ABSTRACT

The minimal constraints imposed by a conservative grammatical-historical exegesis of the Bible on the interpretation of radioisotope data are (1) the initiation of conditions suitable for the support of organic life, and (2) the introduction of living organisms, on planet Earth (3) within a one-week period of time not less than about 6000 or more than about 8000 years ago. Some exegetes impose an additional constraint (4) that all material substance within the Solar System originated during the same week.

Constraint number (4) requires all data for radiometric ages greater than the order of 10,000 years on inorganic material to be interpreted as the consequence of characteristics that were part of the original design at creation, subject to such modifications as may have occurred subsequently as a result of exposure to heat, water and radiation, and not as indicators of age.

Constraints (1) - (3) allow radiometric age data to have time significance for the history of inorganic material prior to its association with a fossil. This time significance could be totally or partially preserved in the relocation that brought a fossil and inorganic material into stratigraphic relationship. Accordingly, without constraint number (4) radiometric age data for inorganic material may be interpreted as the combined consequence of original design at a primeval creation, subsequent exposure to heat, water and radiation, and time.

Data on the concentration of radioactive atoms in carbon that was once part of a living organism, when interpreted in accord with constraints (2) and (3), indicate that during the early centuries following the catastrophe described in Genesis 6-8 the carbon-14/carbon-12 ratio in the biosphere increased at least 200-fold, and possibly more. Remains of organisms that lived during this time now have radiocarbon ages in excess of their true historical age.

INTRODUCTION

Individuals who grant historical validity to the chronologic data in the Hebrew Pentateuch face severe difficulty in relating to radiometric age data. The purpose of this presentation is to examine strategies for harmonizing these diverse categories of data.

BIBLICAL TIME CONSTRAINTS

A logical first step in this examination is a review of the time constraints imposed by a conservative grammatical-historical interpretation of the first eleven chapters of Genesis. On the basis of the chronologic data in these chapters, and in other portions of the Hebrew Scriptures, classical scholars arrived at various estimates for the time when life was created on planet Earth. These estimates ranged between 3616 B.C. and 6984 B.C. (Young, 1879).

By taking 970 B.C. for the year in which the construction of Solomon's temple began (Shea, 1980) and utilizing the data given in Exodus 12: 40, 41; (Genesis 15:13); (Acts 7:6); Genesis 47:9; 25:26; 21:5; 12:4; 11:32; 8:13; 11:20-24; 7:11; 5:1-29 Creation Week can be located readily in the year 4179 B.C., according to the Hebrew text of the ninth century A.D. on which modern translations are based. Allowance for probable difference between age based on birth date and age based on a standard calendar, and
allowance for the likelihood that some of the age data in Genesis 5 and 11 may be rounded approximations, places an uncertainty of ± 10-50 years on a creation date derived in this manner (Brown, 1984).

A similar analysis of the Greek Text (Septuagint) that was translated from Hebrew in the third century B.C. places Creation Week in 5665 B.C. The Hebrew text preserved by the Samaritans (Samaritan Pentateuch) yields 4420 B.C. It is my personal conviction that the balance of evidence favors the Alexandrinus Septuagint text as providing chronologic data related to the age of our world which has suffered the least corruption by copyists and translators.

Between the three currently available ancient sources, we can say that the Biblical text places the origin of our world within ± 1000 years of 7000 years ago, and that about 5000 ± 500 years ago the surface of planet Earth experienced a major breakup and reorganization (the Noachian Flood of Genesis 6-8). These time constraints are based on recognition that while the genealogical lists in Genesis 5 and 11 probably are abbreviated, as are all other genealogical lists in the Bible, the stated time intervals between the listed individuals were essentially correct in the autograph.

TREATMENT OF RADIOMETRIC AGE ASSIGNMENTS AS INCONSEQUENTIAL

Many individuals who are deeply committed to Biblical literalism have reacted to the challenge of radiometric age data by assuming that assignments of radiometric age are meaningless. Such response indicates a commendable confidence in the Bible, and deserves thorough investigation.

Many regions of Earth's surface have a characteristic radiometric age that is consistent among various mineral types and for radioisotopes of widely varying chemical and physical characteristics. Table 1 demonstrates this feature for nine regions of North America. A similar pattern has been observed for rocks obtained from the Apollo landing sites on the moon, with locally characteristic values of potassium-argon and rubidium-strontium age averages in the 3.0 to 4.3 billion year range (Church, 1975), as shown in Figures 1 and 2.

The precision with which diverse radiometric age data may be in agreement is illustrated by the Lake District Batholith (Table 2) and the Coradoc Series (Table 3) of England.

