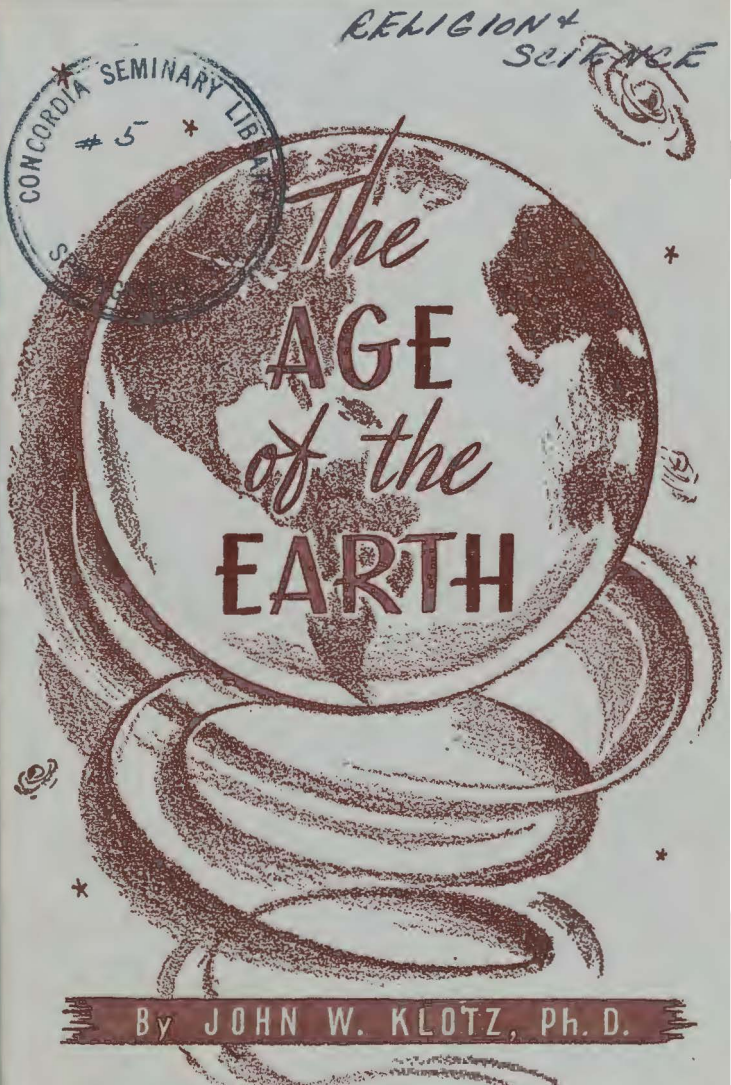
The AGE of the EARTH



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How long has the earth stood? The answer to this question presents us with one of the most troublesome conflicts between scientific theories and the statements of the Scripture. In a very matter of fact way scientists speak of events which are supposed to have taken place hundreds of millions of years ago. They describe many plants and animals which are supposed to have passed out of existence many millions of years ago. They describe the climate of those bygone eras. A carefully developed geological time scale with eras, epochs, and periods has been worked out.

How old do the scientists believe the earth to be? How do they determine its age? How accurate are the methods which they employ? What age does the Bible assign to the earth? These are questions which we propose to explore.

Modern Age Estimates

The most recent calculations of scientists place the age of the earth at about 4½ billion years. Perhaps the most recent figure is that of C. C. Patterson of California Tech who estimates the age of the earth at

about 4.6 billion years. This estimate is based on the dating of granite rock from Manitoba which is believed to be 3.5 billion years old. Presumably the earth itself is older than the oldest rocks: hence a greater age than 3.5 billion years is assigned to the earth. Until recently the oldest known rocks were supposed to be 2 billion years old.

