Radioactivity of Wood

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FORESTERS have long been aware of the multiplicity of uses for wood. Each year finds many new uses for wood and wood products as our technology continues to develop. However, wood is now being used as a measuring tool for scientists in a manner never visualized before, even by the most avid proponents of wood products. The intrinsic composition of the wood itself, more specifically, its content of radioactive carbon (C14), enables scientists to date the age of the wood. The actual age of the wood, when ascertainable, makes it possible to place a date of occurrence on events contemporaneous with the period when the trees were living.

Theory of Radiocarbon Dating

A simplified explanation of the reaction involved in radiocarbon dating follows: Physicists have found that cosmic rays produce neutrons upon initial collisions with components of the air. Oxygen is essentially inert to neutron bombardment, but nitrogen is quite reactive. The neutrons produced by cosmic radiation are radioactive with a half life of about 12 minutes. Therefore, the neutrons either collide with air molecules and lose their energy, or they collide with Nitrogen14 and provide sufficient thermal energy to produce the radioactive isotope of carbon, C14. The following reactions occur as a result of this bombardment:

$$\begin{align*}
(1) \quad N^{14} + n &= C^{14} + H_2 \\
(2) \quad N^{14} + n &= C^{14} + H_3
\end{align*}$$

Radioactive carbon is burned to radioactive carbon dioxide in the atmosphere. It is then mixed by the winds with the inert or normal carbon dioxide C12CO2. The plants growing on the earth's surface utilize CO2 in their photosynthetic process. A major portion of the CO2 utilized from the atmosphere is normal CO2 and a small uniform percent is radioactive CO2. Animals utilize plants, and human beings utilize plants and animals, which means that all living materials contain a certain degree of radioactivity because of the absorption of C14. Assimilation of C14 by living organisms is balanced by the rate C14 is disintegrating to form N14. As soon as the organism dies, however, the assimilation process ceases and the disintegration of radioactive C14 continues—with no compensation. Since C14 has a half-life of about 5568 years, it means that the organism will have lost half of its specific C14 radioactivity after a period of 5568 years. Therefore, we should expect to find that a body 5568 years old would be half as radioactive as a present-day living organism. A Geiger counter would record, therefore, the decreasing radioactivity with increasing age.

According to Libby* there are some 8.3 grams of carbon in exchange equilibrium with atmospheric CO2 for each square centimeter of the earth's surface. There are some 2.6 C14 atoms formed per square centimeter per second and, consequently, the carbon in exchange equilibrium will contain a specific radioactivity of 2.6x60/8.3 disintegrations per minute per gram. This means that the reservoir of carbon has not changed significantly in the last few tens of thousands of years. Therefore, assimilation of C14 has been the same for a long period of time by biological material. This means that with a uniform supply, trees living thousands of years ago attained a C14 content comparable to trees living today.

Since biological materials (wood) contain an assay of 15.3 disintegrations per minute per gram of carbon (from the C14 portion of the carbon), the determination of its present radioactivity will determine its age. The following graph (Fig. 1) from Libby illustrates the rate of disappearance of radioactivity following death corresponds to the exponential decay law for radio carbon as represented by the solid curve. Samples of wood from mummy cases, wooden beams from ancient tombs, and other wood samples that have been definitely dated archaeologically, have enabled a good check to be made of the accuracy of radiocarbon dating from wood.

Geological and Pedological Application

Utilizing charcoal or buried wood, the age of many of our major geological events has been determined accurately for the first time. For example, at the time

Fig. 1. Predicted versus observed radioactivities of samples of known age.

of our various glacial periods, ice masses overrode trees growing on the landscape and buried them beneath tons of mineral materials. From the time the trees were killed and covered by debris, the assimilation of C\textsuperscript{14} ceased and its original radioactivity lessened to the point wherein it became progressively half as radioactive each succeeding 5,568 years.