Additional evidence concerning the significance of radiometric age data is provided by contact metamorphism. Igneous intrusions reset the radiometric ages of country rocks, with the amount of reset diminishing at increased distance from the contact surface, as would be expected on the basis of diminishing temperature change with distance from the intrusion. Immediately at the contact the reset radiometric age of the country rock may be within experimental precision equal to the radiometric age of the intrusive mineral. The most thoroughly investigated example is the metamorphosis of the Idaho Springs formation by the Eldora Stock in Colorado (Hart, et al., 1968; Hoblitt and Larsen, 1975). Figure 3 shows the observed transition of radiotrace age from undisturbed country rock to the Eldora Stock contact. Similar observations have been made for an intrusive basaltic dike at Christmas Lake in the Beartooth Mountains of Wyoming (Hanson and Gast, 1967), and for a basalt plug in the Cathedral Peak Granite of Yosemite National Park (Calk and Naeser, 1973).

From these few examples it should be apparent that an individual who is moderately well-acquainted with radiometric age data should not be expected to respond favorably to any treatment that essentially places these data in a meaningless or inconsequential category. Harmony between radiometric age data and Biblical chronologic data must be sought on a more substantial basis.

THE ZERO-SET HYPOTHESIS

Beyond the 30-50 thousand year limit of radiocarbon dating, a radiometric age for a fossil must be based on associated inorganic material. It is usual to make the implicit assumption that a fossil is at least as old as the radiometric age of material that has replaced original organic tissue, material which contains the fossil, or material that overlies or penetrates the material which contains the fossil. On this basis fossil age assumptions have been made up to as great as about 600 million years for Metazoa, and up to about 3.3 billion years for blue-green algae. This assumption can be identified as: that a process of transport which buries an organism also resets the radiometric age indicators to zero. A more precise and more correct statement of this hypothesis is that radioisotope parent loss, radiogenic
daughter gain, and radiation damage effects in the host mineral that have accumulated since the transport are distinguishable from those which accumulated before transport (fossil burial).

A complete reset to zero is highly unreasonable, except when there has been an interval of high temperature sufficiently extended to drive off a gaseous daughter product (e.g., the argon-40 daughter of potassium-40) or to completely anneal fission tracks (fission track dating). To distinguish daughter product concentration and fission track density that survived transport from that which accumulated after transport would require data for several independent radiisotope systems that have diverse chemical and physical characteristics. Since such data are rarely available, radiometric fossil age assignments are based almost always on the Zero Set Hypothesis. Thus there is a legitimate question as to how much a radiometric age for a fossil indicates real time since the organism was buried, and how much it indicates the radiometric age characteristics of the material in which the organism was buried. Certainly the radiometric age characteristics of soil and rocks in a modern cemetery provide no indication of the time since any corpse was interred there. Should we expect the situation to be significantly different with respect to the organisms that were buried as a result of the erosion and igneous upheaval associated with the world-wide catastrophe described in Genesis 7 and 8?

### SOME NEARLY CONCORDANT RADIOISOTOPE AGES FROM NORTH AMERICA

Ages given in millions of years

<table>
<thead>
<tr>
<th>Rock</th>
<th>Mineral*</th>
<th>206Pb/238U</th>
<th>207Pb/235U</th>
<th>207Pb/206Pb</th>
<th>208Pb/232Th</th>
<th>Sr/Sr</th>
<th>Ar/K</th>
</tr>
</thead>
</table>
| Beartooth Mountains, Montana

| Pegmatite A | U  | 2600 | 2640 | 2700       |             |       |      |
| Pegmatite B | M  |      |      |            |             | 2600  | 2470 |
| Pegmatite B | F  |      |      |            |             | 2700  |      |
| Rainy Lake, Ontario (Rice Bay)

| Gneiss A   | Z  | 2450 | 2600 | 2730       |             |       |      |
| Gneiss B   | B  |      |      |            |             | 2630  | 2520 |
| Gneiss B   | M  |      |      |            |             | 2600  |      |

| Viking Lake, Saskatchewan

| Pegmatite U | U  | 1850 | 1880 | 1910 | 1670       | 1970  | 1780 |
| Pegmatite B | L  |      |      |      |            |       |      |
| Keystone, South Dakota

| Pegmatite U | U  | 1580 | 1600 | 1630 | 1440       | 1650  | 1380 |
| Pegmatite M | M  |      |      |      |            | 1730  | 1550 |
| Wilberforce, Ontario

| Pegmatite U | U  | 1020 | 1020 | 1020 | 1000       | 1030  | 960  |
| Pegmatite Z | Z  | 900  | 930  | 1000 | 990        |       |      |
| B  |       |      |      |      |            |       |      |
| Shenandooh National Park, Virginia

| Gneiss Z   | B  | 1070 | 1100 | 1150 | 1110       | 880   | 800  |
| B  |       |      |      |      |            | 900   |      |
| Bear Mountain, New York

| Gneiss Z   | B  | 1140 | 1150 | 1170 | 1030       | 880   | 780  |
| B  |       |      |      |      |            | 930   | 840  |
| Llano, Texas

| Granite Z  | B  | 970  | 990  | 1060 | 850        | 1100  | 1060 |
| B  |       |      |      |      |            |       |      |
| Spruce Pine, North Carolina

| Pegmatite U | U  | 385  | 390  | 400       |             | 375   | 335  |
| Pegmatite U | M  | 370  | 375  | 420       |             | 375   | 335  |
| Pegmatite F | F  |      |      |            |             | 385   |      |

*B, biotite; F, potassium feldspar; H, hornblende, L, lepidolite; M, muscovite, U, Uraninite, Z, zircon.

