remained reasonably constant over the last several tens of thousands of years. And because specimens dated by Carbon 14 could be date checked by tree rings, written history, and other ways, there appeared rather close agreement between the conclusions of Carbon 14 dating and these other methods.

As more and more specimens have been dated, however, scientists discovered that C14 is not the all-purpose dating tool many hoped it would be. They discovered that even within the last 2250 years, discrepancies of 100 years or more were possible.[11]

Earlier than about 250 B.C., however, C14 dating begins to get increasingly inaccurate. Going back as far as 4000 B.C. the true date of a specimen is generally known to be older by several hundred years than the date established by C14 dating. The formula for this discrepancy has been shown to be roughly:[12]

$$T = 1.4R - 1100 \quad \text{(Equation 1)}$$

where T is the true age and R is the radiocarbon age. Thus, a specimen which is shown to be 4000 years old by radiocarbon dating is probably closer to 4500 years old, in actuality.[13]

These corrections and refinements have not invalidated C 14 as a dating tool, but have shown the necessity for more care in evaluating results, and more study to attempt to understand the changes in "I" value over the past millenniums. This brief summary is given to outline some of the known limitations and strengths of the C14 dating method. Because we have established, by Biblical reckoning, 11,013 B.C. as the oldest possible date for living organisms to have existed upon this earth, the results of carbon 14 dating are especially interesting. Dates of thirty or forty thousand years have been discovered by C14 dating. For example, at the Heifers Outwash on the shores of the Caspian Sea, carbon samples have been tested which show human occupancy some 43,000 years ago. Even if this were in error by thirty or forty percent, a date far older than 11,000 B.C. would result. How can this be squared with the Biblical record?

We found in the previous chapters that the Biblical record is the trustworthy record. Therefore, results from the radiocarbon dating method must be carefully analyzed when used to date objects that approach an age of 13,000 years. We, therefore, might suggest one good reason why radiocarbon dating, as it is presently used,

apparently leads us to untrustworthy conclusions for very early dating. That reason is that there is evidence that the worldwide C14 reservoir is still increasing. If it is indeed increasing, the whole carbon 14 method of age dating requires re-evaluation, for this could change in substantial fashion the ages derived from this dating method. Moreover, this could also point to a very young earth.

C14 is produced by the action of cosmic ray activity. Thermal neutrons formed by these cosmic rays enter the earth's atmosphere and react with N 14 to form the radioactive isotope of carbon C14. Cosmic rays are formed from energy sources such as the sun, stars, and possibly supernova explosions which occur every 30 years or so.[14] Scientists assume that these energy sources have been around for a long period of time and have probably produced fairly constant cosmic ray activity during the last several tens of thousands of years. Thus, a state of equilibrium should exist so that the carbon 14 reservoir or inventory remains fairly constant. The total new carbon 14 being formed at any moment of time ought to just equal the carbon 14 ceasing to exist because of its half life of 5730 years. Slight variations are to be expected because of sun spot activity, but in general equilibrium should exist.

Equilibrium does not exist, however. Even before 1955, Dr. Willard Libby, the first man who discovered and developed the radiocarbon dating method, records data that suggest this fact. He indicates in his book, *Radiocarbon Dating*, that the "I" value based on the assumed rate of formation of new C14 equals 18.8 disintegrations per minute per gram.[15] His estimates of the actual figure for worldwide distribution of biological materials is about 15.3. Thus, his figures indicate that the amount of carbon 14 disintegrating at any time all over the world appears to be about 81% of the new C14 being formed (15.3/18.8 = .81). Other scientists have puzzled over this curious situation and have come to no satisfactory explanation for it. R. L. Lingenfelter writes that there is a strong indication that the present natural production rate of C14 atoms exceeds the natural decay rate by as much as 25%.[16] This is the phenomena that would exist if the Carbon 14 reservoir were about 75% full. The most recent figure for the ratio of the disintegrating rate to that of the rate of formation is about 72%. H. E. Suess writes that the most recent figure for the production rate of new C14 is that of Lingenfelter where the value given is 2.5 + .5 dps per cm^2. The decay rate given in the same reference is 108.5 dpm/cm^2 which equals 1.8 dps per cm^2. Thus, the

ratio of the decay rate to the production rate is 1.8/ 2.5 or 72%.[17] This indicates that the C14 reservoir is about 72% fu11.[18]

The Radiocarbon Reservoir Is Still Filling

The evidence suggesting the worldwide C14 reservoir or inventory is only partly full is surely strange if cosmic ray activity which produces the C14 is a long term phenomena. A number of possibilities might be suggested.

1.*During the past 13,000 years cosmic ray activity was severely reduced causing the C14 reservoir to be depleted*. This possibility is rather remote. While there have been short time fluctuations in cosmic ray activity due to sun spots and other solar activity, the sun and stars appear by all the available evidence to have shone with about their present brilliance and energy since the beginning or at least for the last hundreds of thousands of years if the beginning is truly back that far in time.

2.*Something is wrong with the values obtained for the C14 production rate and decay rate*. This, of course, is always a possibility. However, this all important question has been under examination for more than fifteen years now and analyses have been made by competent scientists. Significantly, the results are always on the side of the decay rate being substantially lower than the production rate. While major error is always a possibility, it does not appear at all probable.

3.*A catastrophe occurred within the last 10, 000 years which buried substantial C14*. This is a distinct possibility in view of the Biblical account of the flood. We would then expect the C 14 buildup to be resumed after this catastrophe in accordance with the following equation for the production of a radioactive substance:

$$N = \frac{R}{1} (1 - e^{1T}) \qquad \text{(Equation 2)}$$

Where R is the rate of formation of active atoms, 1 N is the disintegration rate, and X is the characteristic decay constant for the species.[19]

4.*Another possibility is that cosmic ray activity did not begin until 13,000 years ago.* The Bible indicates that man was created 11,013 B.C. on the sixth creation day. Since there is much Biblical reason to believe the six days were each 24 hours long and the Bible records that the sun and stars began to shine the fourth day, they also would have an age of about 13,000 years. Since the sun, moon, and stars were visible on the earth, one would logically expect that when God made them to shine upon the earth, He also caused the light and energy-cosmic rays included to fill space and become immediately available to the earth.

