

TECHNICAL PROGRAM

Following the program of entertainment, President Leon B. Reynolds introduced Dr. A. E. Douglass who gave a most interesting address accompanied by moving pictures and lantern slides. The following is a synopsis of his address.

"TREE RINGS AND DATING OF SOUTHWESTERN PREHISTORIC RUINS"

By Dr. A. E. Douglass, Director Steward Observatory
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The work on tree rings which has led to climatic history and the dating of prehistoric ruins began as an astronomical study. In 1901 the attention of astronomers was strongly directed toward solar problems. There seemed a fair chance that a history of changes in solar radiation would be reflected in the growth rings of the pine trees of northern Arizona. This was based on a belief that the sun affects our weather and that the weather, especially in a dry climate, affects the growth of trees. This sequence of cause and effect has been confirmed by finding the 11-year sunspot cycle unmistakably in the growth of southwestern trees. Other cycles are present but the reality of the sunspot cycle has been confirmed by the fact that its present and absence in the trees since 1600 correspond to observed changes in spot activity since the invention of the telescope. There is reason to think that the other cycles found in trees, greatly confusing the situation, are related to the sunspot cycle in the form of simple fractions of small multiples of the 11-year cycle.

But the relationship of trees to weather has taken on the highest interest because it leads to the two results mentioned above, namely, climatic history and the dating of ruins. In this dry climate the trees act as rain gauges by which a continuous record is maintained in several parts of the tree but most especially in the rings, which may readily be investigated on the surface of stumps or across the ends of logs. A wet year in northern Arizona produces a large ring in the pine trees, and a dry year produces a small ring. This common characteristic over a large area was first observed by the writer in 1911. It makes possible the building of a climatic chronology by what is known as the bridge method. The chronology is first carried back as far as possible in living trees which are carefully compared together, or cross-dated, to eliminate all errors of identity. By similar cross-dating, exact dates are carried from the inner parts of living trees to the outer parts of beams from early Indian villages. In this way we have found that the village of Oraibi was built before 1400 and occupied continuously ever since. By these beams the chronology was extended some 200 years, and then by crossing to beams from still older ruins the ring sequence was extended further into the past. Thus 22 generations of trees have been used to extend a chronology back to 700 A. D.

It is quite evident that when any of the rings in a prehistoric beam are thus dated with precision the date of cutting the tree may be obtained, sometimes with perfect precision and sometimes only approximately. If the beams are complete in growth as in Pueblo Bonito and Aztec very exact building dates are obtained. If the beams are worn down on the outside from long use as in Oraibi and other Hopi villages, a correction has to be made for such wearing, determined by the date separating heart-wood from sap-wood. Thus the development of a climatic chronology in the Southwest has led to the construction of a precise human chronology in the Pueblo area.

All the prehistoric and climatic studies in tree rings must be founded on careful studies of the growth of modern trees in the same area. In this way results are standardized and prevision is obtained of the probable degree of success of cross-dating beams from prehistoric ruins. For this purpose samples are obtained from modern trees, largely by the well known Swedish increment borer, which gives a slender core one-fifth inch in diameter and 8 to 10 inches long. This is rapidly and easily made and supplies large quantities of material used in the comparisons between modern trees. A more complete method and one used very extensively by the author is the V-cut, made in the top of a stump. This is done by two shallow cuts of the saw, each one across the stump, slanting towards the other, and including the center between them. This brings away a triangular piece of wood that gives the complete succession of rings.

When the rings are examined in the yellow pines of Arizona, or the sequoias, they are found to differ in size from year to year. These differences constitute the climatic details which permit cross-dating and the building of climatic and archaeological chronologies. These ring growths at Prescott, in northern Arizona, have been compared with rain-fall and have shown striking similarities. The agreement was 70%, raised to over 80% by a conservation formula. Bearing this interpretation in mind for these dry climates we find that there has been a great drouth in the vicinity of 1900, at which time its chief maximum took place, secondary maxima appeared some 20 years before and after. A previous great drouth took place in the late 1500's, and the greatest of all from 1276 to 1299.

While one may give a rainfall interpretation it is evident that in moist climates the reaction of the tree may be somewhat different. Thus in north Germany the pine trees give a very remarkable record of the sunspot cycle. In fact, over the larger part of north Europe there is an increase of growth during sunspot maximum. There is also a tendency to produce a secondary maximum of growth at sunspot minimum. A similar relationship between sunspottedness and rainfall was first brought out, so far as I know, by the German meteorologist, Hellmann, and I have therefore called it the Hellmann relation.

In studying these variations the mathematical processes were too cumbersome and expensive, and a completely new optical method was devised and published about 1915 and has been subject to improvement since then. This was called the cyclograph method and depends upon interference between a pattern produced by the plot of the original observations and an analyzing plate consisting of equally spaced transparent parallel lines. Applying this method to very large numbers of tree ring records obtained in the western states has brought out the probable existence of a relationship between the cycles in western trees and the sunspot numbers. (As quoted at the end of the first paragraph.)

The studies in climate heretofore described have been generously aided year by year by the Carnegie Institution. The collection work connected with dating Pueblo Bonito and other prehistoric ruins has received valued assistance from the National Geographic Society. This took the form of three field expeditions for the securing of beam material. Indebtedness is also expressed to the University of Arizona and to the Museum of Northern Arizona in Flagstaff, and other institutions.

Archaeological beam material began to arrive in quantities in 1922, chiefly from Pueblo Bonito. The first important beam expedition was carried out in 1923 and continuously from that time specimens have been arriving for examination. As a result of studying this material a prehistoric chronology over 500 years long was constructed whose exact dating

was wholly unknown, but whose continuity was well established. Our modern trees combined with Oraibi beams gave a dated chronology of equal precision, from the present time back to the late 1200's. The interval between the known and the unknown chronologies was supposed to be between 50 and 200 years. The expeditions of 1928 and 1929 were bent on closing this gap. In August, 1928, the first prehistoric date was ascertained in the ruin of Kawaiku in the Jeddito area. Small pieces of decayed wood an inch or so long showed rings which grew in the vicinity of 1400 A. D. On June 22, 1929 the missing link was at last found in the ruin at Showlow, fifty miles south of Holbrook, in northern Arizona. To our surprise the two chronologies overlapped by more than twenty years but owing to the defective growth during the great drought in the late 1200's it had been impossible to recognize corresponding dates. Thus the gap was closed and exact dating was given to more than 400 prehistoric ruins. Of these the largest and most important was Pueblo Bonito in Chaco Canyon, a ruin excavated under the direction of Mr. Neil M. Judd for the National Geographic Society. This ruin was chiefly built in the middle of the eleventh century and its early construction was found to have been in the years 919 to 937.

The human history thus disclosed is of high interest and value for its information upon a question strongly before Americans today: namely, what happens to a people who use up their natural resources without thought for the future. The climatic history is giving unique historical background for the development of a real climatic theory that if brought to a successful conclusion, will have immense economic value.

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Meeting adjourned at 9:40 P. M.

HAROLD B. HAMMILL

Secretary-Treasurer