The Geological Time Scale

The first of the geological eras, the Archeozoic, is one which provides no fossils but gives evidence of life in the graphite deposits which have been found. It was followed by the Proterozoic Era, from which simple fossils are believed to have been found. These two eras are supposed to have lasted until about 540 million years ago. They are believed to have been followed by the Paleozoic Era which lasted until 200 million years ago. This, in turn, was followed by the Mesozoic Era which lasted until 60 millions years ago. This present era is given the name Cenozoic.

Older Methods of Determining the Earth's Age

When scientists first turned their attention to the problem of the age of the earth, they were struck by the possibility of determining it quite accurately by a study of erosion–deposition rates. Soil is continually being carried down from the higher areas of the earth's surface and deposited in lower areas. Much of

this deposition occurs at the mouths of rivers. Careful measurements were made in the various delta areas, such the Nile delta in Egypt and the delta of the Mississippi in the United States. On this basis it was determined that the earth was approximately 50 million years old.

Another method employed at one time was the measurement of the quantity of salt (sodium chloride) in the seas. It was believed that all of the salt came originally from land areas. The rain, as it came down and percolated through the soil, was supposed to have leached out the salt and carried it to the sea. It was believed that by measuring the rate at which salt is being brought down to the seas today it would be possible to determine with a fair degree of accuracy the age of the earth.

Scientists themselves soon recognized that these methods were neither satisfactory nor accurate. It was very apparent that erosion–deposition rates are not constant, that they vary from year to year. It was also recognized that the salt content of the sea could not give an accurate indication of the age of the earth, for as salt is being carried into the seas from the rivers, some is being removed from the ocean by crystallization into rock. Indeed, some men, such as Odum, have suggested that the cycle is completely closed, that just as much salt is being removed from the oceans by crystallization as is being carried into them from the rivers. He believes that possibly the whole sedimentary cycle is in a state of equilibrium.

The Uranium Time Clock

Another reason for rejecting those methods of determining the age of the earth is the belief that a more accurate method has been found in the so-called "uranium time clock." This is based on the relative amounts of certain radioactive substances and their end products which may be found in various rocks. Uranium, the heaviest naturally occurring element, breaks down spontaneously into a series of elements finally becoming lead. Because this is a nuclear reaction, the rate at which this breakdown occurs is constant: it can neither be speeded up nor slowed down by processes which we know today.

Actually there are three possible "clocks", all of which operate in the same general way. Uranium 238 (U^{238}) decays to lead 206 (Pb^{206}) which is also known as Radium G. Uranium 235 (U^{235}) decays to lead 207 (Pb^{207}) which is also known as Actinium D. Thorium 232 (Th^{232}) decays to lead 208 (Pb^{208}), which is also known as thorium D. In addition to these three kinds of lead produced by the decay of radioactive elements, there is a fourth kind of lead which has an atomic weight of 204. The first three kinds of isotopes of lead are said to be radiogenic: the fourth kind is said to be non-radiogenic.

There are a number of substances found in the course of the distintegration of uranium and thorium into lead. Each of these substances disintegrates into the next one in line in a fixed, measurable period of

time which, so far as we know, cannot be changed. This time is usually measured in terms of half life, the period it takes half a given amount of a radioactive substance to disintegrate. In some cases the half life is believed to be millions of years: in other cases only a small fraction of a second.

Premises on Which the Reasoning is Based

In arriving at the age of a given rock, it is assumed that the rock contained only thorium and uranium and none of the decay products at the time of its formation. It is also assumed that we can determine the amount of uranium or thorium originally present. A third assumption is that the rate of decay, which is constant today and cannot be either speeded up or slowed down, has been constant since the time of the origin of the rocks.