This is an interesting possibility. If we explore this a bit we discover that in 13,000 years, beginning from a zero reservoir of C14, the build-up would be such that today the inventory would be 79.4% full. This is found from the equation:

$$D = 100\,(1 - e^{-1}) = (1 - 2^{-T/5730}) \qquad \text{(Equation 3)}$$

where "D" is the decay rate expressed as a percentage of the formation rate, and "T" equals the time in years since disintegration began or since the beginning of C14 production. The assumption that no C14 was created before the six days is supported by the fact that Genesis 1:2 records that there was darkness over the face of the deep. Light was not brought into being until the first day (Genesis 1:3), which eventually became regulated by the sun, moon, and stars on the fourth day. The darkness suggests a lack of cosmic ray activity even as the presence of the light bearers on the fourth day suggest a full-orbed cosmic ray program from that day forward. Moreover, C14 is not found in the earth's interior. This in itself is not conclusive, for if the earth is indeed millions of years old, any C14 created at the beginning would have completely disintegrated. But if the earth is 13,000 years old, the absence of C14 in the earth's interior strongly suggests that C14 was not included as a part of the original creation.

5.*Possibly the true state of affairs is a combination of these last two possibilities*. The production of C14 perhaps began some 13,000 years ago, and a percentage of it was buried by the flood. This is suggested by the relationship of the 79.4% reservoir based on uniform build-up for 13,000 years, as compared with the

actual reservoir size of approximately 72%. Even this is not conclusive, however, and we must look in greater detail at other evidence related to C14 dating to discover more precisely what actually happened.

In any event, the partially filled reservoir that does exist indicates that we may not assume that the specific activity of carbon has been constant in the past, and all C14 ages which cannot be independently checked against other dependable dating methods cannot be assumed to be correct. In general a reservoir that is filling would appear to give dates far older than the true dates if there was constancy in the C12 inventory. Thus, we receive a possible insight into the reason for the existence of C14 dates which are far older than 11,000 B.C. Moreover, we sense a real correlation between the partially filled C14 reservoir of today and the Bible information which points to an earth 13,000 years old. The C14 dating method may be the bridge that will bring the scientific evidence into the Biblical framework.

Thus, we have seen that radiometric dating methods are not at all trustworthy as a means of establishing a timetable for the earth's existence. The necessity of viewing the available evidence in the light of unverifiable assumptions negates any possibility of trustworthy conclusions. The anomalies that are ever present emphasize the tenuous nature of conclusions derived by these dating methods.

Moreover, an examination of the Carbon 14 dating method has not only shown one important reason why ages derived from this dating method are much too old as compared with the true ages shown in the Bible, but it has also shown that this method, if properly used, potentially provides very close agreement with the Bible.

Other dating methods could well be examined, but to do so is beyond the scope of this book. For a further discussion of the question of the unreliability of radioactive dating methods such as uranium-thorium-lead and rubidium-strontium methods, the reader is encouraged to read Chapters 1 to 4 of the book by Melvin A. Cook *"Prehistory and Earth Models"* (London, Max Parrish, 1966), and *"The Genesis Flood"* (Morris and Whitcomb, Presbyterian and Reformed, 1965, pages 333-385).

Let us press on with our study. Can we utilize the dependable characteristics of the carbon 14 evidence together with the absolute truth of the Bible to obtain more information regarding past climatic conditions? In the next chapter, we shall attempt this difficult assignment.

NOTES:

[1] Richard L. Armstrong, "K-Ar Dating of Plutonic and Volcanic Rocks in Orogenic Belts," *Potassium-Argon Dating*, O. A. Schaeffer and J. Zahringer (ed.), Springer-Verlang, New York, Inc., 1966, p. 120.

[2] *Ibid*., p. 120.

[3] G. H. Curtis, "Problem of Contamination in Obtaining Accurate Dates," *Potassium-Argon Dating*, p. 155.

[4] David Fisher, *et al.*, "Ages of Pacific Deep Sea Basalts, and Spreading of the Sea Floor," *Science*, June 7, 1968, p. 1106.

[5] C. S. Noble and J. J. Naughton, "Deep-Ocean Basalts, Inert Gas Content & Uncertainties in Age Dating," *Science,* Oct. 11, 1968, p. 265.

[6] O. A. Schaeffer, "Tektites," *Potassium-Argon Dating*, Springer-Verlang, New York, 1966, p. 166.

[7] Robert L. Whitlaw, "Radiocarbon Confirms Biblical Creation," *Creation Research Society Quarterly,* Sept., 1968, p. 82.

[8] J. R. Arnold and M. Honda, "Record of Cosmic-Ray Intensity in the Meteorites," *Journal of Geophysical Research*, Oct., 1961, p. 3519.

[9] E. Vilisek and H. Wanke, "Cosmic-Ray Exposure Ages and Terrestrial Ages of Stone & Meteorites Derived from Cl^{36} and Ar^{39} Measurements," in *Radioactive Dating,* by International Atomic Energy Agency, Vienna, 1963, p. 383.

[10] P. S. Goel and T. P. Kohman, "Exposure History of Meteorites from Cosmogenic Cl^{36}, " *Radioactive Dating*, 1963, p. 415.

[11] Hans E. Suess and Minze Stuiver. "On the Relationship Between Radiocarbon Dates and True Sample Dates," in *Radiocarbon, the American Journal of Science*, Yale University, New Haven, Conn., Vol. 8, 1966, p. 537.

[12] *Ibid*., p. 539.

[13] Please see Appendix IX for a brief discussion of tree-ring dating as it relates to the Biblical chronology.

[14] V. L. Ginsburg, "The Astrophysics of Cosmic Rays," *Scientific American*, Feb., 1969, p. 61.

[15] W. F. Libby, *Radiocarbon Dating* (Chicago, University of Chicago Press, 1955), p. 7.

[16] R. E. Lingenfelter, "Production of Carbon 14 by Cosmic-Ray Neutrons," in *Review of Geophysics*, 1963, p. 61.

[17] H. E. Suess, "Secular Variations of the Cosmic-Ray Produced Carbon 14 in the Atmosphere and their Interpretations," in *Journal of Geophysical Research*, Vol. 70, 1965, p. 5946.

[18] Please see Appendix X for a further discussion of Lingenfelter's conclusion in 1970 that the decay-production ratio is close to unity.

[19] Gerhart Friedlander and Joseph W. Kennedy, *Nuclear and Radio Chemistry* (John Wiley & Sons, New York, 1st ed., 2nd printing, 1956), p. 132.

Chapter 13

Can We Reconstruct the Past?

Now that we have begun to understand some of the problems with carbon 14 dating, as well as some of its dependable characteristics, it would be interesting to try to use it as a tool to attempt a reconstruction of the past. In view of the fact that the Bible indicates that the world is about 13,000 years of age, carbon 14 should prove ideal as a help in this effort because 13,000 years is easily within the time span of carbon dating.

To attempt this reconstruction without the Biblical statement, which alone gives an exact timetable, would be exceedingly foolhardy. As we have seen, there is no trustworthy method of checking the errors of carbon 14 dating earlier than written history, but the Bible gives us an absolutely accurate timetable of history. Moreover, it gives some clues concerning such phenomena as the conditions of the world before the flood and the scope and magnitude of the flood. Thus, we have considerable information which is denied the scientist who chooses to rely only on the secular evidence.