(Data from Tilton and Hart, 1963.)
FIGURE 1. Potassium-argon ages for Apollo and Luna landing sites on the Moon. (From Church, 1975.)

FIGURE 2. Rubidium-strontium ages for Apollo and Luna landing sites on the Moon. (From Church, 1975.)

TABLE 2
LAKE DISTRICT BATHOLITH

<table>
<thead>
<tr>
<th>Radiometric Age in Millions of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skiddaw Granite</td>
</tr>
<tr>
<td>Fluid inclusions in quartz</td>
</tr>
<tr>
<td>Muscovite</td>
</tr>
<tr>
<td>Whole rock (1)</td>
</tr>
<tr>
<td>Whole rock (2)</td>
</tr>
<tr>
<td>Shap Granite</td>
</tr>
<tr>
<td>Whole rock (1)</td>
</tr>
<tr>
<td>Whole rock (2)</td>
</tr>
</tbody>
</table>

-Data from Shepherd and Darbyshire (1981).

TABLE 3
ORDOVICIAN CARADOC SERIES

<table>
<thead>
<tr>
<th>Radiometric Age in Millions of Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>447 ± 3</td>
</tr>
<tr>
<td>238U-206Pb</td>
</tr>
<tr>
<td>420 ± 5</td>
</tr>
<tr>
<td>K-Ar</td>
</tr>
<tr>
<td>447 ± 7</td>
</tr>
<tr>
<td>Rb-Sr</td>
</tr>
<tr>
<td>451 ± 21</td>
</tr>
<tr>
<td>Fission Track</td>
</tr>
</tbody>
</table>

-Data from Ross, et al. (1976).
INHERITED RADIOHETRIC AGE

It is abundantly reasonable that a fossil age assignment based on the radiometric characteristics of associated minerals might be related more to the radiometric characteristics of these minerals before association with the fossil, than to the real time since this association began. But for such an interpretation to be plausible it must be supported by an adequate sample of fully established examples.

Volcanics which are associated with organic material that can be dated by radioactive carbon generally have a potassium-argon age much greater than that given by radiocarbon for the eruption (Stapor and Tanner, 1973). A prime example is the 485,000 year K-Ar age for volcanics from a Mt. Rangitoto (Auckland, New Zealand) eruption which destroyed trees less than 300 years ago (McDougall, et al., 1969). Lava rock from Mt. Capulin in northeastern Mexico has nearly four times as much radiogenic argon-40 as would be expected to have accumulated during the age of this rock, as established by radiocarbon dating, if the rock were pure potassium (Hennecke and Manuel, 1975). Germany, California, Alaska, and the Hawaiian Islands have furnished notable examples of volcanic eruptions which did not reset the potassium-argon radiometric clock to zero (Dalrymple and Lamphere, 1969, pp. 120-144).

An oil well in southwestern Louisiana that was drilled into formations which have a conventional geologic age in the 5-25 million year range (Miocene) produced drill cuttings from shale at the 5190 foot level that has a K-Ar age of 254 million years. When the shale cuttings were ground and screened into component particle size, the average K-Ar age was found to be 164 million years for particles less than one-half micron in diameter, 312 million years for particles in the 10-2 micron diameter range, and 358 million years for particles greater than 10 microns in diameter (Perry, 1974). It is evident that the larger ratio of surface to volume for the smaller particles favors diffusion loss of the argon-40 that was inherited from the source of this shale. The radiometric age characteristics of the sediments into which this well was drilled reflect the radioactive age characteristics of the source areas drained by the Missouri and Ohio river systems, not the time of sediment placement (Hower, et al., 1963; Bailey, et al., 1962).

In contrast with an earlier perception that potassium-argon ages for glauconites provide a minimum real time age for sediments due to the ready diffusion of argon through the glauconite crystal lattice, it has now been established that a K-Ar age for a glauconite

![Figure 3](image-url)
should be considered suspect as too old, due to possible incorporation of radiogenic argon along with potassium at the time of glauconite formation. K-Ar ages ranging from 12.3 to 519 million years have been reported for glauconitized coprolites from the Gulf of Guinea that are considered to be geologically less than 100,000 years old (Odin and Dodson, 1982, Part I, pp. 277-305).

