way, by a tug of war. This was held just above the present village, where an inscribed rock still marks the spot. The losing side founded the neighboring village, Hotevila, and a large part of the old town was left desolate, but it was not unowned, as we found.

WE LIVE WITH THE HOPI TO OBTAIN
SPECIMEN BEAMS

We needed some one to live a month or two in Oraibi and make borings in every available old timber. Mr. L. L.

Hargrave was selected. In order to command the full coöperation of the Indian chief, Tawa-Guap-Tiwa, I carried along a present of purple chiffon velvet, which was so lovely that I was afraid to show it to Mrs. Douglass for fear it would never get out to the Indian reservation. The chief's exclamations and gestures of delight on receiving the gift showed how keenly it was appreciated.

We rented two rooms in an Indian house, and the old chief, who spoke only a few words of English, called on us often. Others, whose knowledge of English was as limited as was ours of Hopi, came likewise. They were all socially inclined; smoked our cigarettes as if born to the brand and seemed to enjoy teaching us their language.

The logs sought for our dating work were all ceiling beams, originally cut to span the rooms and make floors for the rooms above. They extend through the walls and in front rooms project outside, a delight to the tourist and an example to the modern architect. We were equipped



Photograph by Sumner W. Matteson

LIVE SNAKES HELD IN THE MOUTH ARE A PART OF HOPI RITUAL,

After the ceremonial the dancers purify themselves. Oraibi, Arizona, the scene of this dance, has been occupied by Indians since pre-Spanish times.

with a saw to cut cross-sections from the projecting ends of these logs and a tubular borer to drill out cores from the timbers within doors.

We went at once to the abandoned Kwan Kiva, at the southeast edge of town, and bored all the logs in sight, only to find that many were of cottonwood or juniper, which were almost useless for our purpose. Eventually we realized that the much-desired older logs were generally of pine and Douglas fir, whose rings are the best of all. After dating numerous sections, we discovered that the use of these trees ceased about A. D. 1770. Evidently by that time all the available trees within portable distance had been cut down. Thus we learned something of the injurious effects of human occupation on forests.

TURQUOISE APPEASES THE "SPIRIT OF DECAY"

Ends cut with a stone ax then became the distinguishing character. Small chips taken off showed whether the rings had the strong marking of pine or fir, the weak

lines of cottonwood, or the narrow, erratic lines of juniper. Length also helped in the selection. Pre-Spanish beams used in the dwellings are rarely more than eight feet long. Spanish beams are easily twice that and are nearly always found in the kivas, or ceremonial chambers.

We call them "Spanish" because these timbers were salvaged by the Hopi when they destroyed the missions, in 1680; they have been in use ever since, and tradition has it they were originally carried by Indians on foot, mostly from the San Francisco Mountains. There are probably a few long pre-Spanish beams still in use.

At times in our beam gathering we had to appease the spirits for the Indians by inserting a piece of turquoise at the base of the plug with which we filled the hole made by the extraction of a core. This was to prevent the lodgment of the "spirit of decay" in the timber (see page 738).

A rounded log in the Antelope Kiva at Oraibi gave the year 1475 as its outermost ring, and the outside wearing, which at first I thought was intentional, later became recognized as invariable in the



Photograph by Hugh Stevens Bell

OLD WALPI CELEBRATES FOLLOWING A CEREMONIAL DANCE

For three days after the dance, anything a man holds above his head is a present for the first woman who can seize it. The women believe in teamwork, and the contests which they stage are less gentle than football (see, also, illustrations, pages 752, 753, and 755).

oldest logs. It was cut about 1520. Also, a specimen from Moong Kiva, at Walpi, appeared to be nearly complete, and its outside rings gave 1490 as its cutting date. Ladder poles were more recent. One ladder showed one pole cut in 1570 and the other in 1720, which reveals a story of breakage and repair.

WE FIND A BEAM USED FOR 500 YEARS

Naturally I wanted the oldest log. The oldest we found was in that section of Oraibi abandoned in 1906. We entered on the second floor of a three-story house, over a terrace consisting of older rooms filled with rubbish. We went through several chambers and entered into a part of the structure still in good condition. Mr. Hargrave lifted a flat stone on the floor, revealing a hole into the room below.

I swung down a couple of feet onto a rubbish heap made of the sandy sweepings of years from the room above. This had been covered with a thin floor of clay to make a small storeroom some eight feet

square and three feet high. With a flashlight I could look around.

In the center was an upright post, not more than six inches in greatest diameter, supporting the center of the ceiling. It was partly flattened, and as it was holding up the floor of the room above, no cross-section could be taken, but its longer diameter was bored by Mr. Hargrave. The rings of this beam gave a superb series from 1260 to 1344 (see illustration, page 760). Allowing for wearing, it was probably cut as early as A. D. 1370 and had been in use continuously for well over 500 years. The whole log, six feet in length, was finally obtained on August 7, 1929, and is now safely preserved in my laboratory at Tucson. Other timbers, perhaps equally old, are rapidly being broken up by the Indians for fuel.

A BEAN DANCE TO BRING RAIN

Kivas are subterranean ceremonial rooms. One of the best is known as the Moong Kiva, at Oraibi. It is some-



Photograph by Hugh Stevens Bell

HOPI INDIANS SKYLARKING AFTER A WOMEN'S DANCE

The whole village turns out to see the fun, as maidens corner a defiant brave and reduce him to submission, after he has had the audacity to walk down the street with a prize held above his head (see, also, illustration on opposite page).

what larger than the others and is used for more general gatherings.

Our friend, Chief Tawa-Guap-Tiwa, was directly in charge of it. He said, "Are you going to be here to-morrow night?" I had a fleeting thought that he was going to say sternly, "Perhaps you had better not be here." But, on the contrary, he said that there would be a final practice of the Bean Dance from about 8 in the evening to 12. We were invited to take part in the rehearsal.

At 8:15 we heard the big drum, went down the ladder, and took our seats on the bench. The chief's father sat near by, smoking native tobacco in a stone pipe; other participants smoked cornhusk cigarettes. A small cast-iron stove and an ordinary kerosene lamp seemed altogether out of place at this old Hopi ritual. After modest hesitation, Mr. Hargrave accepted the chief's invitation to enter the dance, and for an hour ably represented our party.

Twenty men formed a semicircle in the large end of the kiva face to back. As the

chief beat time on the great drum the Indians chanted their prayer. Within the semicircle sat an older man, who from time to time threw in a word or two.