It must be admitted, of course, that any reconstruction of the past will be speculative. The world is in the bondage of corruption and much of the available secular evidence is untrustworthy. The Noachian Flood was so catastrophic that normally it would defy any attempt at a reconstruction of history. Nevertheless, we would dare attempt such reconstruction only because of the exquisite reliability of the Biblical record.

In making this attempt we, too, must make some assumptions. These will automatically weaken our conclusions. We shall, however, try to minimize these assumptions so that their effect upon the conclusions is minimal.

To begin our reconstruction, let us try to estimate the carbon dioxide conditions which prevailed just prior to the flood and immediately following the flood. In the measure we are able to do this,

we will be able to estimate climate conditions of the past. This in turn should offer clues regarding such phenomenon as the ice age and fossil evidence of past tropical conditions.

We saw in Chapter 12 that the average rate of decay of C14 all over the world was about 72% of the rate of formation. This appears to indicate that the worldwide inventory or reservoir of C14 in the atmosphere, biosphere, and oceans is still increasing or filling. We learned that the formula for the increase is:

$$D = 100\,(1 - e^{-1T}) = 100\,(1 - 2^{-T/5730}) \qquad \text{Equation 3}$$

where "D" is the decay rate expressed as a percentage of the formation rate, and "T" equals the time in years since disintegration began or since the beginning of C14 production. Equation 3, therefore, tells us the present rate of C14 net increase all over the world as well as the increase during the past several thousand years if production of C14 was constant during this period, and if none of the C14 was lost in any way except through disintegration. This equation, therefore, could give us the size of the C14 inventory at a hypothetical point 7,000 years ago when the flood occurred. We must call this a hypothetical point because the flood would have produced such catastrophic changes that violent readjustment would have taken place for possibly a millennium following the flood.

Let us draw the curve of Equation 3 to see what happens at 4989 B.C., the date when the flood had subsided. We are aware that this curve cannot be considered to be absolutely precise. During this 7,000 year period there could have been short time fluctuations in C14 production. Also, some C14 would have been taken out of the available reservoir by the development, for example, of peat bogs and sedimentary rock. On the other hand, some C14 which had previously been buried, would have been freed by the action of weathering, by the burning of peat, and by other natural activity. In any case, the quantities of C14 added or removed by these activities probably are very small compared with the production rate of new C14. Since the 72% figure for the present size of the C14 reservoir is an approximation, we can fairly assume that the reservoir has been building up at a constant rate in accordance with Equation 3 to its present approximate 72% quantity. The curve for this build-up is plotted in Figure 1 (Curve B).

Examining a point on the curve where T = 4989 B.C., we discover that D = 35%. At that time in history the C14 reservoir must have been 35% full in order to build up to its 72% level today. Since, as we saw in Chapter 12, the production rate of C14 is 2.5 dps/cm^2 of the earth's surface, the C14 decay rate immediately following the flood was thus 35% x 2.5 dps/cm^2 which equals 0.875 dps/cm^2 or 52.5 dpm/cm^2. (Even as the decay rate today is 72% of 2.5 dps or 1.8 dps/cm^2.)

Now that we have estimated the C14 inventory immediately following the flood, let us proceed to estimate the C12 situation from the flood to the present time. To do this we must first estimate the specific activity "I" of carbon for the period. C12 is a function of both C14 and "I" in accord with the equation,

$$I = \frac{C14}{C12},$$

where C14 is the decay rate at any moment in time and C12 is the quantity of C12 available at the same moment.

We can obtain "I" by analyzing C14 dates of specimens and comparing these with the true dates. Presently radio carbon dates are determined assuming that "I" has been constant from the time the specimen died until its age was measured. Therefore, any specimens whose C14 age equals their true age, as determined by other reliable dating methods, must have died when the worldwide "I" equaled the worldwide "I" today. On the other hand, if the C14 age of a specimen is older or younger than its true age, then "I" at the time of death was smaller or greater than it was when the specimen was analyzed.

In examining many thousands of specimens, scientists have discovered that from about 250 B.C. to the present, the radio carbon dates agree very closely with the true ages. Thus, we can know that "I" for this period of time has been relatively constant. Therefore, we can know that C12 for this period of time was proportionate to the C14 inventory. We have already seen that C14 has been increasing in accordance with Equation 3. Therefore, for the same period C12 must have been increasing at the same rate, in view of the constant "I" for this period. The cube of this increase is plotted in Figure 2 (cube D).

When we look at the period from the flood to 250 B.C., the evidence is not quite as helpful. This is due to the fact that we cannot

Figure 1

know the exact relationship between the true ages and the radiocarbon ages for this entire period. However, scientists have been able to compare the true age of specimens with the C14 age back to about 3000 B.C. The true age is available through archaeological and tree ring data. They have discovered that earlier than 250 B.C. the true age of a specimen relates to the radiocarbon age by the formula:

$$T = 1.4R - 1100 \text{ (Equation 1)}$$

where R is the radiocarbon age and T is the true age. While this must be considered to be approximate, it is in the right direction and will help us to reconstruct the past within broad limits.

While Equation 1 appears to be true back to about 3000 B.C., we have no way of knowing if it holds all the way back to the flood. It is valid to assume, however, that whatever phenomenon produced the relationship encompassed by the equation probably was in large part a result of the flood. This is suggested by the utter magnitude and character of the flood as compared with any later phenomena that involved the whole earth, the continental division of 3100 B.C. notwithstanding. (We will discuss this division in greater detail in the next chapter.) It is also suggested by the secular evidence. There is no obvious nonconformity or discontinuity in Carbon 14 dating until we go back to the time of the flood. As we shall see later, a whole host of evidence is available to show a serious discontinuity about the time of the flood.

Since we know the flood occurred 4990-4989 B.C. or 6940 years ago (using 1950 A.D. in our calculations), we can estimate the radiocarbon age of a specimen that died at that time by equation 1 as follows:

$$6940 = 1.4\ R - 1100;\ R = 5740 \text{ years}$$

Therefore the carbon 14 age would be 5740 years, although its true age is 6940 years. With this knowledge we can estimate the specific activity "I" that existed immediately following the flood.

For any specimen that dies, the ratio of the C14 to the C12 atoms which we call the specific activity "I", is related to time by the formula:

Figure 2

$I_p = I_d e - T/5730$ (Equation 4)

Where:

T = true age of the specimen

I_d = specific activity in the year the specimen died

I_p = specific activity of the dead specimen today.

Let us now examine a specimen which gives a radiocarbon age of 5740 years. Since its age of 5740 years is determined by assuming the I_d, the worldwide specific activity at its death, was equal to that which exists today we can calculate the I_p which exists in the dead specimen today.