Recently-deposited sediment on the floor of Ross Sea, Antarctica, has been found to have a 250 million year rubidium-strontium age, not zero age. The two major sources for this sediment are the Transantarctic Mountains that have a radiometric age between 450 and 475 million years, and West Antarctica for which the radiometric age is in the 75-175 million years range. The Ross Sea sediments are easily seen to have radiometric age characteristics that reflect a blend of the radiometric characteristics of the source areas (Shaffer and Faure, 1976).

Reference to significant disagreement between radiometric age assignment and geologic age classification appears frequently in the professional literature. A paper that has received widespread attention lists 22 examples of Tertiary Age (65 million years or less, on the conventional geologic time scale) that have rubidium-strontium ages ranging between 70 million and 3340 million years (Brooks, et al., 1976). These examples are listed in Table 4. Each of these examples can be explained best on the basis of varying degrees of inheritance of source area radiometric age characteristics of material that has been transported by plutonic or volcanic processes.

An analysis of 32 worldwide typical granulite samples that have geologic age assignments ranging from 20 million to 3100 million years yielded samarium-neodymium radioisotope ages from 851 million to 3744 million years, and rubidium-strontium ages from 596 million to 3650 million years. All but six of these Sm-Nd and Rb-Sr ages are greater than the corresponding geologic age (Othman, et al, 1984). A set of seven Australian shale samples that have geologic age assignments ranging from 200 million to greater than 3300 million years yielded samarium-neodymium ages ranging from 1870 million to 3780 million years, in each case greater than the presumed geologic age (Allegre and Rousseau, 1984).

The popular concept that radiometric ages of geologic formations relate directly to their real-time age obtains much support from the observation that volcanic sequences, and volcanic-derived sedimentary sequences, usually exhibit a pattern of increasing radiometric age with depth. It is obvious that the upper material in a given undisturbed sequence was emplaced later than the underlying material. But the radiometric age differences between them do not necessarily represent the real-time emplacement intervals. It has been established that the radiometric age profile of a volcanic sequence may be the consequence of:

(1) Chemical and isotope zonation in the magma chamber that furnished the volcanic material;
(2) Circumstances that were progressively more favorable to resetting a particular radiometric clock (e.g. degassing of radiogenic argon) as eruptions proceeded; and
(3) Crustal material incorporated by the magma as it moved upward (Smith and Bailey, 1966; Naesser, 1971; Dickinson and Gibson, 1972; O'hara and Mathews, 1981).

Contrary to the expectation that fission tracks should specify the minimum age of a volcanic formation, there is ample evidence that fission tracks in crustal material that is incorporated by rising magma may not be completely annealed. Consequently an igneous deposit may have a fission track age greater than the time since its emplacement (Naesser, 1971), as well as a radioisotope age that relates more to source material characteristics than to time of emplacement.

In a planet-wide crustal breakup that involved erosion and sedimentation along with igneous activity, as specified by the combination of geologic evidence and the testimony of Genesis 7 and 8, the reformed crustal surface should be expected to have a planet-wide tendency for radiometric age to increase with depth, corresponding to the pattern observed on the flanks of Tertiary volcanos.

Few fossil age assignments are derived from actual radiometric measurements on minerals from the site where the fossil was found. Usually the fossil age is taken from an estimate of the position in the geologic column sequence that corresponds to the formation in which the fossil was located. The currently accepted time scale for the geologic column is based on radiometric determinations. For example, according to the latest London Geological Society geologic time scale the Cretaceous Period extended from
65 million to 144 million years ago. Not every radiometrically datable rock identified as Lower Cretaceous would have a radiometric age in the 120-144 million year range; nor would a rock with a 100 million year radiometric age necessarily have come from a Cretaceous formation. A high degree of selection is required for samples to qualify for use in the establishment of the radiometric geologic time scale. Such samples must meet standards of radiometric control, geologic control, and biologic control.

To meet standards of radiometric control a sample must yield a precise radiometric age, preferably one that is supported by two or more independent radiometric techniques; it must be free of any indication that heat or water have disturbed isotope relationships during its history; and it must yield a radiometric age within the time range expected by the selection committee. None of the samples that yielded the data listed in Table 4 would meet the criteria of radiometric control because their rubidium-strontium ages are greater than would be expected for Tertiary formations. Most of these determinations also lack adequate precision for time-scale calibration.