The men in the semicircle represented the spirits of the rain, who dwell 100 miles away, in the great cloud-covered San Francisco Mountains, near Flagstaff. The man in the center was the Father of the Gods.

The spirits of the rain were saying in effect, "Our brothers in Oraibi are ready to plant their beans. They need rain, so that the beans will grow and supply food for themselves and their families." Then the Father of the Gods calls out, "Yes, let's go and help them."

As I sat watching the dance, I realized that I was one of three terms in a human series: First, the Indians of a neighboring village, who believe that rain is actually controlled by proper magic, performed by their powerful priests; then those before me, who were praying to the more powerful spirits that rule the rain; and, lastly, I, myself, who was there to study the rainfall history in pine timbers



Photograph by Dr. A. E. Douglass

STUDYING BITS OF TELLTALE CHARCOAL, UNDER
MAGNIFYING GLASSES

and learn the great natural laws which govern the coming of the rain. We were all doing exactly the same thing according to our lights.

INDIAN MASKS MADE FROM OLD FELT HATS

In the old days, kivas were rarely opened to strangers. Close collusion with the priests who had them in charge was necessary. On one occasion Mr. Hargrave sent me a core drilled from a large roof beam. It was only two and a half inches long and clearly did not go to the center of that timber. I asked him to try to obtain the remaining section of it on his next trip. He explained that the reason he did not complete the extraction of

the core was that some of the Indians had raised objections to his work in that kiva, and he had been obliged to stop.

I discussed the subject with Chief Tawa-Guap-Tiwa upon my next visit, but he rather evaded the point, and we did not get the remainder of that specimen. I learned, however, that the Bean Dance was coming soon and that old felt hats were needed. I visited a number of friends, collected twenty old ones, and carried them back to Oraibi as a present.

From old felt hats masks can be made, and the gift was very much appreciated. The Indians sewed the brims in a vertical position, made holes for the eyes, and painted noses and mouths. They built up the tops of the hats into very elaborate ceremonial head-dresses and painted them in gorgeous col-

ors. These they showed me with great pride.

Another gift that brought us good will was a present of six turtles. From turtle shells rattles are made and worn around the right leg in ceremonials. We gave the turtles to the important men and then had a conference with the chief of the Ha-Wi-A-Wi clan, in whose village stood the beam whose boring we wanted to complete. I asked him if he would permit us to continue that boring and perhaps to bore one or two other logs. He said he was very sorry, but that the boring would endanger the roof of the kiva. I told him that I knew he was protecting the interests of his people, and especially those

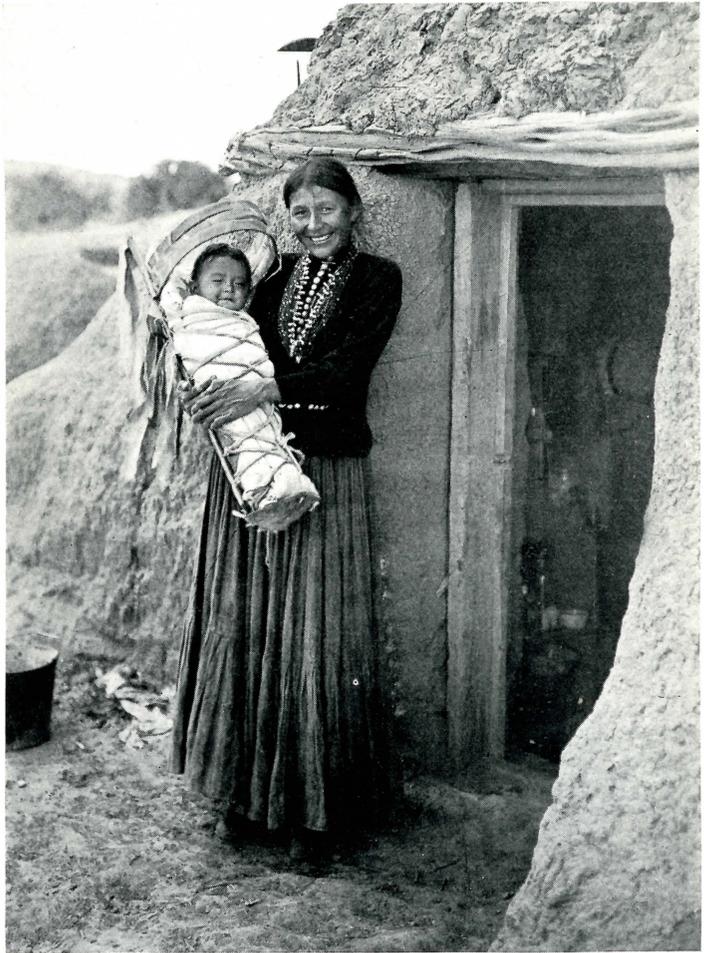
who owned and assembled in the kiva, and I would be guided by his judgment.

He answered that white people rarely or never showed that consideration or understanding of the interests of the Indians. Later he gave his consent for us to go outside the kiva and dig down in the ground until the end of this beam was exposed. There we could find out if it were of value. When we did so we found nothing that would add to our chronology.

Meanwhile, we discovered in the floor some planks which looked old and we obtained permission to examine them. Using a gasoline lamp, I spent most of the time from 5 o'clock in the afternoon until midnight lying flat on the floor, with a lens in my eye, my nose almost touching the boards, counting and measuring the rings in those planks. The only success that those seven hours brought us was to discover from the outer rings of the fourth board that all had grown between the great drought of 1580 and the familiar Spanish dates of about 1640.

INDIAN WOMEN PROVE A STUMBLING BLOCK

In the acquisition of beam material women were always more difficult to deal with than the men. At Walpi we found one kiva near the south end of the mesa which had at least ten good logs. We hunted up the priest of the kiva and his handsome son. We discussed our needs in front of their house. Presently we



Photograph by Neil M. Judd

A NAVAJO WOMAN AND HER PAPOOSE AT PUEBLO BONITO

To the Indians of the Southwest the successful reading of the tree rings in the beams of their old ruins seems as uncanny as foretelling an eclipse of the sun.

discovered that a woman of the household was listening just inside the window, and every once in a while was urging the Indians to charge "everything that traffic would bear."