Let us first calculate the present specific activity of carbon. It can be determined from the known C14 decay rate and the present quantity of C12 atoms. Lingenfelter gives the following figures for the present size of the C12 inventory or reservoir (carbon available in the atmosphere-biosphere-hydrosphere for the carbon cycle).

Table III

		Grams/cm ^{2} of earth's surface
Ocean		
	Inorganic	7.56
	Organic	0.64
	Sediment	0.30
Land		0.16
Air		0.13
		8.79(See Fig. 2, Curve D)

Additionally, he indicates, as we saw in the previous chapter, that the present C14 disintegration rate is 108.5 dpm/cm^2. Therefore the present value of I is:

$$\frac{108.5 \text{ dpm/cm}^2}{8.79 \text{ gm/cm}} = 12.3 \text{ dpm/gm}$$

The figure 12.3 dpm/gm, therefore, is the specific activity that existed in the world 5740 years ago, if "I" had been constant during this period. Thus, the specimen that shows Carbon 14 date of 5740 years would now have a specific activity of:

$$\frac{12.3}{2^{5740/5730}} = 6.15 \text{ dpm/gm}$$

Previously we had shown that a specimen that shows a C14 age of 5740 years is actually 6940 years of age. Since we know its present I_p to be 6.15 dpm/gm we can now calculate the I_d at a point 6940 years ago when the specimen actually died. This equals 6.15 ($2^{6940/5730}$ = 14.2 dpm/cm. This then is the "I" that existed in the world at a hypothetical point 6940 years ago immediately following the flood.

We are now able to estimate the C12 inventory immediately following the flood. We had previously calculated that the C14 decay rate at the time of the flood was 52.5 dpm/cm^2. Since C12 = C14/I, the C12 we are looking for equals

$$\frac{52.5 \text{ dpm/cm}^2}{14.4 \text{ dpm/gm}} = 3.7 \text{ gm/cm}^2 .$$

We now have calculated that immediately after the flood, the following was the approximate situation as far as the carbon reservoir was concerned.

Average C12 content of oceans, atmosphere, and biosphere, 3.7 gm/c^2 (Curve D, Fig. 2).

Average C14 decay rate all over the world 52.5 dpm/cm^2 (Curve B, Fig. 1).

Specific activity of carbon 14.2 dpm/gm (Curve C, Fig. 2).

Let us now establish the carbon situation before the flood. The period 11,013 B.C. to 4990 B.C. will concern us.

Before The Flood

Of the three unknowns, C14, C12, and specific activity "I," the easiest to estimate is C14. Since the reservoir was at zero at 11,013 B.C., and built up in accordance with Equation 3 (Chap. 12), by the

year 4990 B.C., the reservoir should have been 51.8% full (Fig. 1, Curve A). Actually, it probably was somewhat less than this because of the carbon 14 that was buried in peat bogs and $CaCO_3$ buildup as sedimentary rock. We shall see later why this is so. We arbitrarily will guess that this reduced the carbon 14 reservoir by about 10% so that at 5000 B.C. it would have been 51.8-5.2 or 46.6% full (Fig. 1, Curve B). Whether this reduction was actually 10% or as much as 25% or as little as 5% will not seriously alter the general conclusions derived from this discussion.

We have no way of determining the size of the C12 reservoir before the flood at 4990 B.C. but we do have some clues as far as the specific activity of carbon is concerned for about the time just before the flood. As scientists have studied the carbon 14 dating evidence, a great amount of attention is focused on a period about ten to fifteen years ago. The meat from wolley mammoths found frozen by the thousands in Siberia gives a carbon data of a bit older than 10,000 years.[1] A series of samples of inorganic carbonate show dates of from 10 to 15 thousand years ago, thus indicating high carbonate precipitation about that time in history. We read, for example, in *Radiocarbons*, about the results of a series of cores that were studied from the Red Sea floor and which give dates of 8875 to 10,675 B.C. The remarks are interesting.

> Samples at depth of 70 cm, 40 cm, and 50 cm give absolute age for onset of unusual conditions which lead to precipitation of submitted 'hard crust' in Red Sea. This is the first instance that cemented calcareous rocks have been cored from ocean bottom. It is expected that precipitation of $CaCO_3$ took place at the end of the last glacial period as a result of temperature increase and temporary separation of basin 'from Indian Ocean.' [2]

We shall determine as we continue our study how these unusual conditions were probably a result of the flood.

In another series of tests a great many samples of inorganic carbonate were studied to determine the age of freshwater inorganic carbonate deposits. Uncorrected ages of the samples showed ages of 20,000 to 37,000 years.

> Corrected C14 ages show that major carbonate accumulation occurred 10,000-15,000 years ago. . . . In any case, corrected ages more closely approximate true age of 'young' organic carbonate than any ages of same material determined by the C14 method thus far.[3]

These examples are given to indicate that in the period 10,000 to 15,000 years ago, as determined by radiocarbon, there was especially great activity of carbonate deposition. Another series of dates relate to this same period. Standard Oil Co. initiated a project dealing with the nature of organic matter in marine sediments. They report:

> One of the surprising results of this study has been the discovery of liquid hydrocarbons in recent sediments from the Gulf of Mexico. Celephatic and aromatic hydrocarbons have been identified in ten recent marine sediment samples from four different locations in Texas and Louisiana, in which specimens representing near shore or off-shore locations . . . were included. Depths of these sediments ranged from a few inches up to a hundred feet below the water floor... . If one were to extrapolate the data obtained on a 106 foot core of sediments taken from the floor of the Gulf of Mexico 7 miles off Grande Isle, a cubic mile of these sediments would contain 4,500,000 barrels of a parafin-nathene, aromatic, and asphaultic mixture resembling crude oil . . . Ages of 11,800 - 14,600 ± 1400 years were obtained for the hydrocarbons extracted from several sections of the Grande Isle core of recent sediments. A composite carbonate sample from the entire core proved to be 12,300 ± 1200 years old.[4]

Moreover, a date of about 10,000 B.C. is assigned to the end of the last great glacier periods known as the Wisconsin and the Allerod. Frederick Johnson writes:

> In 1951 Flint compared the Allerod horizon in Germany, England, and Ireland, dated about 8850 B.C., with the two Greeks horizon, dated about 9450 B.C.; he concluded that the essential agreement of the dates implies that deglaciation of Northern Europe was contemporary with that of North America.[5]

Interesting, too, is the dearth of radiocarbon dates that are found to be older than 15,000 years. John D. Milliman and K. O. Emery, for example, write that of eighty radiocarbon dates used in determining past sea levels, only fifteen show older than 15,000 years.[6]

Excess carbonate deposition, oil deposits, the death of thousands of animals by some unknown means, all point to a drastic phenomenon about 10,000 to 15,000 radiocarbon years ago. Surely, an unusual amount of change took place in the world about that time. Could this have been related to the flood? It certainly appears so.