Radiometric ages greater than within the expected range are categorized as due to incomplete resetting of the radiometric clock at mineral formation, to selective physical removal of the parent isotope by heat or water after mineral formation, or to infusion of the daughter isotope (argon-40, e.g.) after mineral formation. Radiometric ages

<table>
<thead>
<tr>
<th>Location</th>
<th>Association</th>
<th>Apparent Age (million years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>Absaroka volcanic field; andesites</td>
<td>3340±1540</td>
</tr>
<tr>
<td>United State</td>
<td>Western Grand Canyon, hawaiites</td>
<td>300±290</td>
</tr>
<tr>
<td>United States</td>
<td>Western Grand Canyon; alkali basalt series</td>
<td>1100±240</td>
</tr>
<tr>
<td>United States</td>
<td>Colorado Plateau; basalts</td>
<td>960±240</td>
</tr>
<tr>
<td>United States</td>
<td>Snake River plain; King Hill basalts</td>
<td>940±210</td>
</tr>
<tr>
<td>Spain</td>
<td>Jumilla, alkalic complex; jumillites</td>
<td>780±390</td>
</tr>
<tr>
<td>United States</td>
<td>Snake River plain; Craters of the Moon basalts</td>
<td>620±60</td>
</tr>
<tr>
<td>United States</td>
<td>Absaroka Volcanic field; shoshonites</td>
<td>470±50</td>
</tr>
<tr>
<td>Peru</td>
<td>Arequipa volcanics; andesites, dacites</td>
<td>440±70</td>
</tr>
<tr>
<td>Uganda</td>
<td>Napak alkalic complex; nephelinites, ijolites</td>
<td>380±340</td>
</tr>
<tr>
<td>Peru</td>
<td>Barroso volcanics; andesites, dacites</td>
<td>310±50</td>
</tr>
<tr>
<td>United States</td>
<td>Columbia River group; basalts, andesites, dacites</td>
<td>290±80</td>
</tr>
<tr>
<td>United States</td>
<td>Basin and Range; basalts</td>
<td>200±70</td>
</tr>
<tr>
<td>United States</td>
<td>Northwest Great Basin; basalts, andesites</td>
<td>190±80</td>
</tr>
<tr>
<td>United States</td>
<td>Navajo alkalic province; trachybasalts, lamprophyres</td>
<td>170±110</td>
</tr>
<tr>
<td>United States</td>
<td>Leucite Hills, lamproites, orendites</td>
<td>150±80</td>
</tr>
<tr>
<td>New Zealand</td>
<td>East arc, North Island; basalts, andesites</td>
<td>110±20</td>
</tr>
<tr>
<td>United States</td>
<td>Cascades, Glacier Peak; basalts, andesites</td>
<td>110±90</td>
</tr>
<tr>
<td>United States</td>
<td>Cascades, Mt. Lassen; basalts, andesites, dacites</td>
<td>100±50</td>
</tr>
<tr>
<td>Uganda</td>
<td>Budeda alkalic complex; ijolite series</td>
<td>80±50</td>
</tr>
<tr>
<td>United States</td>
<td>Bearpaw Mountains alkalic complex; syenites, etc.</td>
<td>80±40</td>
</tr>
<tr>
<td>Uganda</td>
<td>Torror alkalic complex; phonolites, nephelinites, etc.</td>
<td>70±5</td>
</tr>
</tbody>
</table>
below the expected range are readily categorized as due to selective physical removal of a daughter isotope by heat or water (or annealing of fission tracks) after mineral formation. (Episodic selective introduction of the parent isotope late in the history of a mineral is a possible but relatively unlikely cause of a radiometric age that is "too young.")

To meet standards of geologic control a sample must come from a formation with a clearly established position in the generalized geologic column sequence. This position may be established by its stratigraphic relationship as determined by mapping and/or by index fossil content. Mapping would trace to a location at which the appropriate fossil content could be established. Geologic control and biologic control are interrelated. To meet the highest standard for radiometric time scale calibration a sample should independently meet both geologic and biologic criteria, i.e., it should come from a position that is fully established by geologic mapping, and it also should come from a formation that contains an appropriate index fossil for its presumed location in the geologic column. Table 3 provides an example of a set of data that meets the standards for radiometric time scale calibration.

For further investigation of the criteria and procedures by which the standard radiometric geologic time scale has been developed the reader should consult Harland, et al., (1964), Harland, et al. (1971), Cohee, et al. (1978), Harland, et al., (1982), Odin, (1982), and Snelling (1985).

The validity of the radiometric geologic time scale is brought into question by radiohalos—regions of radiation damage surrounding a microscopic inclusion of radioactive material. Coalified wood from Triassic and Jurassic sediments (248-213 million year conventional geologic age, respectively) has been found that contains radiohalos (Gentry, et al., 1976). If one assumes an in situ decay in the inclusion centers of these halos, the lead-206/uranium-238 ratios present may be expressed in terms of uranium-lead ages ranging between 236 thousand years for Triassic specimens to 2.9 million years for Jurassic specimens, in reverse to what might be expected. There is presently available no evidence to exclude the possibility that essentially all the lead-206 in these halo centers was introduced (either directly or as parent polonium-210 or lead-210) together with uranium, and did not accumulate from parent uranium since the inclusion centers were formed. Thus the radiometric data for these halo centers do not support the presumed geologic age for the sediment in which they are found, but rather are consistent with any age between a few thousand years and about 1/50 of the presumed geologic age.

