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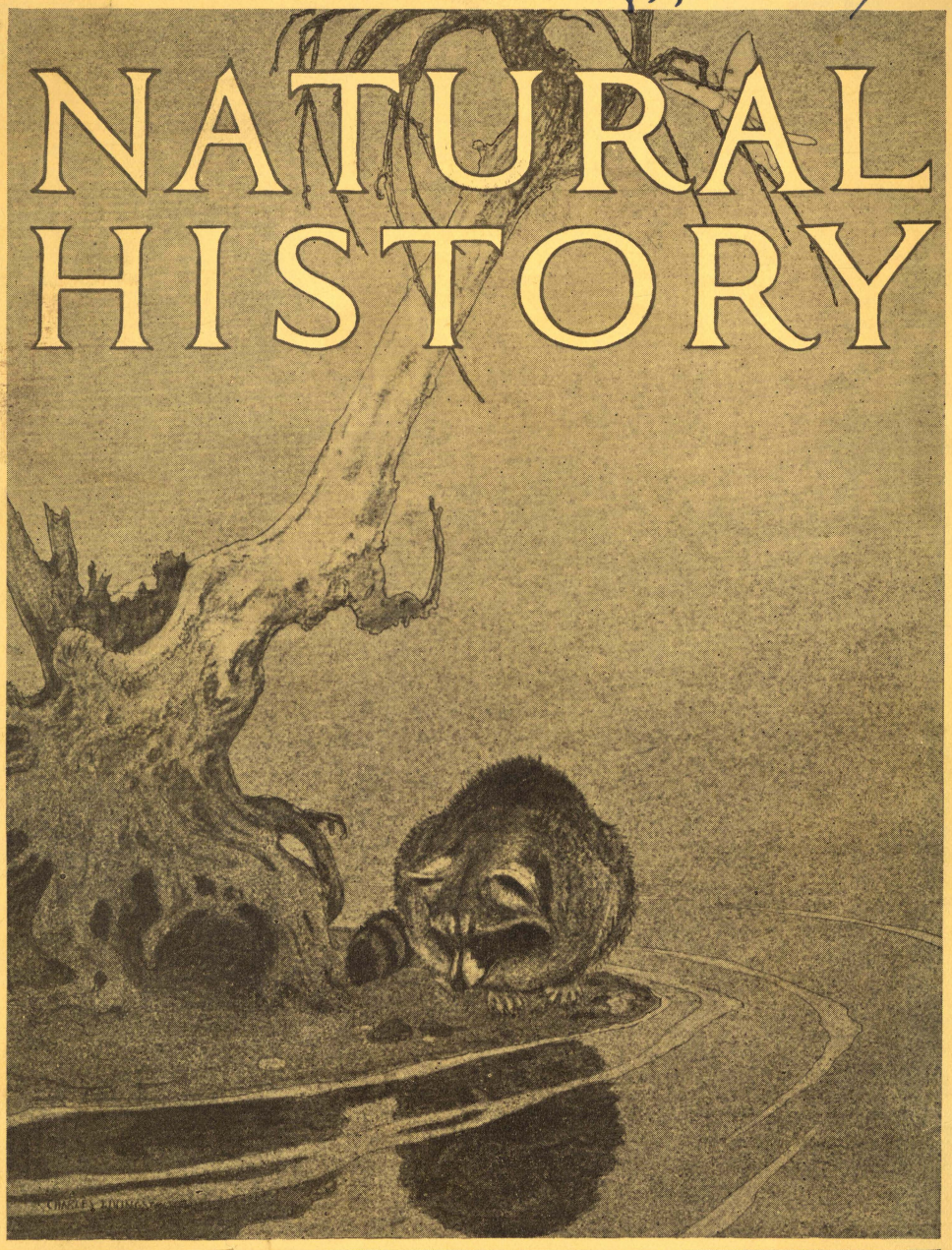
NATURAL HISTORY



JOURNAL OF THE AMERICAN MUSEUM OF NATURAL HISTORY

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NATURAL HISTORY

THE JOURNAL OF THE AMERICAN MUSEUM

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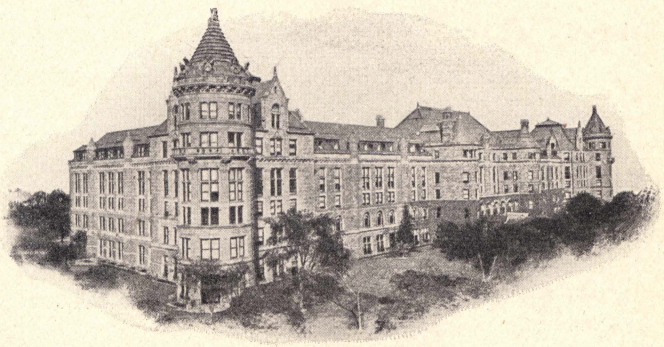

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JET AND TURQUOIS INLAY

These objects were found in the ruin of Pueblo Bonito by members of the Hyde Expedition

DATING OUR PREHISTORIC RUINS

THE SEARCH FOR CIVILIZATION'S TIME CLOCK IN THE SOUTHWEST MAY REVEAL DEFINITE FACTS REGARDING THE STORY OF MAN IN PREHISTORIC AMERICA

BY

CLARK WISSLER

FOREWORD.—The Archer M. Huntington Survey of the Southwest was organized in 1909 by Clark Wissler, curator of anthropology in the American Museum, to include work among the living Indians of the American Southwest as well as a search for the history of the builders of the ruins so numerous throughout that region. The persons who have taken an active part in the investigations are: P. E. Goddard, R. H. Lowie, H. J. Spinden, N. C. Nelson, Leslie Spier, E. H. Morris, and M. L. Kissell, of the American Museum staff. In addition, a special investigation of the Zuñi was made by Prof. A. L. Kroeber, of the University of California. The tree-ring investigation has been delegated to Prof. A. E. Douglass, of the University of Arizona, the originator of the method. The entire investigation to date has been supported by Mr. Archer M. Huntington.

FOR many years a band of wild Indians concealed themselves in a bit of wilderness in the mountains of California, but were at last reduced to a single man, who, after a hopeless struggle against hunger and want, staggered forth into civilization and into captivity. Through the humanity of two or three professors in the University of California, he was given a home. He became the subject of many investigations. One of these professors, an expert in archery, soon found that, although the Indian had always used the bow, his archery was inferior. The professor out-shot the Indian in every trial. Like every true professor, he began to inquire into the reasons for this, making a number of experiments, the outcome of which was that the white man excelled the Indian solely because his methods were better. There is a profound truth in this result. The civilized man of today is far more efficient than the man of the Old Stone age, chiefly because his methods are superior. The graduate of a medical college handles a case of typhoid, whereas an African conjurer would make a mess of it, the difference being one of technique. And we shall not be far wrong if we say that man has advanced in proportion to the improvements in his methods, particularly in his methods for getting at the facts.