So our interpreter suggested that we go to the kiva and talk. There we informed the chief of our customary price for each log that we bored; but that, as this was a kiva and as the logs were larger than usual, we would pay double the usual sum. They replied that since this was a most sacred spot and the god himself dwelt in a niche which we could see, they would have to charge four times our regular



Photograph by Sumner W. Matteson

A PLAQUE WEAVER OF MISHONGNOVI

She is wearing a silver necklace of squash-bloom pattern. Near the Hopi pueblo of Mishongnovi, in Arizona, are two sandstone pillars. One has fallen. The name means "at the place of the other which stands erect." This pueblo was searched for old timbers, but produced none of special significance.

price. All I could see in that abode of the god was a handful of prayer sticks.

Finally we reached a compromise, and if we had made our borings at once all would have been well. But we did not have our instruments with us at the time. Several days later some one had raised an objection to our boring those particular logs and we were not permitted to touch a single one.

HOPÍ PUEBLOS BUILT ABOUT 1400

We looked through Shipaulovi and Mishongnovi without finding many prom-

ising specimens. We also visited the three villages close together on the first mesa: Walpi at the southern end, Hano at the center, and Sichomovi at the northern end of the shoestring. The inhabitants of these villages had all moved to the high mesas after the rebellion of 1680.

We found that the Government had recently brought in a large number of fresh spruce logs from the Black Mesa, 40 miles away, and the Indians had used these to rebuild their kivas and had cut up the wonderful old Spanish logs and beams for firewood. Hence the dozen specimens from Walpi gave no new information, and there is little prospect of more in the future.

After making large collections from old Oraibi and from Shongopovi and seeing a few specimens from the other villages, it seemed to me fairly evident that we would gain nothing by further search in the Hopi villages. The earliest

cutting date discovered was close to the year 1400. One or two logs could be interpreted as having been cut a little before that, but after all our effort no additional piece was found whose inner rings began earlier than 1300. The inference seemed obvious; the pueblos abandoned following the revolt of 1680, when the Hopi erected their present villages, were built about 1400; in the case of Oraibi, alone, the original site has been occupied ever since.

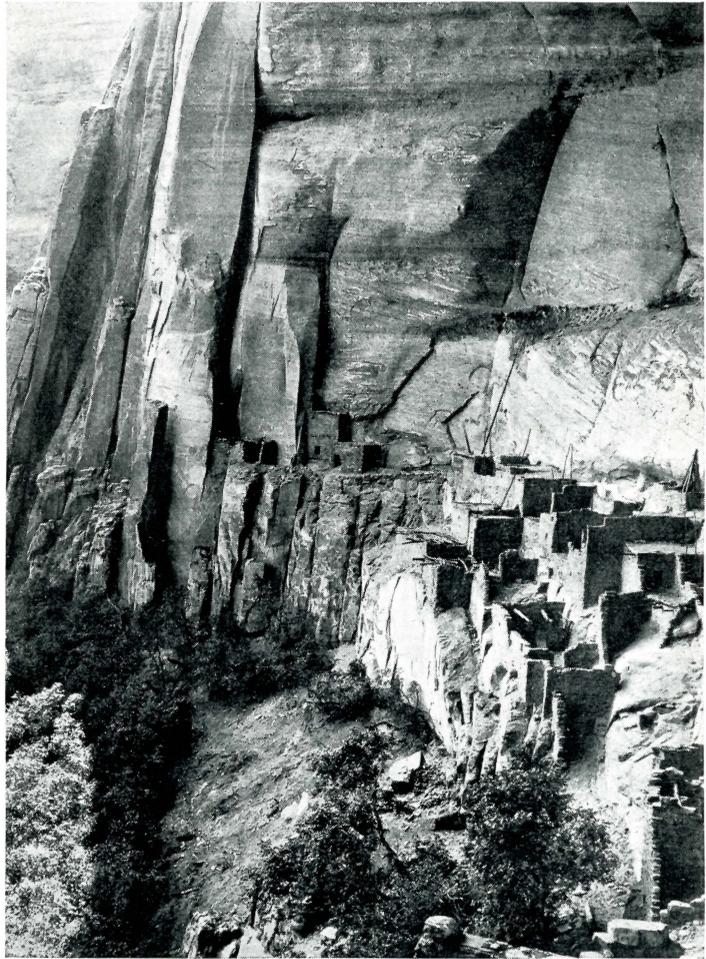
Thus the early work of 1928 indicated that available Hopi beams were not suf-

ficiently old to link definitely our two tree-ring chronologies (see page 769). The question was, Where should we next look for some older locality whose building period preceded that of Oraibi—in short, the locality from which the Hopi Indians had last migrated?

FRAGMENTS OF POTTERY PROVIDE A PRICELESS CLUE

To answer this question a survey was made of that area known archeologically to have been inhabited by the Hopis in pre-Spanish times. Fragments of pottery were collected at each important ruin; from the shards a sequence of development was obvious. Black-on-white and a form of red ware began in very old times. Then the red changed into a polychrome-on-red. Later the beautiful yellow Hopi pottery began to appear. The development continued with improving fineness of decoration until interrupted by the Spanish influence. Then pottery-making fell into a decline which lasted until about 1897, when Nampeyo (see illustration, page 742) saw her opportunity to inspire a revival of the art.

The relationship between the latter years of the prehistoric and the earlier years of the historic chronologies to this sequence of pottery types was easy to determine. Pueblo Bonito, in New Mexico; Keet Seel, near the northern border of Arizona; and Turkey Hill Pueblo, near Flagstaff, had given final building dates covering the late prehistoric chronology. Their pottery, therefore, would necessarily be-