None of these premises or assumptions is necessarily true. Regarding the first assumption: assuming that the story of Genesis is correct, there is no reason why God should not have placed some of the decay products, such as radium, into the rocks at the time of Creation. Radium is an element, just as uranium and thorium are elements. If these decay products were present in the rocks from the beginning, calculations based on the assumption that only uranium and thorium were present in the beginning would be incorrect. In this connection we might note that the elements above radium have a relatively long half life: those below radium in the series have a relatively

short life. Uranium I, for instance, has a half life of 4.5 billion years. Uranium II has a half life of 270,000 years. Radium itself has a half life of 1600 years. If the rocks contained radium from the beginning, then the half life of Uranium I, Uranium II, and other elements above radium would have to be excluded from the age determinations, and calculations based on the assumption that only uranium was present in the beginning would give figures that are much, much too high.

There is also the distinct possibility that some of the parent or daughter atoms have escaped from the rocks since their formation. This makes it almost impossible to determine the actual amount of uranium present in the beginning. Radon, which follows radium in the series, is a gas. Much of it is likely to escape from the rock in which it occurs.

Another possibility that must be considered is the possibility that a remelting of the rock may have altered the relationship of the uranium or thorium and lead. In this way the rocks may be younger or older than they appear. Blum calls attention to this problem.

Physicists must correct for both these possible errors in their calculations. They recognize the problems involved. Hurley points out that we have no assurance we can estimate accurately the amounts of the parent isotopes present or that some of the parent or

daughter atoms have not escaped from the rock. Hahn and Walling say that unaltered thorium minerals are practically unknown.

Nor can it be denied from a philosophical standpoint that the rate of decay *may*, under some conditions, have been greater than it is today. True, in scientific work we are bound by the principle of uniformity. We must assume that processes went on in the past at the same rate at which they are going on at present, unless we have fairly conclusive evidence that the rates were different. We have no such evidence in the case of the decay of uranium and thorium. However, we must at least grant the philosophical possibility that this may be true and that further study may disclose some conditions which alter the decay rates.

The Utility and Reliability of the Clock

Not only is there reason for questioning at least the first two of the premises on which the uranium time clock is based, but there are also reasons for questioning its utility and reliability on other grounds. The number of rocks which can be dated by this method is limited. While it is true that more and more uranium is being discovered each year, uranium must still be regarded as not too widely distributed a mineral. Highly radioactive minerals are found almost exclusively in pegmatites. These occur as dikes transversing other forms of igneous and crystalline rocks. Peg-

matite itself is relatively uncommon, and only a few pegmatites carry radioactive minerals.

Another problem is that most pegmatite masses cannot be accurately associated with the geological time scale. The time scale has been set up largely on the basis of fossils found in the rocks. Geologists would like to be able to correlate the uranium time clock with what might be called the fossil time clock. But this is rarely possible, since most of the pegmatite dikes are found in rocks which have few or no fossils.

There is still another difficulty which bears on the reliability of the uranium time clock. The clocks are not entirely accurate. Hurley says that no single clock is entirely trustworthy. Yet it is not very often that more than one clock is at hand to date a given rock mass. Moreover, when it is possible to use more than one clock, they rarely agree. Hurley says that close agreement of the three clocks is the exception rather than the rule. While it is true that one clock does not say thousands of years and the other millions of years, differences of several hundred percent in the figures are not unusual. Certainly a difference of such magnitude does throw doubt on the accuracy of the clocks.

For example, Kerr and Kulp report the following figures for rock taken from the Sunshine Mine near Kellogg, Idaho:

Uncorrect determination (a determination which did not take into consideration alterations in the rock through melting and recrystallization, loss of the gas radon, etc.)

	1050±50 million years
Pb^{206}/U^{238} ratio:	710±10 million years
Pb^{207}/U^{235} ratio:	750±10 million years

Determination corrected for errors: 850±50 million years.