Wells, in his remarkably readable *The Outlines of History* calls attention to the generally recognized fact that the status of astronomical knowledge is an index to the degree of civilization. And the fundamental thing in astronomical affairs is precision in the reckoning of time. This science began with the first efforts of primitive men to keep a date and advanced bit by bit until today the clock and the calendar are so intricately interwoven with our civilization that they could by no possible means be eliminated without destroying the whole fabric. One would have even more chance of keeping his rug after pulling out the warp than of maintaining a civilization without calendars or clocks.

But, you ask, what has this to do with ruins in the United States or elsewhere? It has everything to do with them. All of the earth sciences and all of those having to do directly with man are eternally concerned with time in one form or another. Geology, that dignified and imposing science of the rocks, would be a ghastly chaos without its periods, and what are these periods but marks on the time chart of creation! So, when we set out to study ruins, we are concerned first and last with their time-relations.

In 1909 Mr. Archer M. Huntington expressed himself as sufficiently interested in the prehistory of southwestern United States to finance a systematic survey of the ruins found there, with a view to discovering their time-relations. In other words, men

Photograph by N. C. Nelson

SECTION OF REFUSE HEAP AT PUEBLO BONITO, CHACO CAÑON, NEW MEXICO

Something of the history of any human settlement may be learned by examining the accumulations of débris thrown out from day to day during the life of the community. At Pueblo Bonito, one of the largest and most interesting ruins in the Southwest, and one from which the American Museum possesses extensive collections, the accumulated refuse lying in front of the village forms a long mound measuring about 75 x 500 feet at the base and all of 16 feet in height. In 1916 two separate trial sections were made, of which the above is the highest. The results were disappointing in that the broken pottery, and other industrial remains found showed comparatively little change during the supposedly long process of accumulation. Elsewhere in the Southwest the stylistic changes, for example, in pottery, are often very marked

were to be sent out to seek in these ruins the marks by which they could be arranged in order, according to their ages. So a research staff was organized to grapple with this problem and has been engaged upon it at intervals during all the succeeding years.

At the outset it was conceived that since the earth left telltale marks of its progress in the rocks and sands, so man in and about these ruins must also have left the record, if one could find out how to read it. Just lately, for example, a celebrated European geologist has been touring this country to see how the clays beneath our soil are laid down and he is reading in their hitherto imperceptible lines the successive pulsations of time. So in the case of the ruins, it promises to be but a matter of method, and the Archer M. Huntington Survey may be said to have as its object the discovery of civilization's time clock in the Southwest. Once with its key in our hands we can unravel many of the mysteries of the cliff dweller, the mesa dweller, and the builders of the great pueblos like Bonito and Aztec.

Experience in other parts of the world, particularly in Egypt and western Europe, suggested that the most likely means of dating ruins was to be found in the fragments of pottery scattered about. Pottery is truly an art, for while it has utility, it is at the same time so plastic in origin as to give almost free rein to styles of artistic expression and the use of decorative technique. Further, though pots are easily broken, their pieces are practically indestructible, so whenever and wherever pottery was made, one may find the samples. The record, therefore, is in the simple potsherds, and our problem was to find a method for reading it. Descriptions of technique are apt to be wearisome, so we will content ourselves with a few of the simpler steps in the method of dating ruins by potsherds.

In the first place, where things pile up on the ground, the first to go down will be at the bottom of the heap. In the days of our pioneer forefathers, a cabin was built in the forest, and a clearing made. As the ashes accumulated in the fireplace, they were dumped out behind the cabin. Here also were cast the sweepings from the hearth, bones, broken glass, dishes, etc. So, in the course of time, a considerable heap was formed in which was recorded, in one way and another, the story of what went on in the cabin. Now, it so happens that most of the ruins in southwestern United States are of the community type, that is, they contain a number of rooms, in a few instances as many as five hundred, one to a family. The families usually cast their ashes and sweepings in one place, where from year to year the community dump grew and grew, until in some cases it reached a depth of twenty feet. It was in these dump heaps that our investigators found part of the answer to their questions. Such a deep deposit of ashes and other waste contains several kinds of pottery and of these the oldest is at the bottom and the latest at the top.

This method of dating, according to which is above and which is below, is, for convenience, called the method of superposition, or the stratigraphic method, because it has some analogy to the earth's strata which the geologist interprets in terms of time.

If the people once living in what is now a ruin in southwestern United States had never moved away and had always rebuilt near the same spot, there would be little difficulty in reading their history. All we would then need to do would be to dig a trench through the accumulated ashes, sweepings, etc., and study the markings and contents of the exposed sections, where everything is laid down more or less successively in order of time. But nowhere is the problem so simple. Every now and then the population shifted. For aught we know, new peoples came as conquerors and evicted the rightful owners.

Photograph by G. H. Pepper

DETAIL OF CEILING IN PUEBLO BONITO

This rectangular room has ceiling beams of pine placed transversely and covered with a layer of willow stalks, which in turn is covered with cedar bast; a four-inch layer of adobe over this formed the floor surface of the room above. The bark-stripped beams and peeled willows give the ceiling the most ornate appearance of any in the pueblo