Since the awesome, earth-shattering flood of Noah's day actually did happen about seven thousand years ago (4990 B.C.) according to Biblical reckoning, we expect to see evidence in the secular record of this world-wide catastrophe. The examples we have just cited, and a great many more which could be offered, do indeed show that about 10,000 to 15,000 radiocarbon years ago tremendous changes occurred in the earth. I believe we are on safe ground to assume that these completely unusual, out-of-the-ordinary, unexplainable conditions can be only the results of the Noachian Flood.

With this in view let us continue our reconstruction by selecting an average date of 12,000 radiocarbon years before the present as the date of the flood. Use of a figure a few thousand years older or younger should not significantly change the results of this reconstruction.

Using a flood date of 12,000 years B.P. (before present) will give us the tool that we need to discover the "I" or specific activity of carbon that existed in the world just prior to the flood. Once we know "I" at that point in history we can calculate the carbon available to the carbon cycle just prior to the flood. With that in hand we will be able to see the impact of the flood upon the world as we compare these figures with those we have previously calculated to be true just after the flood. The radiocarbon date of 12,000 B.P. is, of course, based upon the assumption that the specific activity "I" has been constant through the ages. Since we have already seen the "I" value has not been constant and since we know the true date of the flood (4990 B.C.), we can determine the "I" that probably existed just before the flood. A specimen that now shows an age of 12,000 years must have an "I" at present of:

$$I\ (\text{present}) = I\ (12{,}000\ \text{yrs. B.P.}) \times \frac{\qquad}{\qquad} =$$

$$12.3 \times \frac{\qquad}{\qquad} = 2.84\ \text{dpm/gm}^2.$$

Since the specimen now shows an "I" of 2.84, its "I" at 4990 B.C. which is 6940 B.P., should have been:

$$2.84 = I\ (4990\ \text{B.C.}) \times \frac{\qquad}{\qquad};$$

$$I\ (4990\ \text{B.C.}) = 6.6\ \text{dpm/gm}.$$

Therefore, the "I" which existed immediately before the flood, I (4990 B.C.) equaled 6.6 dpm/gm (Fig. 2, Curve C).

We now have estimated the specific activity occurring just before the flood to be about 6.6. Since we previously estimated the C12 reservoir to be 46.6% full, the C14 value should have been 46.6% x 2.5 dps/cm^2 or 1.16 dps/cm = 69.6 dpm/cm^2 (Fig. 2, Curve B). The carbon reservoir should then have been

$$\frac{\text{C14}}{\text{I (4990 B.C.)}}$$

which equals 69.6/6.6 or 10.5 grams/cm^2 (Fig. 2, Curve D).

We have now determined the following:

	Immediately Before Flood (4990 B.C.)	Immediately After Flood
Average C14 decay rate all over world	69.6 dpm/cm^2 (Fig. 1, Curve B)	52.5 dpm/cm^2 (Fig. 1, Curve B)
Average C12 content of oceans, atmosphere, and biosphere	10.5 gm/cm^2 (Fig. 2, Curve D)	3.7 gm/cm^2 (Fig. 2, Curve D)
I (specific activity of carbon)	6.6 (Fig. 2, Curve C)	14.2 (Fig. 2, Curve C)

The Flood Depleted the C14 Reservoir

A serious problem has now arisen. If the C12 content of the world before the flood was about 10.5 grams/cm^2 and after the flood only 3.7 grams/cm^2 as we previously calculated, what happened to the rest of it? Obviously, the balance of it was buried by the flood of Noah's day. It was taken out of the reservoir by becoming coal, oil, and sedimentary rock. Additionally, some of it was covered by the glaciers that spread over the world.

If that is true, would a like percentage of the C14 have been taken out of the C14 reservoir? If this is so, since C12 was reduced from 10.5 grams to 3.7 grams, the C14 reservoir which approximated 69.6 dpm/cm^2 before the flood should have been proportionately reduced to about 24.5 dpm/cm^2 after the flood (Figure 1). This is in serious conflict with the figure 52.5 dpm/cm^2 which we previously calculated as the post-flood condition. How can we account for this discrepancy?

Again the Bible comes to the rescue. The Bible indicates that a great quantity of new water was provided as a result of the flood, and we can show that at least some of this water surely contained much C14. In Genesis 7:11 we read that the fountains of the deep opened up as did the windows of heaven. Thus, God teaches that the flood was produced by waters overflowing from the bowels of the earth and waters from the heavens. Biblical statements show that such water would have been available.

We read in the creation account that God began with water. Genesis 1:6-8 declares:

> And God said, Let there be a firmament in the midst of the waters, and let it divide the waters from the waters. And God made the firmament, and divided the waters which were under the firmament from the waters which were above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day.

The Bible then declares that the waters under the heaven were gathered into one place and the dry land appeared (verse 9). This account informs us that there are waters above the heavens as well as waters from which the earth was formed. This information is supported by other Bible references. In connection with statements that outline the creation of the heavens and the earth, we read in Psalm 136:6:

> To him that stretched out the earth above the waters: for his mercy endureth for ever.

We read in Psalm 148:4:

Praise him, ye heavens of heavens, and ye waters that be above the heavens.

These verses together with the Genesis creation account agree entirely with the statement of Genesis 7:11 that God opened the fountains of the deep and the windows of heaven. Surely God is

teaching that there is water under the heavens as well as far out in deep space. Only the idea of water in deep space appears to satisfy the Biblical teaching of waters above the heavens.

The concept of waters under the heaven from which the earth came forth or upon which the earth was spread is readily seen by the secular evidence. It is seen in the oceans as well as in the waters under the continents and oceans which exist as underground rivers, lakes, and seas. Also, it is seen in the fact that so much of the continents are composed of sedimentary, that is, water-formed, rock.

It is seen in the waters that are expelled during volcanic action. We know that the opening of the fountains of the deep, on a large scale, would have been equivalent to the new waters that are produced by the activity of volcanoes. The evidence of the rupturing of the ocean floors can be seen in dramatic fashion in the great volcanic rifts that exist on the floors of the oceans. We will discuss these sea floor rifts in greater detail in the next chapter.