A. O. Nier gives the following results as typical of various determinations (ages in millions of years):

Sample	*Method I*	*Method II*	*Method III*
A	1003	945	1030± 15
B	265	245	430± 40
C	3180	1830	2570± 70
D	1730	770	1340±200

To show the results when the uranium time clock can be correlated with the geological time scale, we have the following results of determinations made on Swedish kolm and reported by Knopf. The fossil evidence indicates that the rock dates from the late Cambrian period, approximately 500 million years ago. One uranium time clock method gives us a figure of 380 million years. A second method gives us a figure of 770 million years. To reconcile these figures, it is assumed that both clocks are wrong because of the escape of radon. Correcting both figures gives a probable real age of 440 million years, which is regarded as very close to the age indicated by fossils.

As indicated above, two of the chief reasons for the inaccuracy of the clocks are the disappearance of some of the decay products, such as radon, and the possibility of an alteration of uranium or thorium and lead relationships through a remelting of the rock.

Another reason for the inaccuracy is the difficulty of determining the actual amount of non-radiogenic lead, lead which is not the product of radioactive decay processes. Pb^{204} is generally assumed to be non-radiogenic. It is believed, though, that some of the Pb^{206}, Pb^{207}, and Pb^{208} is also non-radiogenic. The amount of the different isotopes that is non-radiogenic varies in different samples. If Pb^{204} is absent, it is generally assumed that the lead present is radiogenic. However, if Pb^{204} is present, there must be some common or non-radiogenic lead present, and the problem faced is that of determining how much is radiogenic and how much is not.

Mattauch expresses the opinion that of the many lead age determinations of various types, only five to eight are even apparently free from objectionable features. Goodman and Evans express the same opinion. With all of these difficulties and problems, there is good reason for being very cautious and critical in accepting the results of age determinations by the uranium time clock.

Other Methods of Measuring Time

For dating organic remains, two methods are employed at present. The results of these methods do not tell us how old the earth is: they cannot be used to date rock masses. But they do, it is believed, tell us how old various organic remains are, and this does have some bearing on the age of the earth, since the

earth cannot be younger than the organic remains which it contains.

The Fluorine Method

The first method involves a measure of the amount of fluorides found in bones. One of the materials originally present in bone, hydroxyapatite, is gradually changed to fluorapatite as the bones are percolated by fluorine charged waters. Fluorapatite is extremely weather resistent, and it is believed that a measure of the fluoride contents of bone will give a fairly accurate indiction of their age.

Of late, however, there have been some who have questioned the accuracy of this method. For one thing it is known that water varies in its fluoride content from time to time and from place to place. It is also possible for humans to have access during their lifetimes to water from deep wells to which animals do not have access. Such water is likely to contain large quantities of fluorine compounds. Stewart believes that the method is of limited reliability and warns against the subjective pitfalls that surround such chemical dating.

Radiocarbon Dating

A more important method today is the C^{14} method of dating organic materials. This method is also known as the radiocarbon method or the atomic calendar. It depends on the amount of radioactive car-

bon to be found in organic remains. Cosmic rays, which enter our atmosphere from outer space, change nitrogen to C^{14}. Some of this C^{14} unites with oxygen to form a radioactive carbon dioxide, and this is used by plants to form food. In this way C^{14} is incorporated into plant tissue, and when plants are eaten by animals, it is incorporated into animal tissue. This incorporation of C^{14} into tissues ceases with the death of the organism. The half life of C^{14} is $5{,}568 \pm 30$ years. The age of organic matter is determined by the amount of C^{14} still present in the tissues. This method of dating organic remains is believed to be accurate up to about 25,000 years. A newer method is being developed which it is hoped will be accurate up to about 44,000 years.

Where it has been possible to correlate these dates with known historical dates, it appears to be fairly reliable. A number of tests have been made, and these have agreed rather closely with known historical dates. However, there are some difficulties associated with the method. It is possible for materials to have their radioactivity diminished by the entry of "dead" or non-radioactive carbon which will increase the apparent age. It is also possible for the radiocarbon content of materials to be enriched by physical and chemical processes, which would decrease their apparent age.