Photograph by E. H. Morris

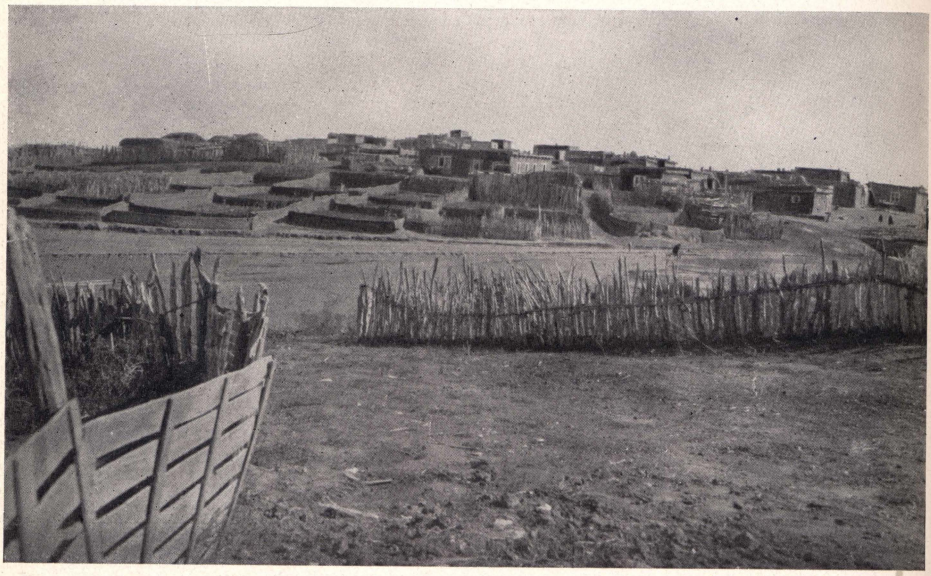
CEILING CONSTRUCTION AT THE AZTEC PUEBLO RUIN, NEW MEXICO

The Pueblo Indians from the earliest times to the present appear to have used only two types of ceiling construction, of which the above is the simplest and most common. Heavy timbers up to eighteen inches in diameter served as chief support and were laid usually (not so in the illustration) two or more feet apart and across the long axis of the chamber. Resting on these came a longitudinal course of lighter timbers, placed only a few inches apart. Next above was placed a transverse course of thinly split timbers, or else sticks, laid as close together as possible. This in turn was covered with a layer of twigs, bark, or grass and then capped with a few inches of clay or adobe, pounded down hard. The surface of the adobe, if it was to serve as a floor, was sometimes coated with blood and then smoothed and polished with a stone

Photograph by N. C. Nelson

VILLAGE OF TAOS, NEW MEXICO

This is the northernmost of the Pueblo villages in the Rio Grande Valley and one which has been sufficiently conservative to have preserved for us another type of communal house construction. The village consists of two main buildings, each four or five stories high. These buildings are terraced in the shape of a rough pyramid, in place of being terraced only on the south side, as in the case of Acoma. The doors, windows, and chimneys, as well as the hive-shaped ovens to be seen on the ground level adjoining the buildings, are of European origin. Population in 1910 was about 500



Photograph by N. C. Nelson

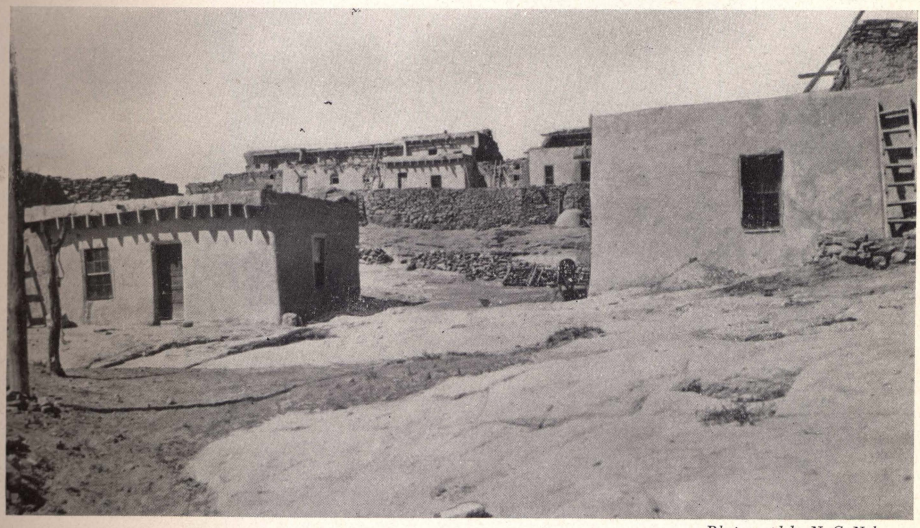
VILLAGE OF ZUÑI, NEW MEXICO

This is the largest Indian village in the United States, having a population of about 1700. It is the home town, as it were, of a separate tribe or linguistic stock, many members of which live in outlying settlements during the farming season. The apparent rise of ground on which the village stands is due in part to the accumulated débris of fallen houses surmounted by later constructions. Until recently the building material consisted largely of sun-dried clay or adobe. The fenced areas are garden plots. The Zuñis were the first of the Pueblos to come in contact with the Spanish explorers more than 350 years ago

Photograph by N. C. Nelson

STREET SCENE IN ACOMA, NEW MEXICO

This Keresan village is unique in several respects. It is built on top of an isolated rock about 360 feet high, and has occupied that fortress-like situation since before the white man invaded the country in 1540. Probably, therefore, it is the oldest inhabited community in the United States. Again, this village, housing today about 700 people, preserves for us one of the most highly developed types of ancient Pueblo architecture. Thus it consists of three long, parallel, communal buildings, all facing south, there being no doors or windows in the north wall, which latter rise sheer two or more stories, as seen in the left of the picture. In the foreground at the east end of the principal "street" may be seen the water reservoir, occupying a hollow in the surface of the great rock. This stronghold was stormed and partly burned by the Spanish in 1598



Photograph by N. C. Nelson

VILLAGE OF LAGUNA, NEW MEXICO

This village was founded in historic times, which partly accounts for its lack of architectural compactness. Thus here, in addition to the modern doors and windows, we see isolated one-story houses, strongly suggestive of the breaking up of the communal form of organization. To this might be added the further fact that the greater number of the population credited to this village, 1441, actually live in small outlying settlements, all far more favorably situated for agriculture and stock raising than is the home village itself

