CURRENT SCIENCE—50 YEARS AGO

Tree Ring Dating of Archaeological Finds*

By R. Maclagan Gorrie, D.Sc.
(*Indian Forest Service.*)

THE reactions of the annual rings of wood laid down in the ordinary process of a tree's growth have been known for long to show some definite relationship to the climatic conditions under which the tree has grown. The credit for employing timber rings as a means for the accurate dating of prehistoric monuments goes to an American worker, Dr. A. E. Douglass, of the University of Arizona. By profession an astronomer, he first became interested in tree ring data in an effort to locate sunspot cycles through the drought periods associated with them. Beginning as a casual enquiry into climatic influences, it developed into an appreciation of the valuable and accurate record which tree rings can add to local climatic history, and was then applied to the accurate dating of many of the prehistoric Pueblo ruins and cliff dwellings of the American South-West.

These relics of a past civilisation had long intrigued archaeologists, but there was much doubt and argument over their actual age until tree ring dating changed speculation into hard fact. Some of these cliff dwellings were thought to be as old as 1000 B.C., but the earliest so far excavated has now been definitely dated 919 A.D., showing an error of almost 2000 years on the previous calculations based on other archaeological matter. So accurate is this method of dating that the years of construction and occupation of individual houses have been worked out from the charred remains of roof timber and from unconsumed charcoal fuel. The Pueblo building activities are shown to have fallen off with each drought period until a great drought in the years 1276 to 1299, which was so severe that it completely destroyed most of their agricultural system of small inundation canals.

During a recent visit to America I had the privilege of studying Dr. Douglass' methods at Tucson, Arizona, and was much impressed by this example of scrupulous exactness in detailed research; so, a short account of the technique of his tree ring dating should be of some interest to scientific workers in various fields. Starting with the identification of individual year-rings in different trees from the same region, a calendar was gradually built up dating from living trees as far backwards into the past as contemporary trees or recently felled stumps would reach. It was found that the very arid and severe climatic conditions of the South-West were more or less common throughout eastern Arizona and western New Mexico, thus including the whole of a large zone of early Indian activity in the Colorado and Little Colorado basins, and extending further east into the Rio Grande basin. Throughout this vast area the main periods of drought have been a general experience, so that a characteristic pattern of the rings in any tree living in such a period becomes recognisable as a "signature".

Individual trees of course show minor inconsistencies, and in a completely canopied forest a sudden access of light to a crown by the death or removal of its neighbour trees will probably produce a wider ring than could be credited to any small increase in moisture. Actually most of the western yellow pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga taxifolia*) which have yielded the best data have grown in a very open forest type, for the country is so arid that it can best be described as an open dry savannah of scattered pine and juniper trees standing in open grasslands, not unlike the dry *rakh* of the Punjab and Central India except that the tree species are mostly conifers instead of Leguminosae. Just how far such data from moister and close-canopied forest types would be serviceable is doubtful, for Dr. Gouglass' attempts to extend his tree ring chronology into the moister Californian forest types, with their temptingly long-lived species such as *Sequoia gigantea* and *sempervirens*, have not been so successful. The easier the growth conditions for the individual tree, the less it reacts in its growth to the hardship of individual years of drought, *i.e.*, it is "complacent" while the tree living in more trying conditions is more "sensitive" in its registration of drought years.

From present-day specimens the data can be carried back into the past by searching for timber from old dwellings, comparing their records, and linking them by "crossdating" them to the ring patterns of known age. Gradually a series can be built up, the outer rings

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* Published in *Curr Sci.*, Vol IV, October 1935, p. 225.

of such old logs being matched with the oldest parts of modern trees. Small specimens can be cut from living trees with a simple boring instrument such as the Pressler's borer, which extracts a thin sliver of wood $\frac{1}{8}''$ thick and showing the rings upto 3" from the living bark. This, however, is not strong enough to sample the indurated wood of very old logs, and Dr. Douglass has used as a borer a steel tube 1" in diameter with saw teeth at the end, which extracts an 8" sample. Where a butt or stump is exposed, a triangular sample of the whole series of growth rings can be taken by making two slanting saw cuts across the face through the heart of the log, thus nicking out a piece on which every ring is exposed in cross-section.

In the actual analysis of rings, complications commonly met with are first, that small rings may be missed altogether, and second, that the double rings frequently caused by two wet seasons in one year may be mistaken for two annual rings. These can only be recognised after considerable practice, double or false rings having no sharp edge of ripened and flattened cell-walls such as characterise true autumn wood. This feature of false rings is a common source of inaccuracy in forest statistical work when doing ring counts to calculate the period of time required to grow trees of a given diameter, and even after considerable experience in wood anatomy one is liable to be misled. The only way to ensure accuracy, therefore, is to build up a chronological table of ring patterns from so many samples that the elusive microscopic ones and the locally common false ones are cancelled out over as wide a district as possible.

It was many years before a complete chronological table for Arizona could be built up, and in the interval the gradually accumulated data for the prehistoric timber from various excavated sites and derelict dwellings were built up into a "floating" table of relative dates. The position of this floating table in history could only be defined when sufficient links had been found to fill the gap beyond the oldest modern pine trees near Flagstaff, Arizona, which reached back to 1707. Many of these links were found in the roof beams from Hopi Indian dwellings, some of which are still in use with timber which has been felled several centuries ago. The last link connecting the floating table with this well-verified historical scale which stretched back to 1300 was finally provided by a buried and charred beam which was so fragile that it had to be well wrapped with twine before it could be lifted.

The coincidences between wood samples are more easily traced from small rings than from large ones, and the rings on each sample are charted on graph paper, giving an exaggerated upright line value for each small ring inversely proportional to its size. A non-technical account of the work so far accomplished by Dr. Douglass and his helpers is given in "National Geographic Society Contributed Technical Papers; Pueblo Bonito Series, No. 1," Washington, 1935.

From a social aspect it is interesting to find that although the eclipse of the old Pueblo culture was in part due to a series of severe droughts, it was largely self-imposed through the wide-spread destruction of their upland pine forests by felling, burning and heavy grazing. This was inevitably followed by excessive floods and droughts which rendered impossible their previous agricultural system of flood-water farming on the irrigable bottom lands along the outflows from these pine forest catchment areas. This corresponds roughly with what is happening to-day in many of the drier parts of the United States and the drier tropics of India and Africa, where the natural vegetation has been destroyed by gross over-grazing and injudicious ploughing of natural grass-lands. In such places the contemporary local tree growth records will be found as a lengthening series of microscopic rings, just as in the period when the Pueblo culture was rapidly dying out. Dry spells may be inevitable, but their effects could largely be mitigated if we could, through a better knowledge of climatic cycles, foretell their arrival, and prepare for them through a more conservative use of the local resources of grass and timber. It is to be hoped, therefore, that some research may be taken up to show how far such data can be used to solve Indian problems in human and climatic history.