**SIGNIFICANCE OF INITIAL RADIOMETRIC CHARACTERISTICS**

Since radiometric data may relate more to the initial characteristics of material in which organisms that have produced fossils were buried than to the time since this burial, there is a challenge to determine the significance of the initial characteristics. The initial characteristics at relocation of a mineral (burial of a protofossil) may reflect source material characteristics and also changes that were produced by heat and water during the relocation process. According to Genesis 1, 7 and 8 planet Earth has experienced three major modifications that should be expected to have altered the characteristics of many mineral formations in the planetary crust. These modifications are the appearance of continents and ocean basins on the third day of Creation Week, the subsequent breakup of the crust and reduction of topographic relief until the planet was again completely covered with water (Noachian flood), and the reappearance of continents and ocean basins. Each of these modifications, and particularly the combined effects of all three, should have introduced severe complications into the interpretation of the radiometric data for many of the mineral specimens at our disposal.

If a specimen can be dated by several radiometric techniques (samarium-neodymium, rubidium-strontium, potassium-argon, uranium-lead, fission track, e.g.) there is a possibility for deducing its metamorphic history and its initial radiometric characteristics. This is especially true if such measurements can be made on more than one mineral component, as illustrated by several examples in Table 1 and by the Idaho Springs Formation data in Figure 3. The asymptotic approach of initial radiometric age characteristics to 4.56 billion years, particularly among meteorites and moon rocks, is the basis for placing the solidification age of the Solar System at 4.56 billion years as in Figures 4 and 5. (Solidification age specifies the time over which radiogenic daughter products have been held in close association with their parent radioisotopes.)
An aid to finding an explanation of radiometric age data that is compatible with the Biblical testimony regarding chronology and creation may be found in the lack of any reference in Genesis one to creation of water. Water is presented as in existence on the planet before the first day of creative work is described, and water is manipulated in subsequent creative activity, particularly on the third day. Although no explicit reference is made to the mineral component(s) of the earth ("dry land") that was created on the third day, it is not unreasonable to treat its mineral component(s) on the same basis as the mineral component of the "Seas" that were created on the same day, recognizing that the elementary matter of each of these mineral components had its origin in an earlier primeval creation that is only implied in the Bible (John 1:3; Colossians 1:16). For individuals who have difficulty over the "all that in them is" statement of the decalogue (Exodus 20:11) I would like to suggest that Genesis 1:1-2:4a is an eyewitness style, point-of-observer account, with "all that in them is" being a reference to the organic life that populated heaven (atmosphere), earth (land), and sea (water) as a result of creative activity on days three, five and six.

ISOCHRONs AND MIXING LINES

Figures 4 and 5 are illustrations of what is commonly referred to as an isochron presentation of radiometric data for a suite of samples. To be capable of isochron presentation the individual members of a sample suite must have varying concentrations of a radioactive parent isotope. The parent isotope concentration as the independent variable is plotted on the horizontal axis. The stable daughter isotope concentration is plotted on the vertical axis. The best fit straight line (if such a data representation is statistically justified) through the data points is called an isochron because the ratio of the incremental amount of daughter isotope above the vertical axis intercept (value for zero parent isotope) to the corresponding amount of parent isotope is constant throughout the data range.

The interpretation of an isochron construction depends on one's assumption as to how much of the daughter isotope excess above the concentration corresponding to zero parent concentration accumulated after the suite of samples was formed. If all the excess

![Sm-Nd SYSTEMATICS](image)

**FIGURE 4.** Samarium-neodymium radiometric age isochron for the meteorite Juvinas and Moon samples from Apollo missions 11, 14, 15, and 17. Isochron slope corresponds to neodymium-143 accumulation from samarium-147 over 4.56 billion years. (After Lugmair and Marti, 1978.)
daughter accumulated after sample formation, the slope of the isochron line gives the ratio of accumulated radiogenic daughter isotope to parent isotope, which determines the radiometric age of the sample suite. (This conclusion assumes that the half-life of the parent is known and has been constant throughout the time period in question, and that parent and daughter concentrations have not changed by any process other than radioactive transformation of the parent.)

If all the daughter excess accumulated before the sample suite was formed the isochron is in reality a mixing line that shows varying proportions of two components that were incompletely mixed in the formation of the sample suite. One of these components had a daughter/parent isotope ratio characteristic of the line slope, and the other contained a parent isotope concentration in the range between zero and the lowest value in the sample suite. Accordingly, before mixing one component had an indeterminate radioisotope age (for the isotopes in consideration), and the other component had a radioisotope age given by the slope of the mixing line, which is precisely the same as the radioisotope age specified for the suite with the isochron assumption.