Photograph by N. C. Nelson

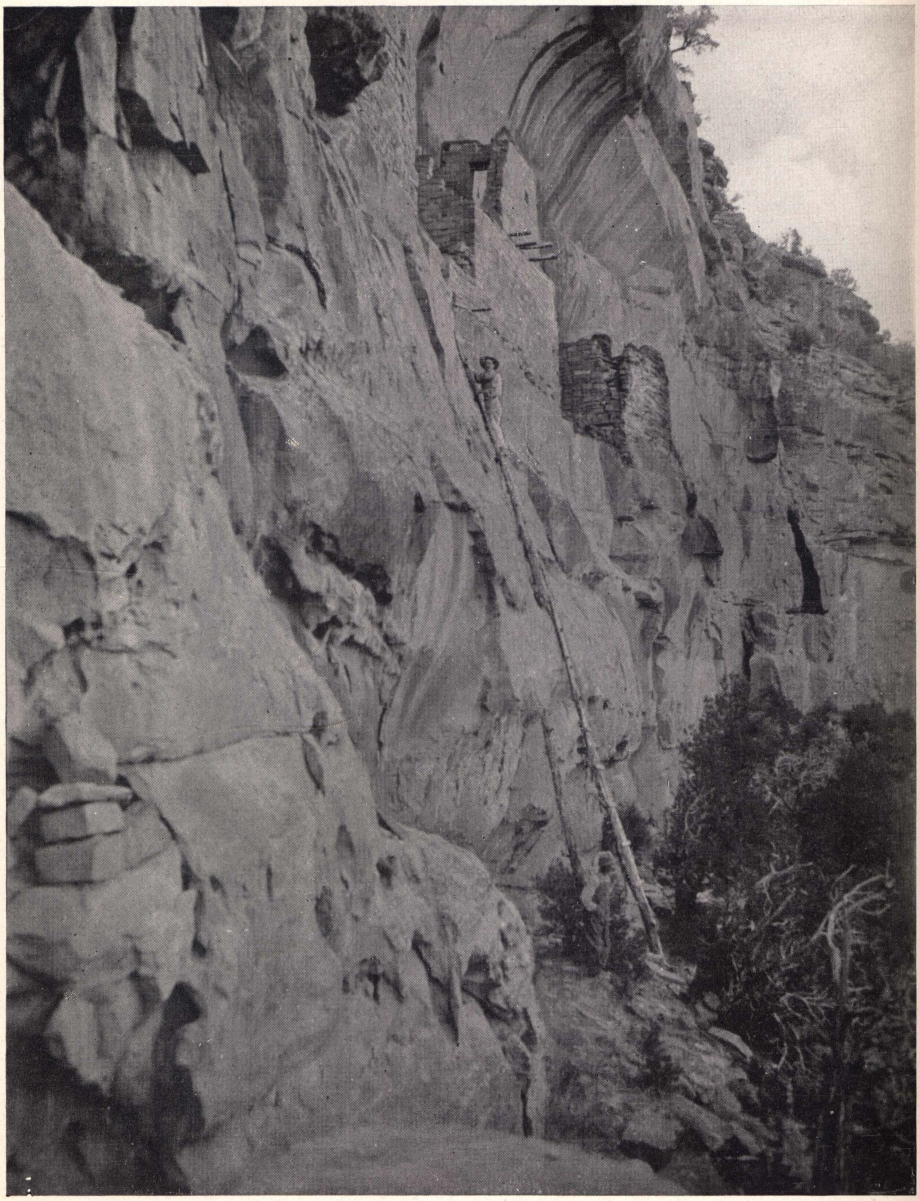
SPRUCE TREE HOUSE, MESA VERDE, COLORADO

Of the several large cliff houses in the Mesa Verde National Park, Spruce Tree House is the most picturesque with respect to situation and is, besides, a fine example of this type of habitation. The ruin was discovered by members of the Wetherill family of Mancos, Colorado, in 1888; it was partly excavated by Baron G. Nordenskiöld, of Stockholm, in 1891, and in 1908, was completely cleared and repaired by Dr. J. W. Fewkes, of the Bureau of American Ethnology. The ruin occupies a shallow natural cave, 89 feet deep and 216 feet long. It contains 114 secular and 8 ceremonial rooms, and it is estimated that it accommodated a population of about 350

Photograph by N. C. Nelson

BALCONY HOUSE, MESA VERDE, COLORADO

Balcony House, so named from the shelf or veranda on the second-story level seen near the extreme right of the picture, is regarded as exhibiting the highest architectural achievements of the Mesa Verde cliff dwellers. It is one of the best preserved ruins of the communal cliff-dweller type, several of the twenty-five rooms being intact. A retaining wall, in places raised high enough to serve as a balustrade, is to be seen along the front of the cave, keeping enemies out and preventing the younger inmates from falling into the deep chasm below



Photograph by N. C. Nelson

CLIMBING TO "INACCESSIBLE HOUSE," MESA VERDE, COLORADO

The manner in which the original cliff dwellers reached their most secure abodes is not always apparent. In some places, where no natural edge gave access, traces of steps cut in the living rock remain; elsewhere, small holes sufficiently large for the insertion of the toes and the grip of the fingers have been chiseled into the steep face of the cliff, sometimes along a horizontal and sometimes along a vertical line. Commonly, however, there is no evidence whatever either of natural or artificial approaches, and we must suppose that the inhabitants entered by means of ladders. To reach some of these eyries is one of the exhilarating features of a trip to the cliff-dweller regions

Anyway, what we do find is that some ruins were occupied for a very long time, others for but a brief time, but none of them for all of the time. So, to get a time chart for the Southwest as a whole, the results obtained from many, many different ruins must be patiently pieced together and by precise methods. Just how this was done is a long but interesting story, but what we are now concerned with are some of the results obtained by the use of these methods.

Before going on we should note that the Archer M. Huntington Survey is making use of other methods of estimating time. Many of the ruins encountered still hold the spruce and cedar logs used to support the ceilings. Now, it so happened that a specialist in the growth of trees had devised a method by which he could tell whether the trees from which logs were cut were growing at the same time, or to what extent their life periods overlapped. This again is a triumph in the precision of method by which the annual growth rings of the trees are read as time charts. So the logs in the ruins were subjected to these methods and some interesting things found out. For instance, all the logs in the great ruin at the town of Aztec, New Mexico, seem to have been cut within a span of nine years or less, which would mean that the whole of the great building, with its four hundred or more rooms, was planned in advance and built with astonishing speed, when we take into consideration that all of these timbers were worked with stone tools and the stones of the walls dressed by pecking with sharp-pointed pebbles. But this is not all, for timbers from the great ruin of Bonito in the Chaco are being compared with those from Aztec to see which ruin is the older. From the results so far, it appears that Bonito is the older by at least a quarter of a century. The work, however, has not yet gone far enough for us to be certain of this. All that we need note here is that where timbers are preserved we can even read the time records in their cross sections. Professor A. E. Douglass, the discoverer of this remarkable method, explains in another article just how the thing is done and shows us how he measures the growth of living trees. Our only point here is that this is another improvement in our methods for dating ruins in the Southwest and was first applied to them by the Archer M. Huntington Survey.

It may be that the work of this Survey has not gone far enough to give us the outlines of man's career in the Southwest, but it can give it with some precision for two large areas in which the most intensive work was done. One of these areas is in the vicinity of Santa Fe, along the Rio Grande in the state of New Mexico, the other is the extreme northwestern part of the state and the adjoining parts of Arizona, Utah, and Colorado, or the basin of the San Juan River. A glance at a map will show that these two areas stand as two large samples of the central area of Pueblo Indian culture and so may be considered representative of the whole. Fortunately, other investigators are working in adjacent fields so that the results of all can be coördinated, thus giving us, for the first time, a chronology for this prehistoric wonderland of our country. Since, as we hinted at the outset, the best indexes to time differences are the changing styles of pottery, so the large historical periods under which the ruins are grouped are named in terms of pottery. This does not mean that these styles of pottery are the only distinguishing characteristics between the periods; each of them can be checked with architectural features, for example, but pottery characters are the most accessible and lend themselves most readily to the method of superposition. So remembering that the successive styles of pottery are merely indexes, and that by them we can determine the time sequence in the historical development of the Indian in the South-

west, the periods in the following chronological table will be understood:

(7) The Historic Period (1540–1921); pottery index, Two-Color Glazed Ware, modern type.
(6) Period of Three-Color Glazed and Painted Wares (?–1540); this is the latest prehistoric period.
(5) Period of Two-Color Glazed Wares, early type.
(4) Late Period of Two-Color Painted Wares.
(3) Early Period of Two-Color Painted Ware.
(2) The Pre-Pueblo Period, crude pottery only.
(1) The Initial Period, or Basket Makers, pottery generally absent.