The existence of active volcanoes gives us some clues as to what we might expect in the way of new C14 being available to the earth when the fountains of the deep were opened during the flood. Water from the fountains of the deep in all probability would have been very similar to present volcanic action since both phenomena produce water from the depths of the earth. An examination of such water shows that it contains some C12 but no significant C14. This is because such water would never have been in contact with cosmic rays which are required for the production of C14. While the Biblical statement (that the fountains of the deep opened up to make available considerable new water to assist in the inundation of the earth), is supported by much secular evidence, such new water would have produced little or no new C14. Therefore, our earlier conclusion that sufficient new C14 was added as a result of the flood to change the available C14 from a theoretical post-flood quantity of 24.5 dfm/cm^2 to a calculated actual 52.5 dpm/cm^2 is not assisted by the knowledge of new water from the depths of the earth.

When we consider the possibility of water from deep space we have another situation altogether. It be shown that it was available as the Biblical record teaches, and it can be shown that it probably contained considerable new C14. Let us examine the question of deep space water in greater detail. In so doing, we will discover answers to the questions relative to the huge quantities of new water necessary to

account for a flood that covered the highest mountain to a depth of 15 cubits.

Water from Deep Space

Heretofore, scientists who have tried to understand the Genesis 7 account, that it rained such great quantities of water for forty days that even the mountains were covered, have contended that the Genesis account was an absurdity. They contended that if all the moisture in the atmosphere could be precipitated, the entire earth would be covered by only a few inches of water, even if we assumed a saturated atmosphere. This, of course, is true. But the Bible does not say that the windows of heaven meant the atmosphere. Could it not mean deep space beyond the exosphere? It could, as we shall see.

For some time scientists have been aware that the hydroxide ion OH is present in outer space. This knowledge alone assures us that the raw materials required for inundating the earth exist in deep space. Also, scientists have discovered huge clouds of water in outer space. This was reported by a team from the University of California in *Science*, March 7, 1969. They report:

> Radio spectral line radiation of water molecules at a wave length of 1.35 centimeters have been measured from eight sources in the galaxy. The sources are less than 7 arc-minutes in diameter, have extremely high brightness, temperatures, and show many spectral features. . .. Seven of the eight H_2O line emission sources which have been observed agree in position with known OH emission sources within the accuracy of measurement.[7]

They add that the apparent size of these H_2O clouds are less than 10^{16} cm (80 billion miles) in size. Therefore, today we have evidence of huge water clouds in deep space.

Thus, we can easily assume that God in His perfect planning caused the earth to go through just such a water storm so that for forty days and nights water poured upon the entire surface of the earth simultaneously. The windows of heaven were indeed opened.

(See Appendix V for additional discussion on deep space water.)

C14 from Deep Space

Did this water contain C14 and if it did, can we reasonably conclude that there was sufficient new C14 provided by this means to

double the C14 reservoir? In fact, if new C14 was provided by this means, some of it would have mixed with the CO_2 in the earth and would have been buried with the C12 and C14 that was here before the flood. Thus, we must anticipate new C14 in a quantity no less than that which would have produced an additional 25-30 dpm/cm^2 of radiation.

The question of the possibility of C14 being present in the deep space water is readily answered. C14 is produced by the action of cosmic ray neutrons, and scientists have discovered cosmic rays everywhere in space. V. L. Ginzburg writes:

> During the past 15 years however, we have come to recognize that the cosmic rays are indeed a weighty and energetic factor, ranking with the stars as a principal component of the cosmos. In these few years we have learned that cosmic rays are truly a universal phenomenon, not only present throughout the space of the solar system of our galaxy and of the other galaxies, but also associated with the life processes of the stars, with supernova explosions, with radio galaxies and with quasars.[8]

The presence of C14 in deep space is abundantly shown by the presence of C14 in some of the meteorites. T. P. Kohman and P. S. Goel write:

> Techniques have been developed for the isolation and measurement of cosmogonic C14 in meterorites.[9]

We thus see clearly that carbon 14 is present in deep space. We may then assume that the water storms of outer space would also contain much C14. Thus, our conclusions that (1) the flood resulted in part from tremendous quantities of new water being poured forth from the Biblical windows of heaven, and that (2) sufficient amounts of new C14 to produce 25-30 dpm/cm^2 of radiation were provided by this new water is clearly possible and indeed is altogether probable in the light of the secular evidence.

How Much Water Inundated the Earth?

We should now estimate the amount of deep space water that was deposited on the earth during the flood. This question requires a bit more analysis. We shall begin by setting forth the present water-continent quantities that exist. From Sverdrup we obtain the following facts.[10]

Area of earth's surface	5.1×10^{18} cm^2	
Area of oceans including adjacent seas	3.61×10^{18} cm^2 =	70.8% of earth's surface
Area of all land	1.49×10^{18} cm^2 =	29.2% of earth's surface
Average depth of oceans	3795 meters	
Average height of sub-airial crust (continents)	840 meters	
Volume of all oceans	1370×10^6 km^3	

Turning now to the Bible, we read the following interesting news in Psalm 104:6-9:

> Thou didst cover it with the deep as with a garment; the waters stood above the mountains. At thy rebuke they fled; at the sound of thy thunder they took to flight. The mountains rose, the valleys sank down to the place which thou didst appoint for them. Thou didst set a bound which they should not pass, so that they might not again cover the earth.

This psalm must be talking about a phenomena which took place after the Noachian Flood, for it reads, "Thou didst set a bound which they should not pass, so that they might not again cover the earth." The significant word "again" indicates that the flood must have occurred already for it surely was an event in which the oceans covered the earth without restriction. This psalm, therefore, gives us the exceedingly helpful information that following the flood there was a deepening of the ocean basins and a rising of the mountains.

From this we may assume that prior to the flood the ocean basins were somewhat more shallow than at present and that during and following the flood there was considerable mountain building. Therefore, we can be assured the waters of the flood did not cover the earth at a depth required to cover the present high mountains.

But the Bible says the mountains were covered. Genesis 7:19 says "All the high mountains that were under the whole heavens were covered." We know, therefore, that mountains did exist before the flood and sufficient new water was added to cover these mountains.

Let us attempt to determine how high these mountains were.

Presently, the continents have an average elevation of 840 meters above sea level. Since the pre-flood mountains were lower than the mountains of today, the average continental height before the flood must have been somewhere between zero and 840 meters high. Yet there were mountains and they must have been considerably higher than sea level. However, since the mountains were much lower than at present, the average continental height must have been considerably less than 840 meters. Let us assume the average continental height before the flood was 340 meters. (A figure 100 meters higher or lower would not substantially change the conclusions of this discussion.) If the highest pre-flood mountain in the pre-flood continent was only about 1000 meters, the new water required to cover this mountain amounted to about 460×10^6 km^3. If it was as high as 2000 meters, the new water would have been about 970×10^6 km^3.