In the course of new road construction, railroad construction, or down-cutting and eroding by streams, buried wood is often exposed. When the age of the wood is determined, it dates the time when the materials were moved in and covered up the trees. In the case of glacial ice, the trees were most often shattered and incorporated into the base of the glacial deposit. (Fig. 2) However, in a few instances, trees growing in valleys were covered standing up by wind and water borne silts. In such cases where the buried forest was exposed by road cutting, the trees were revealed standing upright and growing at several different levels in the old sedimented valley (Fig. 3).

From buried wood samples excavated from under several different deposits at various places in Iowa, it has been possible to determine the chronology of events which have taken place. It should be pointed out that much of the wood that has been buried has been remarkably preserved. In the absence of oxygen the wood is well enough preserved so that histological sections can be made for identification. Even though tremendous compression and distortion of the wood has often resulted from the great weight of materials deposited on top of the wood, the wood retains its distinctive characteristics. Dr. D. W. Bensend, Iowa State College, has made many identifications of histological sections of buried wood for the author, so that it

Fig. 2. A shattered spruce log imbedded in basal portion of Iowan till deposit, twenty-five feet below modern surface in a railroad cut. Age of wood about 35,000 years.

Fig. 3. A forest bed exposed by new highway cut thirty feet below surface. Note the lateral root in foreground and stump in right background. This forest was covered by Pro Cary silts which covered the standing forest about 14,000 years ago.
has been possible to know the type of vegetation growing on the former land surface. In some cases, wood which has been buried for 15,000 years is so well preserved that the bark is still present in an identifiable state. It is of interest to find that the former forest cover in Iowa was not comparable to present species found in the state. Buried wood has been identified as spruce, hemlock or larch, which is a strong indication that environmental conditions were greatly different in past geological time in Iowa, compared to our present climate or vegetational types.

In addition to dating major geological events, radiocarbon dating has enabled soil scientists to determine the alterations due to weathering in the interval elapsing between two geological deposits (Fig. 4). The changes which have taken place since deposit of fresh parent material can be ascertained by study of the soil and evaluating the effect of time on weathering. Determination of the relative age of landscapes has also helped explain the variation in soils and soil patterns within the state, (Fig. 5).

In summary, wood is the most important source of materials used for radiocarbon dating. For events which took place up to about 35,000 years ago (limit of radiocarbon method is about seven half lives), buried or preserved wood enables scientists to place an age value on the wood. The use of wood as a tool in determining chronology is probably the most unique utilization of one of nature's most useful products.
About the Author

Wayne H. Scholtes is Professor of Soils, Agronomy Department, Iowa State College. At present his work is primarily teaching soil classification, soil conservation and forest soils.

Scholtes is a native of Iowa and, in 1939, graduated from Iowa State College with a B.S. in forestry. He obtained an M.F. degree in forest soils from Duke University in 1940, and a Ph.D. degree in soils from Iowa State College in 1951. He worked as a forestry aide with the Lake States Forest Experiment Station and as a Junior Forester with the Forest Service at Ames. In 1941 he was a soil surveyor with the U. S. Indian Service in Minnesota and later transferred to the Soil Conservation Service in Wisconsin and Iowa as Associate Soil Scientist. From 1946 to 1951 he was Soil Scientist with the Bureau of Plant Industry in Iowa. In 1951 he joined the staff at Iowa State College as Assistant Professor of Soils.

Dr. Scholtes is a member of Soil Science Society of America, American Society of Agronomy, Soil Conservation Society of America, Iowa Academy of Science, Sigma Xi, Gamma Sigma Delta and Alpha Zeta. Although most of his time is devoted to teaching, he has published numerous research articles in soil classification, pleistocene geology and forest soils.

Barring acts of God or inordinate stupidities of men, another decade or so should find our economy able to provide material things for the people even more bountifully than now. For we are a nation growing in numbers, rich in resources and blessed with an economic system unmatched as a way of releasing men’s energies and talents. When that day comes we will find that we have multiplied our markets and our needs. Today’s steel mills, today’s chemical plants, today’s work shops for making useful things for home and industry will be totally inadequate. Everything will have to be expanded.

—Wall Street Journal