One of the first things to strike us in this table is that the historic period begins in 1540 and that all before that is prehistoric. This may sound strange, for in the Old World prehistoric often means earlier than a few thousand years B. C. Yet, since the first visitor to the region we are now considering came in 1540, that is when its real history begins. All this serves to show how arbitrary and artificial is the distinction between what is history and what is prehistory. Although six of the seven periods outlined above cannot be dated in the strict sense of the word, we can nevertheless give their relative time-relations, for we can prove one to have come after the other. We can go even further and estimate the length of the periods as shorter or longer in proportion to the territory they cover and the number and variety of their remains. Yet, the details of this cannot be entered into now.

When the first Spanish expedition came on the scene in 1540, they found Indians living in large houses, just as they do today, the Hopi, Zuñi, and the many tribes about Santa Fe which, for convenience, we designate as Rio Grande Pueblos. These are the people of the historic period (7), and it is from the study of them that we can the more readily understand the preceding periods. For example, in 1540 no such people were living anywhere in the valley of the San Juan where we find the great ruins like Aztec and Bonito, excavated by the American Museum; in fact, these great ruins belong to Period 4 in our table, and so far no ruins have been found in that area that fall in any of the later periods, although some of the ruins belong to Period 3 and some to Period 2. On the other hand, we know that the people who, in Period 5, built the ruins farther east, around the upper Rio Grande, copied largely from the older inhabitants of Aztec and Bonito. Anyway, they had the same styles of pottery and the same architectural ideas. This is one of the many interesting points brought out by the Huntington Survey and it means that, in the earlier prehistoric periods, what we know as modern Pueblo culture had its beginnings in the region of the San Juan or that part of the United States adjacent to the four corners of Arizona, New Mexico, Utah, and Colorado. Then, for some reason, the center of culture shifted eastward to the valley of the Rio Grande, with a few outposts elsewhere. Probably it was the same kind of a shift as that from Greece to Rome, or better still, like the movements in civilization that left the glorious Babylon a wreck in the desert.

The cliff houses about which so much has been written and which so stir the imagination are all in and about this same San Juan country. These also belong to Period 4, and some of the houses in what is now Mesa Verde Park were almost contemporary to the great ruins of Aztec and Bonito. Perhaps some of them were earlier; that remains to be found out. Certainly many of the cliff houses of the adjacent parts of Utah are earlier, falling at the opening of this period.

There are many other interesting points in the story of the Southwest, some of which are shown in the arrange-

Photograph by G. H. Pepper

PUEBLO BONITO, CHACO CAÑON, NEW MEXICO

This photograph taken from the cliff shows the west third of the ruin partly excavated. In the foreground may be seen under construction the field laboratory of the expedition

ment of the collections in the American Museum. The attainment of the above chronological outline and the perfecting of the methods noted for reading the time-relations of ruins has been a slow and laborious process and is, like most things of this kind, not the work of a single individual. A number of investigators have given their best efforts to the problem, but the Huntington Survey has predominated in the two regions noted, the San Juan and the east Rio Grande district, through the work of Mr. N. C. Nelson and Mr. E. H. Morris, of the American Museum staff. The work now under way promises to reveal the subdivisions of the periods given in our table and thus render our dating more exact. It seems clear then, that the Archer M. Huntington Survey will in the end contribute something precise and definite to the story of man in prehistoric America. It has already given us better methods and, as we have seen, the attainment of better methods promises new triumphs.

Two fine examples of two-color painted ware from Pueblo Bonito. The colors are black and creamy white

A PAINTED TABLET OF WOOD

From the ruined pueblo of Bonito, New Mexico. The Hyde Expedition

DATING OUR PREHISTORIC RUINS

HOW GROWTH RINGS IN TIMBERS AID IN ESTABLISHING THE RELATIVE AGES OF THE RUINED PUEBLOS OF THE SOUTHWEST

BY

A. E. DOUGLASS*

THE freedom from undergrowth of the pine trees of northern Arizona and their exposure to the characteristic drouths of the country, first suggested to the writer the idea that their chief variations in growth had a climatic origin. Accordingly a long search was made for evidence of climatic effects, which has resulted in the identification, dating, and measurement of more than 100,000 rings in nearly 400 different trees. Many interesting results have been obtained, and an extensive technique of ring-study has been developed. Of that technique the most important feature of present interest is the cross-identification of the growth rings in the different timbers. This was first developed in 1911 in studying trees near Prescott, Arizona, where it was found that nineteen trees out of twenty had ring systems showing marked resemblance to one another. This gave additional confidence in the yearly identity of the rings and the climatic character of their major variations. The extent of area over which this extreme similarity is found may be only a half mile, as in the mountainous region near Prescott, or 50 miles as found between groups in the Sequoia region, or even more than 200 miles, as shown between Flagstaff, Arizona, and Durango, Colorado. Occasional rings of extreme character are found to be alike in the Sequoias of California and in the pines of Arizona, 450 miles away. Very rare rings have been traced across 750 miles of country.

In 1915 Dr. Clark Wissler wrote a letter expressing interest in the study of tree rings and offering sections of beams from ruins in New Mexico. The offer was gladly accepted and a selection was made at once from beams, from surrounding trees, and from trees growing in ruins. From these specimens it was evident that pine and spruce beams were very good for this study, while juniper often was very disappointing. In 1918 Mr. Earl H. Morris, working in the Aztec ruins for the American Museum, sent six sections from Aztec and three from Pueblo Bonito, in Chaco Cañon. The six from Aztec were immediately found to cross-identify, three or four of them very well and the other two or three only fairly. The three from Chaco Cañon have not yet been identified.

Part of this was very encouraging, and in August, 1919, I visited Aztec in order to plan more satisfactorily the next step. I found that the sections had come from a pile of loose beams whose exact locations in the ruins were not known. It was immediately evident that the location of each beam should be known and that a way must be devised to get the rings without injuring the floor beams or other parts of the structure still in a good state of preservation. Accordingly soon after this visit I had special borers made of steel tubing, one inch in diameter, with saw teeth at the one end and brace attachment at the other. Small teeth, some ten to the inch, have proved better for dry beams than coarse teeth of twice that size. These borers were tried out at the laboratory in Tucson and the fine-toothed one sent to Mr. Morris. With patience and skill he has used this borer on the beams at Aztec and obtained for me cores from twenty-six beams located in sixteen different rooms, without injury to the ancient construction of the building.