According to the mixing model interpretation a suite of samples with daughter/parent isotope ratios that plot on a straight line could have originated "yesterday," or at any time within the past 10,000 years (assuming zero parent isotope concentration in one of the components); but the component with a radioisotope age given by the slope of the mixing line is no easier to account for within the past 10,000 years than is the entire suite of samples on a straightforward isochron model. For example, if the data point average lines in Figures 4 and 5 are mixing lines rather than isochrons, the origin of the Solar System can be placed readily at any time within the past 10,000 years, but there remains a challenge to account for the origin of the mineral component that contains the characteristic 4.5 billion year osmium-187/rhenium-187 and neodymium-143/samarium-147 accumulation ratios. Either way, the Biblical creationist must choose between a 4.5 billion year radioisotope age incorporated as a design feature in a recent creation of elementary matter, or as a natural accumulation since a primordial creation of elementary matter long before the Creation Week of the first chapter of Genesis.

Meteorite radioisotope age plots similar to Figures 4 and 5 are produced also for strontium-87/rubidium-87 (Minster and Allegre, 1979), hafnium-176/lutecium-176 (Patchett and Tatsumoto, 1980), and lead-207/lead-206 (Chen and Tilton, 1976). (The lead-207/lead-206 ratio changes uniquely with time due to the differing half-lives of the parent isotopes uranium-235 and uranium-238.)

SUMMARY OF STRATEGIES FOR ACCOMMODATING INORGANIC RADIOMETRIC AGE DATA WITH BIBLICAL CHRONOLOGIC DATA

The discussion up to this point has been limited to radiometric age data for inorganic minerals, particularly those which are associated with fossils. Three strategies have been considered for accommodating these data with the chronologic data in the Hebrew Scriptures.

1. Placing radiometric age data in a meaningless or inconsequential category.

2. Considering radiometric age characteristics as features of design that were variably incorporated by the specific will of the Creator for individual mineral formations in a creation epoch that occurred not more than about 10,000 years ago. This approach allows for subsequent modification by selective effects of heat and contact with water that a mineral may have experienced during its history, but does not allow for contributions from natural radioactive transmutation, since 10,000 years is a negligible span of time in comparison with the shortest half-life (704 million years for uranium-235) among the parent radioisotopes of the natural radioactive decay sequences. This strategy does allow time significance to some radioisotope ages based on isolation of short half-life uranium series daughters (lead-210, e.g.), but calls for reevaluation of the assumptions on which many protactinium and thorium uranium-series disequilibrium dates are based.

3. Considering radiometric age characteristics as the consequence of basic elemental isotope ratios that were established at primordial creation of elementary matter, radioactivity since primordial creation, and modification by selective effects of heat and contact with water. This strategy places emphasis on radiometric clocks typically not being set to zero age when a mineral is transported by igneous, erosion, or solution activity. It considers the radiometric age of inorganic material associated with a fossil as more a reflection of the characteristics of source material than an indication of the time at which the protofossil was buried.
FIGURE 5. Rhenium-osmium radiometric age isochron for 19 meteorites and Earth. Isochron slope corresponds to osmium-187 accumulation from rhenium-187 over 4.55 billion years. (After Luck and Allegre, 1983.)

RELATING INORGANIC RADIOMETRIC AGE TO BIBLICAL CONSTRAINTS

Individuals whose convictions concerning the interpretation of the Biblical statements regarding creation do not allow for a 4.5 billion year age for inorganic material may classify the radiometric features from which this conclusion is derived as primordial characteristics that were introduced in a relatively recent creation. Among Biblical creationists the choice is between relatively complex primordial radiometric characteristics introduced in a creation of elementary matter less than 10,000 years ago, and basic primordial radiometric characteristics introduced in a creation of elementary matter billions of years ago. The accomplishments over days 2-6 of the Creation Week account in Genesis clearly indicate that it is within the Creator's capability to produce the Solar System either way, since there is more complexity in the cellular structure or the biochemical components of either plant or animal life than in the isotopic distribution of the elementary matter in a planet. But if one holds to the definitions of terms given in Genesis 1:8-10, rather than reading modern concepts into the Hebrew terms translated "earth," or using modern concepts in place of the original meaning of the English word "earth," a limited age for elementary matter is not demanded by the Biblical text. Of additional significance is the way the verbs used in Genesis 1:16, 17 are used elsewhere in the Hebrew Scriptures, particularly Genesis 9:13; Exodus 10:26; 25:31; 2 Chronicles 2:18; Job 14:5; and Psalm 104:19.
RADIOCARBON DATING

In many instances residues of radioactive carbon and amino acids offer possibilities for a direct determination of fossil age, since the atoms utilized in the laboratory procedures were part of the protofossil tissue. The amino acid technique for estimating fossil age will be omitted from this discussion because amino acid dates are subject to a large amount of uncertainty and depend on calibration by an independent technique (usually radiocarbon or uranium-series disequilibrium). Recent reviews of amino acid dating have been given by Bada (1985), Brown (1985), and Rutter, et al. (1985).