Photograph by Neil M. Judd

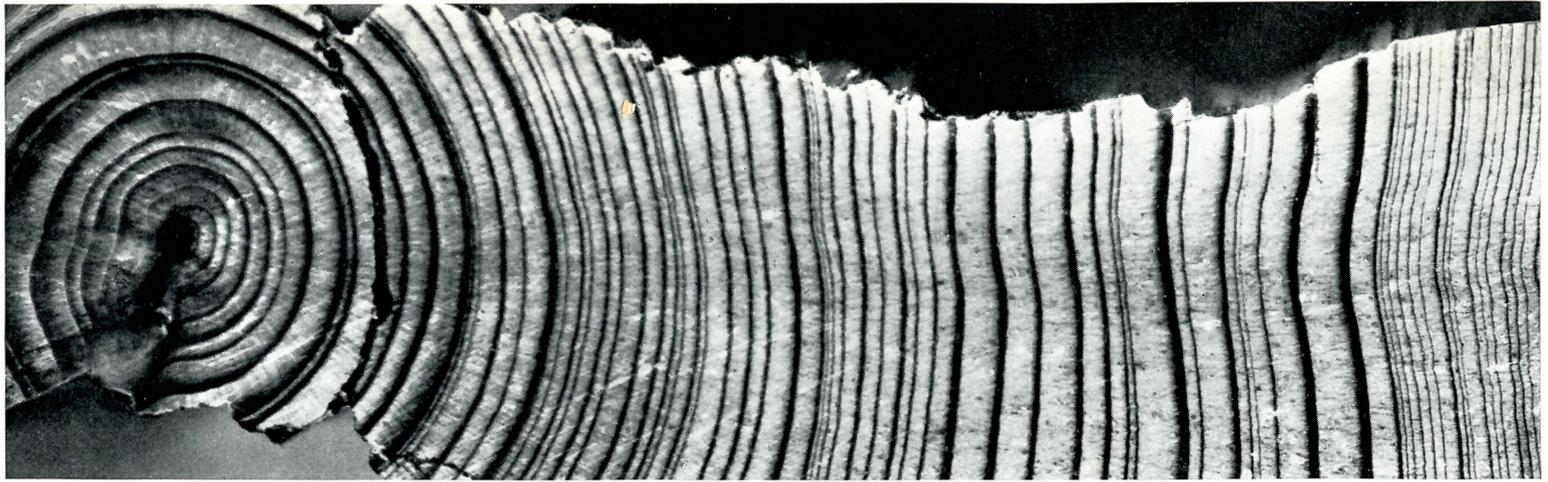
BETATAKIN, IN THE CANYON COUNTRY OF THE NAVAJOS

To this old stronghold of vanished cliff-dwellers, restored by Mr. Neil M. Judd in 1917, beam hunters went in quest of tree-ring testimony. The ruins yielded timbers which showed that Betatakin was occupied as early as 1260 (see upper illustration, page 760).

long to the prehistoric period. It had not developed beyond a polychrome-on-red. But Kawaiku, which has given numerous historic building dates from 1357 to 1495, showed not only polychrome-on-red but, in addition, Hopi yellow ware in great abundance, with both primitive and late designs.

Evidently the point where the two sequences could be joined was close to the latest use of polychrome-on-red and the earliest development of Hopi yellow.

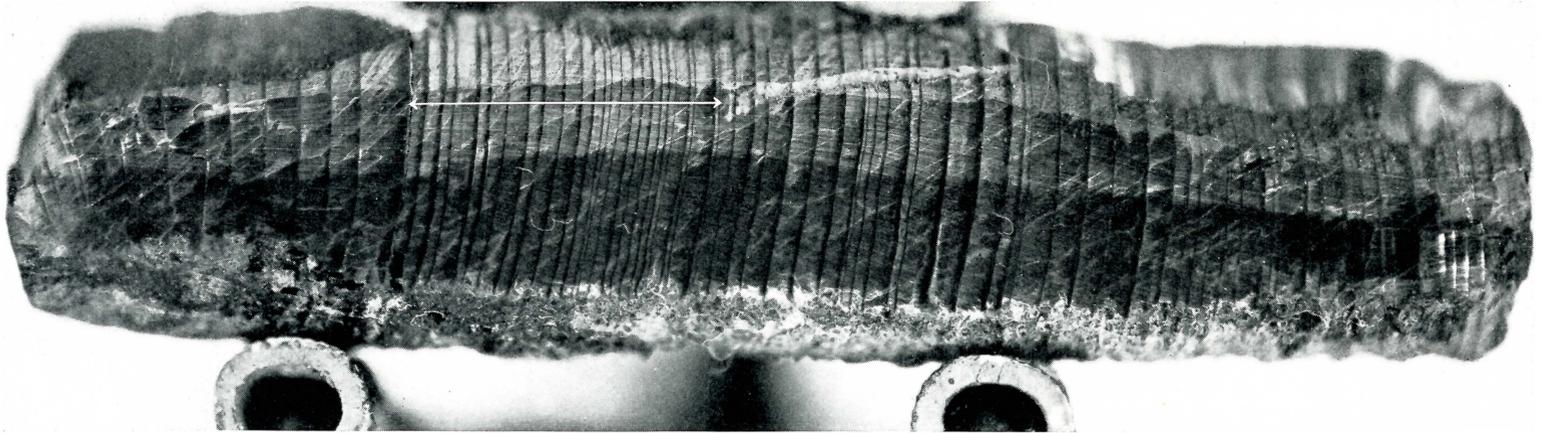
Not until the preliminary work of 1929 did we recognize that a transition orange color, which could be depended on as



A CROSS-SECTION OF A DOUGLAS FIR LOG THAT HELPED MAKE HISTORY

In the search for beams that would tie together the tree-ring stories of Pueblo Bonito timbers and those of living trees, this one found in Betatakin Ruin (see text, page 750, and illustration, page 759), proved to be a missing link that bound the 586 years of the prehistoric chronology together. Its rings show that it started its career in 1073 and was felled A. D. 1260