Another problem is the fact that in general marine shells seem to have a lower C^{14} content than wood, indicating for them an age greater than their actual age. It has been suggested that this is due to the fact that

water from the ocean depths contains carbon that is several thousand years old. When this is incorporated into the shells of marine animals, it indicates an age that is greater than the actual age.

A very important difficulty today is the possibility of contamination of test materials at the time of their examination with radioactive dust from atomic and hydrogen explosions. Not long ago material known to be about 3000 years old gave an age of about 2000 years. Later it was discovered that the material had been contaminated by the fall out from a hydrogen bomb test.

Other sources of error are erratic changes in cosmic ray background, slight changes in counter efficiency, counting of spurious impulses from carbon dust or other sources, and non-laboratory errors. Because of these problems Blau, Deevey, and Gross say that we must be careful not to accept uncritically the results of applying the radiocarbon method to all carbonaceous materials regardless of their origin.

Shrinking Time by Radiocarbon

It is interesting to note that the radiocarbon method has moved up the close of the last Ice Age. Not too long ago it was proposed that the close of the last Ice Age was about 50,000 years ago. About 10 years ago it was generally agreed that this figure would have to be reduced to 20,000 years. Now radiocarbon dating places the close of the last Ice Age at less than 11,500 years ago. Arnold and Libby dated a number of wood

and peat samples from the Two Creeks Forest Bed in Manitowoc County, Wisconsin. Apparently a spruce forest here was submerged, pushed over, and buried under glacial drift by the last advancing ice sheet in this region. The average age of five samples from this region was 11,404±350 years. Studies by other scientists of deposits from Europe confirm this later dating of the Ice Age.

Radiocarbon dating has also shown that oil may be formed much more quickly than was previously believed to be the case. Formerly it was thought that oil was formed only after the original complex organic matter was covered by several thousand feet of overburden and after a lapse of several million years. Yet Smith found hydrocarbons (oil is a mixture of hydrocarbons) in sediments dated as "Recent". A composite sample of hydrocarbons taken from the Gulf of Mexico and dated by the C^{14} method gave an age of 12,300±1200 years—a far cry from the millions of years formerly thought necessary for their formation.

What Does the Bible Say?

Another question that naturally arises when Christians discuss this problem is "What answer does Scripture give?". There are many questions to which Scripture does not give a definite answer, but where it speaks, it speaks with the authority of its Author, God Himself. Many of our English Bibles have the date 4004 B.C. in the margin of Genesis 1. This is the figure arrived at by Bishop Ussher, an Anglican archbishop who worked out the chronology of Scripture and published his results in 1654. In 1701 the dates began to be printed in the margins of many Bibles, and they have been printed in most editions of the King James Version of the Bible ever since. This figure, of course, is not a part of the inspired text.

While it is true that the chronology of the Bible as found in the Old and the New Testament is a most remarkable feature of our Bible, it must also be admitted that these genealogical records contain some very real difficulties which have caused doubt and controversy in the Church from the time of the early Church Fathers to the present day. This much, however, is certain. These genealogies and chronologies are a part of the inspired text, and what St. Paul says in II Timothy 3:15 must apply also to them: they are given by inspiration of God and are profitable for us. God must have had some purpose in recording them, or they would not be in our Bibles.

What shall we say, then, with regard to Scripture and the age of the earth? We shall have to say: That Scripture does not tell us exactly how old the earth is. God did not feel that it was necessary to inform us of that detail. At the same time, a careful study of the Bible indicates that figures of millions and billions of years cannot be accepted by the Christian. The Bible indicates very clearly that we are living on a "young" earth, an earth whose age is measured in thousands rather than in millions or billions of years.

So far as the scientific evidence is concerned, we shall have to say that it is not as impressive as it appears at first. The uranium time clock hardly possesses the reliability and accuracy we should like to see in a scientific tool. C^{14} also has its problems. It certainly would be a mistake to reject the clear indication of Scripture that we are living on a young earth in favor of the datings availabe at present to the scientist.

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