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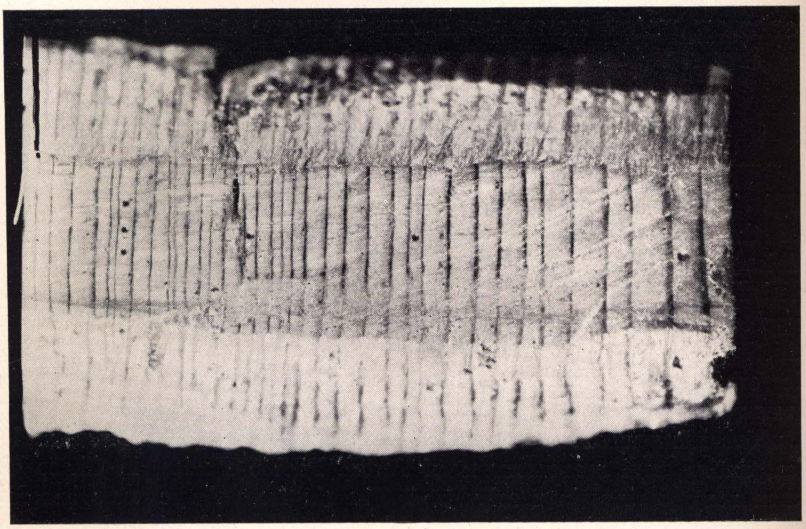


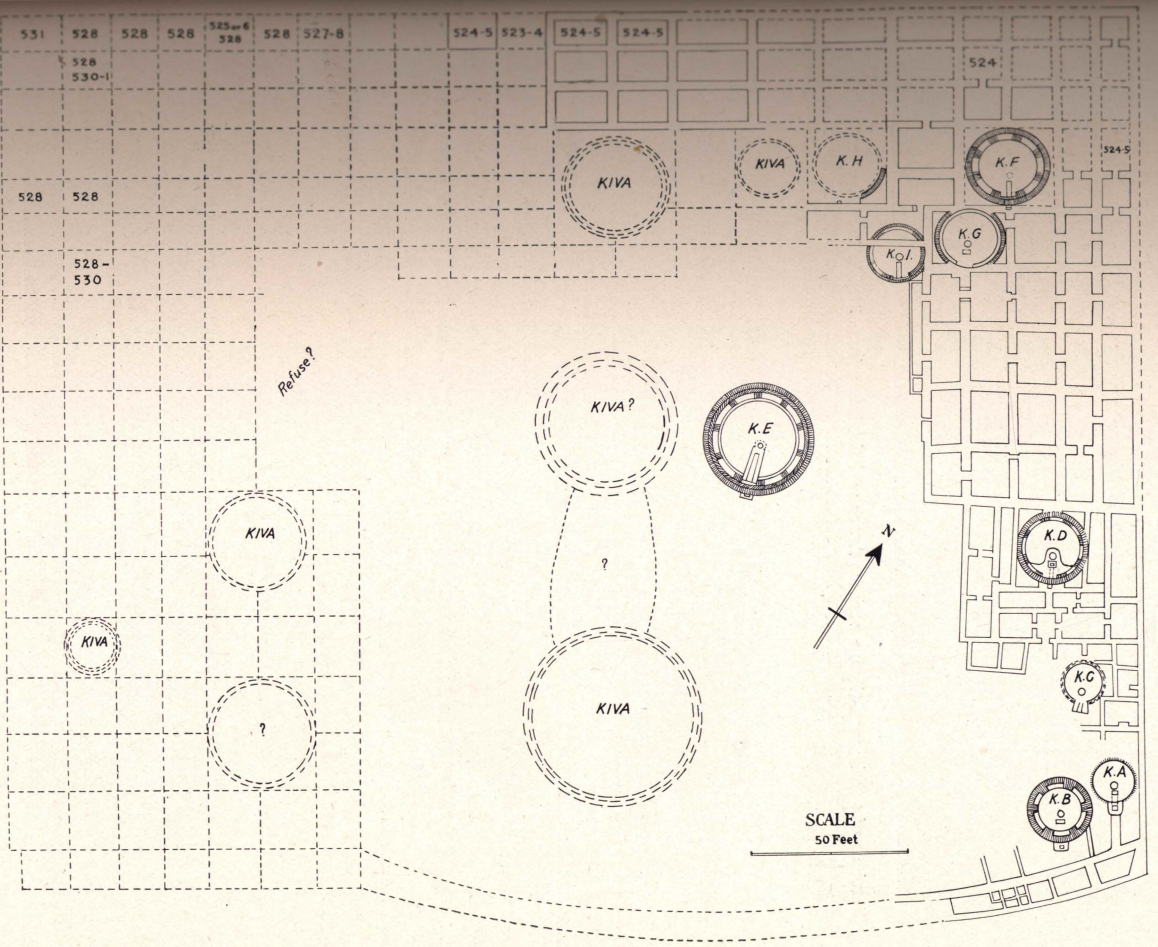
Core from northwest corner room at Aztec, showing latest cutting date, R.D. 531. Three black dots (really pin pricks in the wood) form the century mark, one dot indicates the decade. (Twice natural size)

I obtained finally the ring-records of thirty-seven different beams, of which thirty-two were accurately located in the ruins. About twenty different rooms were included, passing across the large north portion of this great 450-room building. The cross-identification in nearly all was perfectly easy and satisfactory and the relative dates of cutting the timber ascertained. In order to express these conveniently a purely hypothetical date, R. D. (Relative Date) 500, was assumed for one of the larger of the outer rings and all dates expressed with reference to that year, whatever the real date in our era may have been.

It will be seen from the diagram that nine years will cover the time of cutting the various timbers examined and that it was not continuous. The principal cutting years were R. D. 524–25 and 528. The builders probably worked in the forest in the colder part of the year and obtained enough logs to last two or three years. These were used until nearly or entirely exhausted, when more were obtained.