It seems extremely unlikely that the pre-flood mountains were higher than 2000 meters. To cover mountains of such a height would have required so much new water that the pre-flood oceans would have been only about 30% their present volume. On the other hand, we would not reasonably expect the pre-flood mountains to be much less than 1000 meters (3270 ft.). This is especially so in the light of Genesis 7:19 where the phrase "high mountains" is used. Therefore, we may speculate that the highest pre-flood mountains were perhaps between 1000 and 2000 meters and the volume of the pre-flood ocean, including waters from the depths of the earth, was somewhere between 400×10^6 km^3 and 910×10^6 km^3. For the sake of this discussion we will use a figure about midway between these figures, assuming that about 685×10^6 km^3 of water were added from deep space during the flood. The highest pre-flood mountain was then about 1450 meters high (4750 ft.). Any other set of pre-flood conditions within the limits assumed in this discussion can be estimated but will not substantially change the conclusions offered in this study.

This huge amount of water from deep space which could have doubled the ocean volumes (present volume 1370×10^6 km^3) must have contained C14 in an amount which, when added to the C14 already on the earth, would have provided about 52.5 dpm/cm^2 of radiation after the flood. There probably was more C14 than this because some of the new C14 would have been buried by the flood action.

Thus far in our study we have seen that the pre-flood world contained oceans possibly one half the size of our present oceans, the C12 content approximated 10.5 grams/cm^2, and the C14 reservoir had built up so that it showed a disintegration rate of about 69.9 dpm/cm^2. Water equal to the amount of the pre-flood ocean was dumped on the earth in forty days, which brought large quantities of new C14. The geological action that resulted from the flood buried as much as 65% of the pre-flood C12 together with like amounts of C14. The end of the flood saw a world with C12 reduced to about 3.7 grams/cm^2 and the C14 reservoir reduced so that it produced a decay rate of about 52.5 dpm x cm^2.

Hopefully, we have produced a reasonable reconstruction of the carbon situation that existed in the past. With this information we should be able to estimate past climatic conditions because a definite relationship exists between the carbon in the atmosphere (principally CO_2) and world-wide temperatures. Moreover, the amount of CO_2 in the atmosphere is a function of the carbon available in the carbon cycle. Once we know something about past climate conditions, we shall see the reason for such ancient phenomenon as a heavily vegetated earth followed by extensive glaciations over almost a third of the earth's surface. Thus, we shall receive some additional insight into the cause of the phenomenon which is in evidence about 10,000 to 15,000 radio carbon years ago.

Pre-Flood Climate

Let us now examine the conditions that existed in the pre-flood world as far as climate was concerned. Previously, we noticed the following distribution of C12 or CO_2, in the carbon cycle:

C12 per cm^2 of Earth's Surface

7.56 grams in the ocean as inorganic carbon

0.64 grams in the ocean as organic carbon

0.3 grams in the ocean as sediment

0.16 grams in the land

0.13 grams in the atmosphere

8.79

Apparently an equilibrium exists between the carbon in the oceans, atmosphere, and biosphere or land, with a total amount in the world of about 8.8 grams/cm^2 on the earth's surface. What possibly could have been the equilibrium situation before the flood when there was on the order of only one-half as much ocean volume and when the C12 content amounted to something like 10.5 gram/cm^2 all over the world? Let us first determine equilibrium conditions for the earth today, assuming that the ocean was reduced by one-half in volume. If the atmosphere had 0.13 grams, and the land 0.16 grams, we would expect the amount in the ocean to be one-half of the figures for our present full ocean. The figures would look like this:

	Ocean Present Volume	Ocean One-half Than Under Present Conditions
Oceans		
Inorganic	7.56 gr/cm^2	3.78 gr/cm^2
Organic	0.64 gr/cm^2	0.32 gr/cm^2
Sediment	0.3 gr/cm^2	0.15 gr/cm^2
Land	0.16 gr/cm^2	0.16 gr/cm^2
Atmosphere	0.13 gr/cm^2	0.13 gr/cm^2
	8.79 gr/cm^2	4.54 gr/cm^2

Let us change one other condition. The land areas presently cover 29.2% of the world. Let us assume today's conditions of CO_2 concentrations, but let us assume that in addition to the oceans being one half in volume, the land is increased so that it covers about 40% of the earth's surface. (If we assumed the land area was unchanged from what it is today, the conclusions offered in this discussion would be fundamentally unchanged.) We shall see later why we have added to the continental areas. Equilibrium of CO_2 or C12 could then be expected to be approximately as follows:

Oceans	Ocean Present Volume
Inorganic	3.73 gr/cm^2
Organic	0.32 gr/cm^2
Sediment	0.15 gr/cm^2
Land	
$0.16 \times \frac{\text{Land}}{\text{Atmosphere}}$	$= 0.22$ gr/cm^2
Atmosphere	0.13 gr/cm^2
	4.54 gr/cm^2

What would we obtain if the total available C12 were 10.5 gram/cm^2 instead of 4.54%? We shall assume the land and atmosphere would increase at the same rate so that if the atmospheric carbon were doubled, the carbon in the biosphere or land (plants, etc.) would also be doubled. We shall also assume the inorganic carbon in the oceans would increase at the same rate as the organic ocean carbon and the ocean sediment carbon. Thirdly, we shall assume the ocean carbon increased in proportion to the square root of the increase in the land and atmospheric carbon. This is based upon the conclusion of Gilbert Plass[11] who estimates that if the carbon dioxide content in the oceans was doubled, the content in the atmosphere would probably be quadrupled. We cannot know how correct these assumptions are, but they at least should be in the right direction and of the right order of magnitude. The following would result.

Oceans		
Inorganic	3.73 times x =	? gr/cm^2
Organic	0.31 times x =	? gr/cm^2
Sediment	0.15 times x =	? gr/cm^2
	4.19	
Land	0.22 times x^2 =	? gr/cm^2
Atmosphere	0.13 times x^2 =	? gr/cm^2
	0.35	10.5 gr/cm^2

To solve for x we have then the equation:

$$0.35\ x^2 + 4.19\ x = 10.5$$

Solving this we get $x = 2.13$, and $x^2 = 4.5$.

The distribution of the carbon cycle before the time of the flood would thus have been:

Oceans		
Inorganic	3.73 times 2.13 =	7.94 gr/cm^2
Organic	0.31 times 2.13 =	0.66 gr/cm^2
Sediment	0.15 times 2.13 =	0.30 gr/cm^2
Land	0.22 times 4.54 =	1.00 gr/cm^2
Atmosphere	0.13 times 4.54 =	0.59 gr/cm^2
		10.49 gr/cm^2

The important change is in the atmospheric carbon. We see that the carbon dioxide of the pre-flood atmosphere was perhaps at least four times more concentrated than it is today (0.59 as compared with 0.13). Plass suggests that calculations show that if the carbon dioxide were decreased by 50%, the average temperature would have been decreased by 6.9° F.[12] A rise of 400% in CO_2 should then give us reason to believe that the pre-flood world was some ten to fifteen degrees warmer than today. The earth being this much warmer along with a high CO_2 concentration would have been ideal for development of the heavy growth of plant life all over the world that is actually shown by the fossil record.