760



A TIMBER TALE OF FAT YEARS AND LEAN

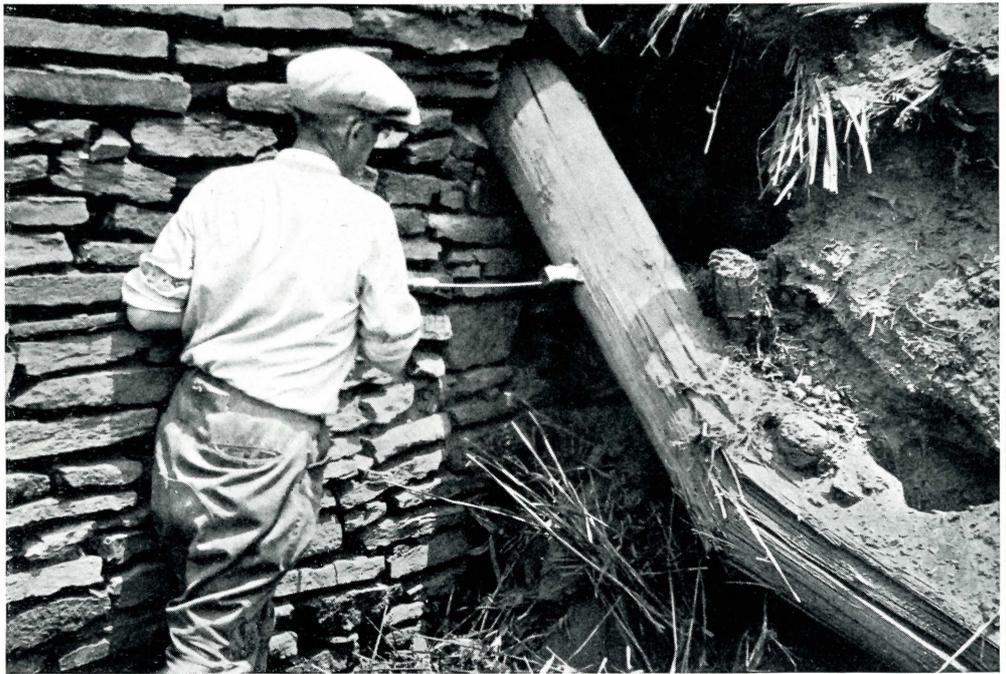
Photographs by Dr. E. F. Carpenter

This is an enlargement of a 3½-inch core cross-section of a beam taken from the old house at Oraibi (see, also, illustration, page 746). In the thin group of rings at the left center is revealed the story of the tree's hardships during the great drought between 1276 and 1299 (see text, pages 749 and 754).



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FAR UP ON THESE CLIFFS OF NORTHERN ARIZONA THE HOPIS LONG AGO BUILT THEIR TOWN OF WALPI, STRATEGICALLY LOCATED FOR DEFENSE (SEE, ALSO, PAGES 744 AND 745)
Walpi means "the place of the notch." The ancestral Hopi clans who first settled here built their homes below the site of the present village.



Photograph by J. C. Clarke

EXTRACTING A CORE FROM A LOG AT WUPATKI

When impracticable to cut a cross-section from a log, the necessary data which its tree rings record can be obtained by drilling the beam and removing the core (see page 760).

pottery of the linking era, came between the red and the yellow. This was an important guide in the selection of ruins for our subsequent search.

A BIT OF CHARCOAL GIVES A VALUABLE DATE

When I first became interested in the possibility of dating prehistoric ruins through tree rings I was very particular as to the specimens worth looking at. I told the archeologists that only pine beams six inches or more in diameter and in good condition could be used, and it is true a large number of first-class specimens enriched our collections. Then, to extend the known chronology, specimens were accepted in poor condition.

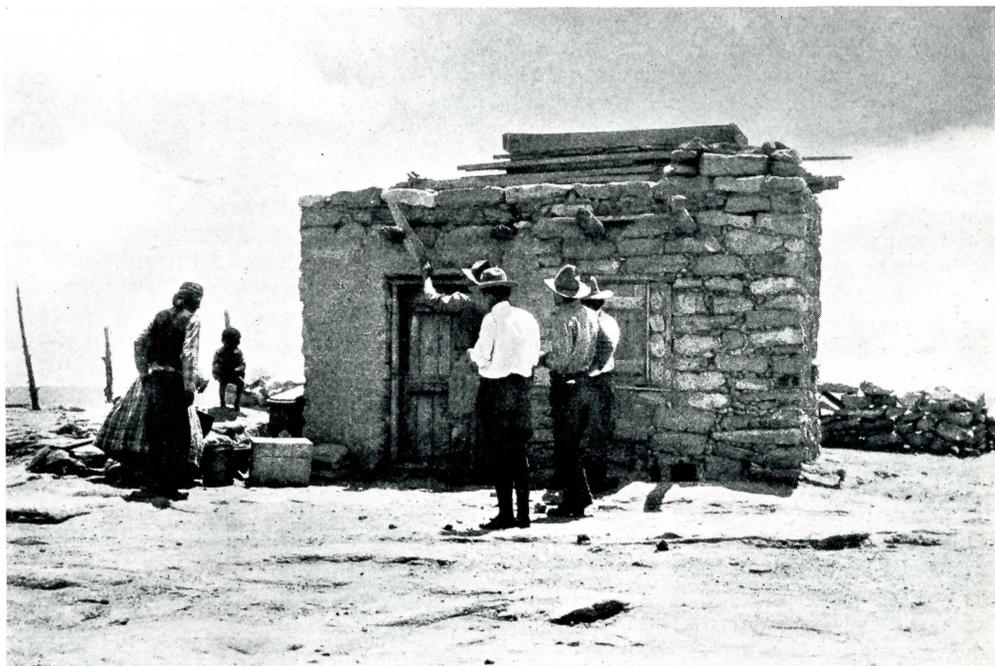
But many of the sections from Pueblo Bonito were burned; we had to find a way successfully to treat charcoal. At first frail specimens were dipped in melted paraffin. Later, this method was improved upon: the fragments were soaked in a solution of paraffin and gasoline. This solution we now keep on hand, and fragile pieces are immersed in it as soon as they come out

of the ground, or, if not, they are kept covered by fresh earth until they can be put in the solution. If the pieces are apt to fall apart they are tied with string and then soaked.

The first specimens from the Jadito Valley ruins were mere chips scratched from old *débris* heaps near the mesa edge. These were brought to me with misgivings, for many were only as large as one's thumb, and a little pressure would crush them to powder. But, to my surprise, we found in some bits a series of rings closely resembling those between A. D. 1365 and 1420. These pieces came from Kawaiku.

I attached a high degree of importance to this dating, and yet refused to rely upon it completely because too much depended on it; for, if correct, it would be the first pre-Spanish ruin in the southwestern United States to receive an actual and exact date.

Absolute certainty was finally obtained in a piece of charcoal as big as one's fist, found in an old kiva at Kawaiku. The rings looked favorable; we carefully bound the fragment and soaked it in the paraffin



Photograph by Dr. A. E. Douglass

THE FIRST BEAM EXPEDITION FINDS A TALKATIVE TIMBER

From this modern house at Sichomovi beam hunters took a specimen whose tree rings show that it was cut by Indians nearly 100 years before Columbus reached the New World.

solution. Subsequent examination showed that the rings could be followed from center to outside, and they gave an absolutely perfect sequence from 1400 to 1468, as reliable as if they had been dated at the time and sworn to before a notary. This established conclusively the correctness of all the other dates which had been obtained of approximately that same period.

KAWAIKU OCCUPIED BOTH IN HISTORIC AND PREHISTORIC TIMES

Then other specimens came to light, carrying our ring sequence back to 1300 and forward to 1495, and showing that new dwellings were erected in this village shortly before the first Spaniards, Pedro de Tobar and Fray Juan de Padilla, reached Awatobi in 1540.