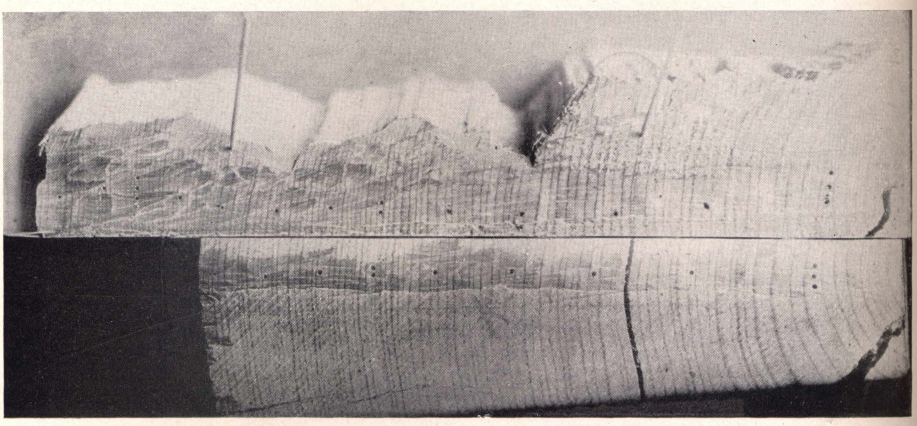
As a result of this study, the beams brought back to the American Museum by the Hyde Expedition to Chaco Cañon, twenty-five years ago, were examined and sections cut from seven. Of these one was cedar and could not be interpreted and one was a small pole used in pueblo floor construction to lay upon the beams. Two were posts, the rest ceiling beams. It was noticed that a peculiar sequence of rings occurred near the outside of each. This made the determination of the relative cutting dates in this group very easy. Then it was recollected that a similar sequence existed in the Aztec beams. Upon careful comparison the cross-identification between these ruins became absolutely convincing. Similarity was found for the years R. D. 480–84, 475, 470, 461, 454, 448 or 449, 435, 432, 427, 423, 418, 408, 406, 402, 393–95, etc. There is no doubt that the beams in Aztec and Pueblo Bonito were living trees together during more than a hundred years and that the cutting of the timbers for Aztec followed that for Pueblo Bonito by from forty to forty-five years.

Finally one beam from Peñasco Blanco, a few miles down the Cañon from Pueblo Bonito, appears to have



PLAN OF THE AZTEC RUIN

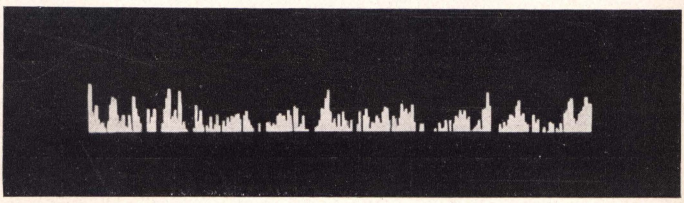
This shows the location of the dated beams, with the relative dates of the cutting of the timbers, and the condition of the excavations at the end of 1917. Much has been done since



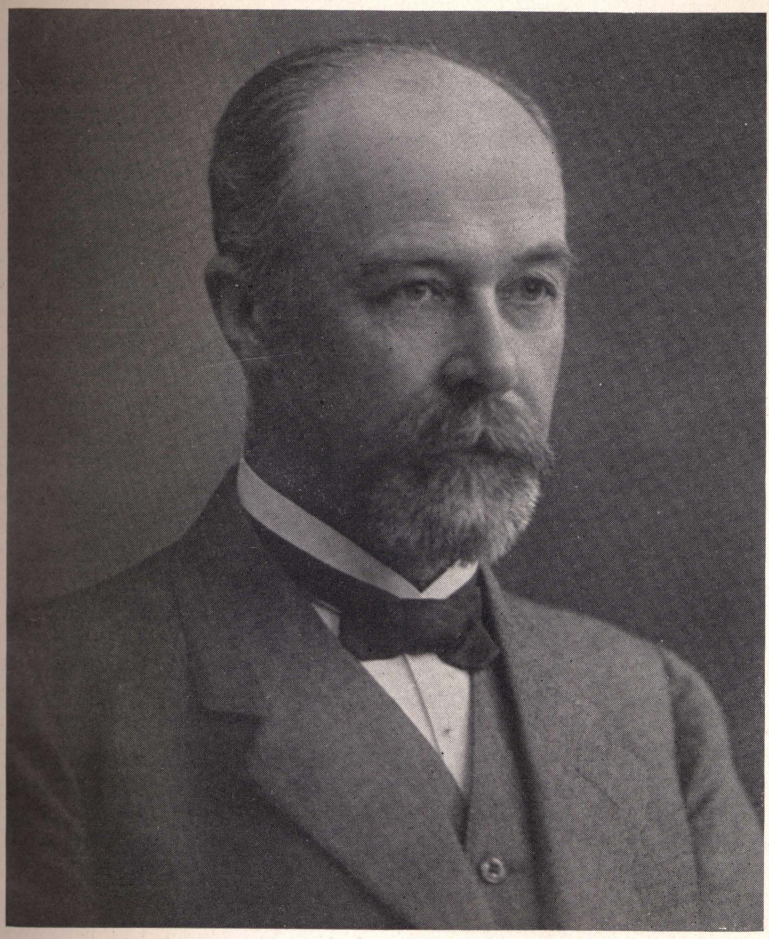
Sections of two beams, the upper from Aztec and the lower from Pueblo Bonito, placed side by side with their rings matching, to show how much the Aztec timbers grew after the Pueblo Bonito timbers had been cut

been cut about twenty years after the greater number of the Pueblo Bonito beams. Two of these Pueblo Bonito beams are from identified rooms, namely 32 and 36 as numbered by the Hyde Expedition.

In conclusion I should state that an extensive study has been made of the types of growth records which most nearly resemble the rainfall periods in localities near by and very careful selection and weighting of the Aztec and Pueblo Bonito curves of tree growth have been completed. The resulting curves have been combined and standardized and show yearly growth as in the accompanying figure. This curve undoubtedly gives us a fair idea of rainfall variations near this ruin during the two centuries preceding its construction. There is reason to hope that by the aid of the Sequoias it may sometime become possible to determine just how long ago this particular sequence of variations occurred in northwest New Mexico.



Tree growth at Aztec and Pueblo Bonito from R.D. 288 to R.D. 527, arranged to test climatic periods by an optical method



Baron Gerard De Geer, Professor of Geology, University of Stockholm

BARON GERARD DE GEER AND HIS WORK

BY

JAMES F. KEMP*

AMERICAN and Canadian geologists and many others interested in geological science have recently had the great pleasure and privilege of welcoming on this side of the Atlantic Baron Gerard De Geer, past-president of the International Geological Congress of 1910, professor of geology in the University of Stockholm, and foremost among the European investigators of the great Ice Age. Baron and Baroness De Geer, with two experienced assistants, have been applying in Canada and the northeastern United States the methods of investigation already carried by them to an almost perfect technique in Scandinavia. Very promising results are indicated, and in Canada and the United States the full publication of the report of the expedition will be awaited with deep interest. Geologists in these two countries have already profited greatly by field trips, conferences, and lectures extended by our distinguished visitors.