Plass writes[13] that the earth's climate was warmer during most of geological time; presumably the atmosphere then contained a much higher percentage of carbon dioxide. His conclusion is adequately supported by our CO_2 calculations.

Post-Flood Climate

Let us now examine the carbon equilibrium after the flood as it existed in the oceans, biosphere, and atmosphere. While equilibrium might not have come for hundreds of years after the flood, we can establish a theoretic condition immediately after the flood, inasmuch as we have some idea of the impact of the flood on carbon availability. As we saw earlier in our study, the carbon inventory plunged from an average amount of 10.5 g/cm^2 over the entire surface of the earth to an average amount of 3.7 gr/cm^2 after the flood.

In making our calculation we must realize that as a result of the flood, the oceans were increased to a volume equal to today. Moreover, the continental areas were probably somewhat reduced in size due to the areas of land which became the continental shelves and slopes of our present earth.

Ocean		
Inorganic	7.56 times	x = ? gm/cm^2
Organic	0.65 times	x = ? gm/cm^2
Sediment	0.30 times	x = ? gm/cm^2
	8.51	
Land	0.16 times	x = ? gm/cm^2
Atmosphere	0.13 times	x = ? gm/cm^2
	0.29	3.7

Thus, the gross continental area approximated that of today. Therefore, we assume today's conditions of carbon residency in arriving at the post-flood situation.

Thus, . . . $29x^2 + 8.51x = 3.7$, and $x = 0.43$ while $x^2 = 0.18$. Thus, the following obtains for the post-flood situation.

Oceans	8.51 x 0.43 =	3.66 gm/cm^2 of the earth's surface
Land	0.16 x 0.18 =	0.03 gm/cm^2 of the earth's surface
Atmosphere	0.13 x 0.18 =	0.03 gm/cm^2 of the earth's surface
		3.72 gm/cm^2 of the earth's surface

Again the important fact to note is the great change in the atmosphere carbon. We see that immediately following the flood, the average carbon dioxide content of the atmosphere was about one-fourth of what it is today, or about 5% to 6% of what it was before the flood. Thus, we may conclude that the average world temperature was ten to fifteen degrees F. colder than today or from twenty to thirty degrees F. colder than before the flood. No wonder extensive glaciation was introduced by the flood. Plass records:

> Calculations show that a 50% decrease in the amount of carbon dioxide in the air will lower the average temperature of the earth 6.9° F. We can be reasonably sure that such a sharp drop in temperature would cause glaciers to spread across the earth.[14]

Obviously a drop of 20° to 30° would have multiplied the potential for extensive glaciation to occur. Moreover, there must have been extremely severe oscillations of temperatures in the world following the flood as mountain building occurred and as equilibrium was again established. This could easily have given rise to some of the evidence that results in the common belief that there have been several periods of glaciation during the earth's history.

The Glacial Epoch

Thus far we have calculated that the world before the flood was 10° to 15° F. warmer than today. We have also seen that the flood caused a worldwide temperature reduction of 20° to 30° F. so that the average temperature became a 10° to 15° F. colder than today. Now the intriguing question must be asked: Is secular evidence available that shows that the world was this much colder in the past? The answer

to this question is affirmative if we examine the evidence relating to the glacial epoch or ice age.

Scientists today have noted that the continents are covered by glacial ice to an extent of 10.4% of the earth's surface. In the past the ice cover was much more extensive inasmuch as evidence shows that some 28% of the continents were covered. At the height of the ice age the more extensive glaciation must have existed in a world that was substantially colder than today. Estimates of the lowering of the world's temperatures during the ice age have been made by a number of scientists. The *Encyclopaedia Britannica* describes the making of one such estimate and indicates that a temperature drop of 7-8° C (12.4-14.4° F) was characteristic of the ice age. There we read:

> At the height of the glacial ages at least 28% of the land area of the world was covered by glacier ice. At present more than 10% is so covered. But during the inter-glacial ages and in pre-glacial time, apparently very little if any glacier ice existed. Thus, the present day has somewhat less the aspects of a non-glacial climate than the inter-glacial ages. It is therefore desirable to compare the climates of the glacial ages with non-glacial climates as well as with present-day climates.

Glacial cirques (theatre-like valley heads fashioned by the action of snow fields at the heads of individual glaciers in mountainous terrain), bear a rough general relation to the snow line or lower limit of perennial snow. Through measurements of the altitudes of cirques in many parts of the world the approximate position of the snow line at the height of the latest glacial age has been determined. Wherever measured, the former snow line is lower than the snow line of today, at the equator as well as in polar latitudes.

In order to determine the glacial-age climate of a coastal point A, point B on the same coast is located by finding the place where the present snow line has the same altitude as the glacial-age snow line of A. The present climate of B is then taken as representative of the former climate of A. The method is rough, but over a wide region it gives consistent results. Coastal points such as A are seen to have received much greater precipitation than now, and to have had mean annual temperatures of the order of 7° C. to 8° C. lower than now, whereas in interior regions the increase in precipitation and decrease in temperature, compared with present conditions, were less pronounced. In other words, the sub-polar climate belts were shifted

toward the equator during the glacial ages. This shift may have amounted to as much as 15° of latitude.

The pluvial conditions of the dry regions of middle and low latitudes support this conclusion in that they appear to show equatorward shifting of the middle-latitude belts of rain-bringing cyclonic storms. The evidence of fossil animals in the northern hemisphere likewise indicates southward shifting of the cold northern climatic zone through many degrees of latitude.

On the other hand, the evidence of fossil plants and animals indicates that during the inter-glacial ages the climatic zones were shifted toward the poles, and that more than once these zones, in the northern hemisphere at least, have been pushed north of the positions they occupy at present. It is generally believed, though it has not been conclusively proved, that these climatic shifts were synchronous throughout the world. In summary, the climatic changes were world-wide and apparently contemporaneous; the climatic belts were shifted alternately, equator-ward and pole-ward; and changes in mean annual temperatures amounted to several degrees centigrade.[15]

Table VI. Lowering of Temperature During the Ice Age

Climatic Evidence	Pleistocene Lowering of Temperature (°C)	Author
Dryasotopcetala in Central Europe	6-10°	Gagel, Range, Werth
Picea glavic and P. Mariana in Texas	8° in July	Potzger, Tharp
Picea and Abies in Florida	7-8° in July	Davis
Frost fissures in Central Germany	11°	Soergel
Frost fissures in Montana	8°	Schafer
Depression of snowline in the Alps	6°	Penck
Depression of snowline in Colorado	5.5°	Anteus