A group of wood fragments in another place showed a series of cutting dates from 1357 to near 1400. At the same time, a bit of pine built into the wall as a door lintel gave a very dependable late prehistoric date for the original walls.

Thus we had ample evidence that Kawaiuku was occupied both in the latter

years of our prehistoric sequence and the earlier years of our historic chronology. Hence this ruin, or one of its neighbors, gave promise of being a desirable site in which to search for those particular rings that might unite the two series. No doubt the desired wood was here, but the ruin covered some nine acres and it would be difficult to say where that wood could be found.

We were far from discouraged when our second expedition closed without having contributed any appreciable results toward the linking of our two chronologies. The one Oraibi specimen (see text, page 754), whose center was at A. D. 1260, was of the utmost importance, but it was all alone and covered a period of time from which surviving timbers were few and usually badly defective. Yet the prospect of ultimate success in tying them together seemed brighter than ever! By the spring of 1929 we were convinced that our pottery sequence could be used as a reliable guide in finding ruins of the desired period.

Of course, the question arose: Could the needed specimens even now be on

our shelves? An illustration of how unsuspected treasures may pass unregarded, even in the ring student's laboratory, is afforded by an incident of the preceding year. On my first visit to the National Geographic Society's excavations at Pueblo Bonito, in 1922, Mr. Judd gave me, among other pieces, a very fine section from a horizontal wooden base supporting a ceiling log in one of the large kivas. At that time the specimen disclosed nothing I could recognize. I put the whole group of 15 specimens to one side, as not revealing anything of importance.

Five years later I undertook a reëxamination of them in the light of some other material with which I was working. Then it was that this section of the horizontal wood base became eloquent with its story. It covered an entirely new century and extended the prehistoric chronology backward 107 years. It showed that the tree from which it was derived had been cut when it was approximately 337 years old.

Recollecting this case, I repeatedly examined all material that might help unite the two chronologies, but failed to discover anything not previously disclosed.

WUPATKI AND PUEBLO BONITO BUILT WITHIN 70 YEARS OF EACH OTHER

That the conclusions of competent archeologists were dependable as to the probable decades in which the two sections of our calendar would join may be illustrated by another experience. About 35 miles northeast of Flagstaff there is a fine old ruin known as Wupatki. I asked one of my archeological friends his opinion as to the relative ages of that ruin and of Pueblo Bonito. He replied that such evidence as he had examined indicated that they were of approximately the same age. When I examined timbers from the two ruins in my laboratory and applied the usual methods of dating, I found that the old village on the slope of San Francisco Mountain, in Arizona, showed a building date only 70 years after those of the more famous pueblo in Chaco Canyon, New Mexico, 220 miles away.

What then was the next step? We had identified a locality in the Jadito Valley which was apparently inhabited during portions of our two time periods and presumably through the years that linked them together. Other Jadito ruins, espe-

cially Kokopnyama, seemed favorable and equally likely to contain material covering this period. But each of these ruins was nearly ten acres in extent and we were without any means of knowing just where to dig.

Probably beams at a depth of 10 feet or more were in good condition, but a search for them would mean deep, long-continued excavation. Nearer the surface, timber of the age which we desired would be badly decomposed unless previously burned by fire. Hence evidence of rooms destroyed by fire was the essential clue in future work. Several of the ruins south of Holbrook gave indications of being near the right age and were in the midst of the pine forest. Their colder climate and the abundance of freely burning wood made charcoal far more likely to be found there in quantity.

SHOWLOW RUIN OFFERS BRIGHT PROSPECTS

These considerations provided a background on which to plan the third expedition. In the early spring of 1929 a reconnaissance was made of the pre-Spanish Hopi region where orange-colored pottery or its imitations were found. After excluding wonderfully interesting sites along the Little Colorado River, four ruins—Kokopnyama, in the Jadito Valley; Kintyel or Wide Ruin, to the southeast; Showlow and Pinedale, 100 miles south, in the great pine forest of the Mogollon Rim—were selected for examination.

Of these, the Showlow and Pinedale ruins made the stronger appeal because of their proximity to growing pines. Even between these two, first choice went to Showlow because from it pieces of charred wood had already been reported. When a fire occurred in this communal dwelling and some of the ceiling beams began to burn, the walls evidently collapsed and smothered the flames, thus converting some of the timbers into charcoal which has resisted decay.

This wood was finally examined in the new laboratory of the Association for Research of the Southwest, by courtesy of Mr. Harold S. Gladwin, Director, and clearly pointed toward Showlow as the place where the material should be found which would unite our chronologies.

Mr. Hargrave and Mr. Emil W. Haury left Flagstaff on June 11 to begin work

at the Showlow ruin, while I remained behind to set up a temporary laboratory in quarters which Dr. Harold S. Colton, the Director of the Museum of Northern Arizona, kindly placed at my disposal.

Help was obtained for unpacking and dipping the specimens in liquid paraffin as they came in. Material arrived rapidly from the Showlow party. Among the first important specimens were portions of several logs, in the form of charcoal, of course, which showed dates in both the historic and the prehistoric series.

A NOTABLE FIND IN
THE MIDST OF A
RUBBISH HEAP

After getting the ring sequence from those logs, Mr. Judd and I left Flagstaff early Saturday morning, June 22, for Showlow. When we arrived there, shortly before noon, we found that another log had just been discovered at the extreme north end of the ruin. It had been found only a foot below the present level of the ground, in an area, however, from which earth had been removed in recent years.

The general area in which the men were working is one where modern things intermingle with ancient ones. There are 20th-century houses, cisterns and stone walls, barns, chicken yards, and fences covering the site of what remains of the prehistoric buildings, most of which were razed many years ago.