Baron De Geer is now in his sixty-

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third year. His university training was gained in the ancient seat of learning of Sweden, Upsala, where the traditions of Linnæus and Berzelius still linger. While yet a candidate for his degree, he began his work on the Swedish Geological Survey in 1878, and soon became especially attracted by the problems presented by the moraines, sands, and clays left by the retreating continental glacier in the geological times just preceding our own. In 1882 he made the first of five trips to Spitzbergen, then a No Man's Land in the Polar sea. In 1896, 1898, and 1901 he went again, and in 1910 he conducted a large party from the International Congress of that year. The Spitzbergen work has thrown a flood of light on the geological formations of this far northern land and has given a clue to the structure and large tectonics not alone of the islands but of the North Atlantic ocean bottom, as well.

Baron De Geer's most interesting results have been attained, however, in the study of the laminated clays which were deposited in many parts of Sweden from south to north. It appears that the melting and retreating continental glacier backed up in front of it extended bodies of fresh water, which often reached considerable depths next the ice itself. Into these waters the sediment-laden streams, fed by the melting ice, poured from tunnels in the bottom of the glacier just as they do now from the fronts of glaciers resting on the surface in the valleys of the Alps and elsewhere. In the warm seasons the melting was great and the supply copious; in the winter the melting ceased and the streams failed. Following the cold months the supply of water and suspended sediment was renewed and passed through the annual cycle of the seasons. The sediments in the cold and heavy waters spread out over the lake bottom and, as they settled, produced widely extended deposits of laminated clays.

The laminated clays thus were laid down in annual layers of the same significance as are the rings of growth in a tree trunk. As melting waned in the autumn, the amount and coarseness of the sediment fell off, giving a layer of fine, fat clay, which is easily recognizable and which marks the close of a year's work. By its aid the annual increments can be detected, measured in thickness, and counted. They vary widely. Some may reach six inches when the summer was unusually hot and melting was copious. Some may be only an inch or even less, corresponding to cold summers which may have been occasioned by sun spots. When the annual layers have been measured by ingenious and expeditious methods, the thickness of each one can be represented to scale by a vertical line, and the lines can be drawn in series, standing one half centimeter apart upon one base line for a long series of years or measurements. When the summits of these vertical lines are connected, a saw-tooth curve results which practically shows the ups and downs of the seasons, the very hot ones being shown by high summits in the curve, the very cold ones by low notches.

After years of work in developing these methods, Baron De Geer realized that, of the markedly hot seasons, each prevailed over a wide area, and would be recognizable by its especially high summit in the curves which were plotted for separated places perhaps many miles apart. The summit was necessarily preceded and followed by characteristic ups and downs. Matching the curves soon revealed such startling uniformity that individual years could be correlated without an appreciable chance of error. Still more remarkable was the later discovery that curves taken in Finland across the Baltic Sea and the Gulf of Bothnia, as well as others over the mountainous divide in Norway, could be matched with those established in Sweden, and the same years in each could be recognized. Now comes the question, can they not also be matched and compared with those taken in North Amer-

ica, since study of comparative meteorological records today brings out a practical uniformity in hot years and cold years on both sides of the Atlantic.

Baron De Geer was therefore moved to come to America, measure as many exposures of laminated clays as possible, plot the curves, and compare them with his series of similar ones in Scandinavia. In the four months since his arrival in August last he has found exposures of much interest in Vermont, Quebec, Ontario, Wisconsin, New York, and in the Connecticut Valley of the New England States. In the elaboration of the details he will be greatly aided by his assistants, Dr. Ernst Antevs and Dr. Ragnar Lidén. The former is spending a year in the United States, working over the problems during the closed season at one or two of the American universities, and with the coöperation of American and Canadian friends and colleagues, will resume field work when the warm weather comes around again. Should the establishment of correlated years result for both sides of the Atlantic it would be a great step forward.

In Sweden Baron De Geer has reached a measurement of about 13,500 years for the retreat of the continental glacier across Sweden. For the first portion of the time of retreat, which is represented by the area lying between the terminal moraine in Denmark and Germany, and which is partly beneath the North Sea, measurements are less accessible than for the succeeding stages. The latter are, however, almost, if not quite as accurate as if he could have counted the rings of growth on a gigantic, long-lived tree. In southern and central Sweden 5000 years have been established, with an almost negligible limit of possible error, and in northern Sweden 8500 years with a possible error of one or two centuries.

Various interesting corollaries follow. For instance, a deposit of prehistoric flint implements has been found on a delta in Sweden whose relations with known laminated clays can be made out, giving a pretty accurate clue to the number of years ago that primitive users of flint followed the retreating ice into Sweden. Again, the continental glacier extinguished plant life, and, on its retreat, gradually the vegetation followed it northward. The actual number of years can now be quite closely made out, and the time required to change inhospitable sands, gravels, and clays to soils capable of supporting the present plants and trees can be determined. A chronology is afforded for the distribution not alone of plants, but of animals as well. Should a parallel chronology result for America, we shall be able to check the estimates of time already based on the retreat of the crest of Niagara Falls, on the retreat of the Falls of Minnehaha, of the Mississippi, and the one or two local attempts by American observers to count clay layers in single localities.

NOTE.—The arrangements for the trip of Baron De Geer and his party through the United States and Canada were under the general charge of the American-Scandinavian Foundation, with coöperation from the International Educational Alliance. The following groups of American and Canadian geologists cordially joined in making the trip a success: President Henry F. Osborn, of the American Museum of Natural History; Director George Otis Smith, of the United States Geological Survey; Dr. I. C. White, president of the Geological Society of America; Vice Chancellor Adams, of McGill University; President Branner, of Stanford University; Professor Chamberlin, of Chicago University; Professor Coleman, of Toronto University; Dr. W. O. Hotchkiss, director of the Wisconsin Survey; Professors Kemp and Luquer, of Columbia University; Dr. Leverett, of the United States Geological Survey; Professor Lindgren, of the Massachusetts Institute of Technology; Professor Scott, of Princeton; Dr. Upham, of Minneapolis; and Professor Woodworth, of Harvard. An executive committee consisting of Consul General Lamm, of Sweden, Mr. John G. Bergquist, Dr. I. C. White, Dr. Waldemar Lindgren, Dr. H. G. Leach, president of the American-Scandinavian Foundation, with Dr. J. F. Kemp as chairman, gave attention to the details. Baron De Geer lectured at Chicago, Columbia, Cornell, Harvard, and Michigan universities; and before the American Geographical Society, the American Philosophical Society, the Carnegie Institution, the National Academy of Sciences, and the New York Academy of Sciences. At the annual meeting of the last-named he was elected one of the limited number of Honorary Members.

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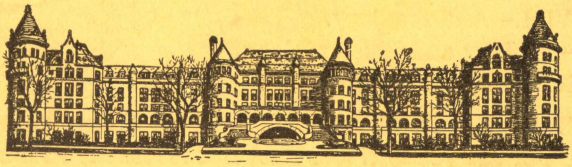

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