Furthermore, Mr. Edson Whipple, who owns the larger part of the property, had overturned every room in the old village



Photograph by O. C. Havens

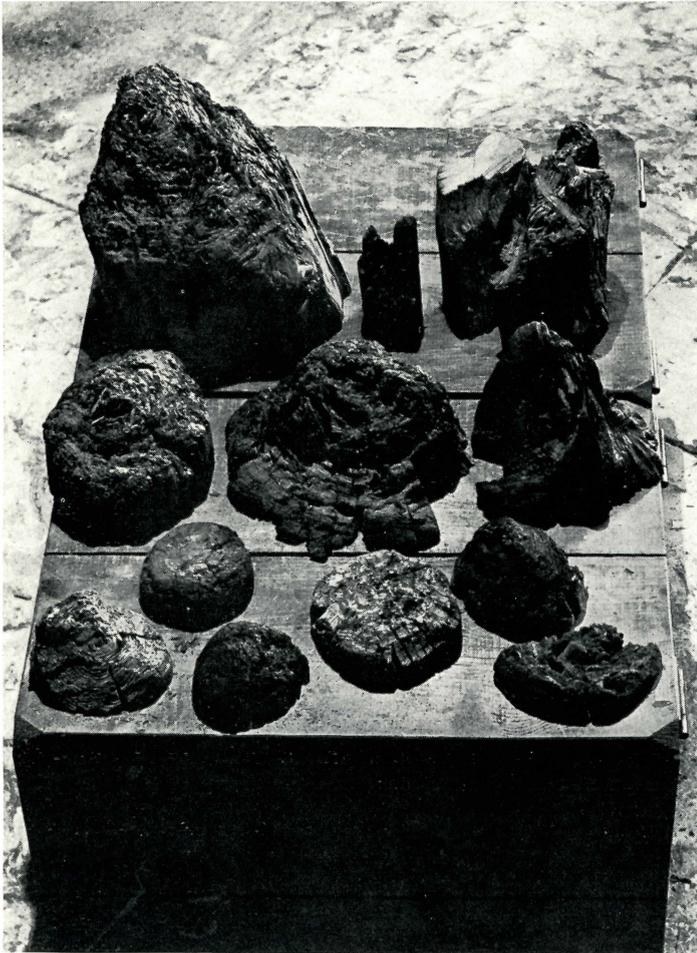
CHARLIE PINTO, A ZUÑI WORKMAN AT PUEBLO BONITO

The Zuni tribesmen have been capable assistants on the National Geographic Society's numerous expeditions in the Southwest. They are good-natured, quiet, and industrious and strict conformists to their ancient religion.

in his search for primitive pottery and the extension of his gardens over leveled masonry and crumbled walls.

Our men, therefore, in their search for fragments of charred beams, found at every turn the discards of 19th and 20th century culture—here a piece of packing box, there a beef bone with sawed ends, and elsewhere a broken pickle bottle or the top of an old tin can.

But it was easy to note the difference between prehistoric wood and modern fragments. The old timbers had disappeared entirely except in the form of charcoal or near-charcoal. Some of the frag-



Photograph by Dr. A. E. Douglass

ANCIENT STONE AXES CHOPPED THESE ROUGH BEAM ENDS

The work of estimating the age of beams is often expedited by examining their ends. From Mexican traders of the 17th and early 18th centuries, the Hopis acquired sharp-bladed metal axes and soon many Indians forsook their dull stone implements and acquired the white man's tool. These beam ends—natural wood, not charcoal—reveal the dull, mashing blow of the thick-edged primitive stone ax.

ments we recovered had, in their charred form, survived the centuries, but still showed that they had been patiently worked smooth with sandstone rasps by Indians of the long ago.

BEAM HH39 PROVES TO BE THE LONG-
SOUGHT KEY

But among the valuable material we found at Showlow first place must go to the log taken out just after Mr. Judd and I arrived. It was found in a horizontal position and resembled an ordinary round

beam which had been burnt off at the end in the form of a cone, as is common with burnt logs.

As a precautionary measure for holding it together, we bound it carefully with cotton twine; but, even so, the specimen fell to pieces, and not until then did we discover that our supposedly solid log was merely a conical shell of charcoal and near-charcoal from which most of the wood untouched by fire had decayed.

But, for all that, it was clearly a fragment of exceptional value. We gave it the field number HH39 (see illustration, page 769), after which I commandeered Mr. Whipple's old tool house and spent most of the afternoon working on it there.

Its outer parts were at once recognized as belonging to the 14th century, rings being traceable nearly to A.D. 1380. The record it gave us after 1300 was absolutely satisfactory, with no question whatsoever remaining as to the dating.

Following its rings inward to the core, we saw the record of the great drought. Here were the very small rings that told of the hardships the tree had endured in 1299 and 1295. As we studied the rings further toward the center, 1288, 1286, 1283, and 1280 each told the same story we had found in other beams of lean years and hard living. Also, there were the years 1278, 1276, and 1275, the ring for each corroborating the diary entries other logs had given us.

Then came the years of the seventh

decade of the 13th century, and the stories told by their rings agreed in every detail with those told by the rings for the same years in the Oraibi beam (see text, page 754).

But whereas the Oraibi beam could tell us nothing back of 1260, Showlow's HH39 did not stop there. Here was its account of 1258, a hard year, and of 1254, an even harder one. Presently it told of 1251 and 1247, years when all the trees were singing "How dry I am."

We were getting down close to the center now. But the rings were clear and easily understood. Finally came the one at the very core, and from its central ring (see illustration, page 769) we learned that this charred old stick began its life as a promising upright pine A. D. 1237, just ten years after the Sixth Crusade moved eastward to compel the Saracens to restore Jerusalem.

NOT A GAP BUT A BRIDGE

The history within that carbonized bit of beam held us spellbound; its significance found us all but speechless; we tried to joke about it, but failed miserably. We felt that here was the tie that would bind our old chronology to our new and bring before us undreamed-of historic horizons.

Later that evening we gathered under the spluttering old gasoline torch in the village hotel, and beneath its flickering light, by the use of my skeleton plots of prehistoric tree rings, we began to determine whether our historical chronology, now extended back from 1260 to 1237 by Beam HH39, might not overlap the old chronology.

As we studied these rings the answer came. The ring in our old chronology that represented its 551st year matched perfectly with that of the ring for the year 1251 in Beam HH39. And then our big surprise! We had not a gap to bridge, as we had thought, but one we had closed without knowing it!

Our two chronologies had covered an overlapping period. But those rings of the old series which overlapped the new at 1260 had been gathered from such small fragments that I had never been willing to accept their evidence as to this overlapping. To be sure, I had dwelt upon this possibility at times, but always rejected it

as unconvincing. It was Beam HH39 that cleared away all doubt.

Even after our evening's study I wanted to make further examination of one or two rings at the uncertain extremes of my two chronologies; but to my colleagues I declared that the coincidences were so striking and the situation looked so cheerful that, at such a late hour, we could well afford to sleep upon it.

But I could not sleep. Lying awake, I visualized all the individual rings concerned in this agreement and became completely satisfied that the relationship between our prehistoric and historic ring records had been definitely ascertained.

It still remained to examine with even further care the rings recording the great drought in the late years of the 13th century to see if by any chance anything had been overlooked. It would be necessary to prepare a complete photographic record of rings from the beginning of Pueblo Bonito chronology down to the present time; also, a complete review must be made of some 5,000 beam fragments, charred and otherwise, to get the various building periods in the 40 ruins from which they had come.

PUEBLO BONITO REACHED ITS HEYDAY IN 1067

But when I finally went to sleep it was with the consciousness that my old chronology had begun A. D. 700; that the earliest beam we had recovered from Pueblo Bonito had been cut A. D. 919 from a tree that was 219 years old when cut; that Pueblo Bonito had reached its golden age in 1067 and was still occupied in 1127.

The next morning I returned to our beams. More deliberate study added new strength to their story. The years between 1260 and 1295, the earliest in the historic chronology, had been dated by the Oraibi log alone; likewise the late years of the prehistoric sequence had many defective rings in the great drought period which ended it. It had been the uncertainties arising out of these conditions that had made impossible the determination of the overlap without additional beam material.

But when we found Beam HH39 it proved to be the bridge over which we could pass the deep chasm of remaining



Photograph by O. C. Havens

A PANORAMIC VIEW OF PUEBLO BONITO, EXCAVATED BY NATIONAL GEOGRAPHIC SOCIETY EXPEDITIONS

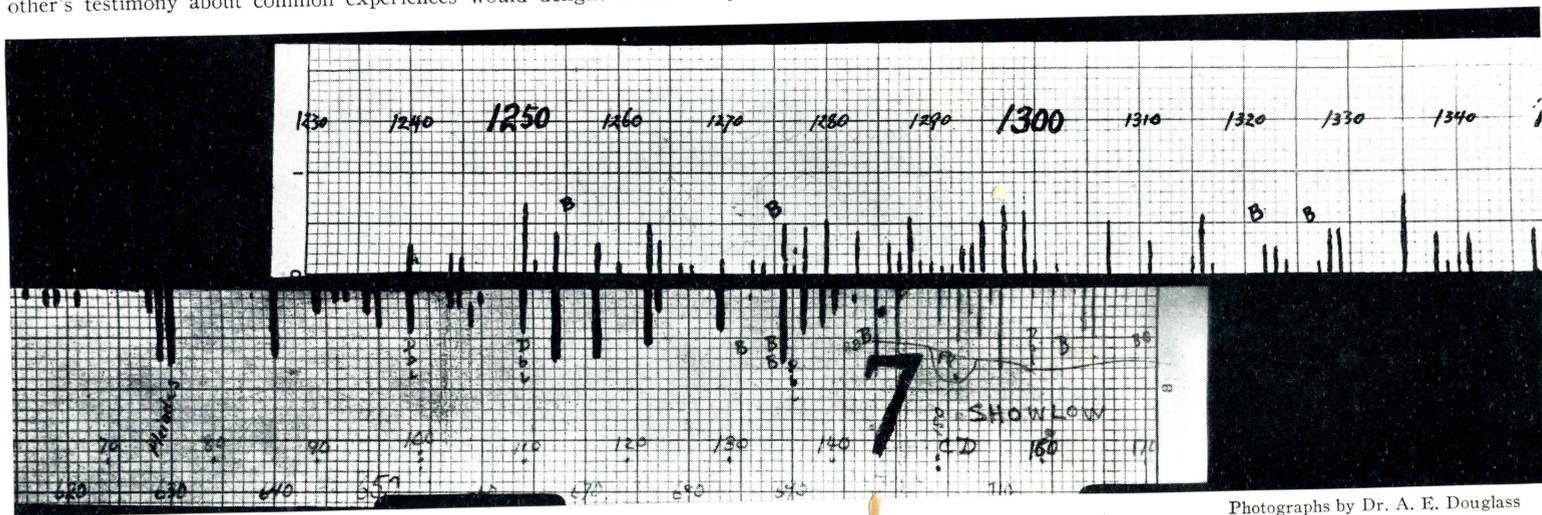
These ruins, set apart as the Chaco Canyon National Monument by President Roosevelt, are the oldest definitely dated pueblo remains in the American Southwest. The colossal communal dwelling was under construction in 919 and the settlement had reached its heyday in 1067 (see text, page 767).



THE KEY TO THE SECRET OF THE SOUTHWEST—CHARRED RINGS OF BEAM HH39 (SEE TEXT, PAGES 767-770)

This fragment, photographed in reflected light, shows some of the pre-Columbian tree diary entries. The ring indicated by the arrow records rainfall conditions in 1247; the one designated by a star tells of conditions in 1275. The closeness with which timbers of the same age corroborate each other's testimony about common experiences would delight a trial lawyer's heart.

769



Photographs by Dr. A. E. Douglass

MATCHING THE STORIES THE TREE RINGS TOLD

To make them readily accessible for comparison, one with another, each tree-ring specimen was carefully plotted. The long black lines on these original field records represent severe drought years; the shorter ones, less severe years. The lower plot, of specimen HH39 (see above) from Showlow, brought joy to the expedition members when its principal drought years were found to coincide with those in the upper plot, made up of timber records previously dated.



Photograph by Neil M. Judd

THE RESCUE OF THE "ROSETTA STONE" OF AMERICAN ARCHEOLOGY

The end of Beam HH39, found at Showlow Ruin, was carefully wrapped with twine until the whole charred log could be uncovered and taken out (see text, page 766).

uncertainty. Its respective ends, figuratively speaking, rested upon staunch abutments in both the old and the new sequences.

Its inner rings overlapped the late decades of the old chronology by 49 years, the final ring resting on the year 537 of that sequence; its outer ones overlapped the earliest 120 years of the new, the last one reaching to 1380.

Thus the 26 years from 1260 to 1286, which had belonged to both chronologies, were definitely matched and their union confirmed by Beam HH39, which in American archeology is destined to hold a place comparable to Egypt's Rosetta Stone.

The successful dating of the many ruins of the pueblo area that this research has made possible (see map, page 743) enables us now to correlate the increases of rainfall that permitted these villages to expand and the drought years that placed upon them the heavy hand of starvation.

With careful archeological study we shall perhaps be able to trace the movements of clans and test tribal traditions which have been so often quoted as the early history of these people. In the combination of climatic conditions with tribal activities we have a rich field for studying the influence of climate on human history.