Since there is less than one carbon-14 atom for every 500 billion nonradioactive carbon atoms in the tissues of living organisms, any nitrogen-14 daughter accumulation from radioactive decay of carbon-14 is undetectable among the large amount of nitrogen-14 normally present in these tissues. Consequently radiocarbon dating must be based on a comparison of the current residual concentration of carbon-14 with the concentration of carbon-14 that was maintained in the sample when it freely exchanged carbon with its environment (i.e., was living). Carbon-14 concentrations in dead organic material cover the entire range from contemporary values to below the threshold of unquestioned detectability. Neanderthal archeological sites provide samples that have carbon-14 concentrations ranging from about 1/125 of contemporary reference levels to below the threshold of unquestioned detectability. On this basis Neanderthal man is specified to have lived over a time span extending to within about 40,000 years ago (125-26.97; 6.97 carbon-14 half-lives of 5730 years = 40,000 years).

The 40,000 carbon-14 year age for the most recent Neanderthal population represents a real-time age only if the C-14 concentration in living members of this population and their surroundings was the same as it is in modern organisms. To establish the C-14 concentration that was characteristic of any time in the past it is necessary to have a sample that has not exchanged carbon with its surroundings since that time, and also has a real-time age established by an independent method. In his development of the C-14 dating technique Willard Libby was able to demonstrate a close one-to-one relationship between C-14 age and real-time age as far back as the early part of the second millenium B.C. (Libby, 1955), the limit of the range over which samples with well established historical ages were available.

Figure 6 summarizes high precision work that has been done to determine C-14 concentrations in living organisms of the past by measurement of the current C-14 residue in wood that has been dendrochronologically dated. If C-14 concentrations in the biosphere throughout the past had been the same as in recent time, the data points in Figure 6 would all fall on the heavy straight line (one-to-one correspondence of C-14 age with dendro age, assuming all dendro age determinations are precisely equal to real-time age). Points above the heavy line indicate a C-14 concentration below the contemporary reference level (C-14 age greater than real-time age); points below this line indicate C-14 concentration above the contemporary reference level (C-14 age less than real-time age). The most recent treatment of the data covered by Figure 6 is given by Klein, et al. (1982).

CARBON-14 EQUILIBRIUM IN THE UPPER BIOSPHERE

The dendrochronologic data represented in Figure 6 were derived from Sequoia and Bristlecone Pine and may be considered to precisely represent real time as far back as the last quarter of the second millennium B.C. For earlier time periods the data represented in Figure 6 were derived entirely from C-14 dated segments of dead Bristlecone Pine wood. Though almost universally accepted as the best available standard for converting C-14 age into real-time age, the Bristlecone Pine dendrochronology as extended over the 1500-7000 B.C. range is subject to question.

The data represented in Figure 6 do establish unquestionably that ten-year averages of the C-14 concentration in the upper biosphere (air, land, fresh water, mixed surface layer of the ocean, and the organisms contained therein) have been constant within plus or minus about 3% of a mean value over the past 3500 years. This conclusion is equivalent to saying that C-14 in the upper biosphere has been in essential equilibrium over the past 3500 years, i.e., that the C-14 input has been balanced by C-14 loss. The input is from generation of C-14 in the upper atmosphere (10-80 kilometer height) through nuclear reactions initiated by primary cosmic rays (principally protons) from outer space. The principal loss is diffusion and sediment transfer from the mixed surface layer of the ocean to the deep ocean, and by deposit of sediment on the ocean floor. It is only in sediment and carbonate deposits that the 5730 year half-life radioactive decay provides the major loss of C-14 from the biosphere (Olson, in press; Brown and Rouse, 1983).
A direct, experimental determination of the extent to which C-14 concentrations in the deep ocean and in sediments may be in equilibrium is prevented by the lack of samples for which a reliable independent age determination can be made.

CARBON-14 AGE LIMITS

The threshold at which a particular laboratory can detect C-14 sets an upper limit to C-14 age that can be determined by that laboratory. All samples with a C-14 concentration below this threshold are "infinite age" as far as that laboratory is concerned. For some laboratories "infinite" C-14 age samples are any samples with C-14 concentration below about 1/38 of the contemporary reference level, i.e., samples with C-14 age beyond approximately 30,000 C-14 years. Laboratories which have the most elaborate facilities for reducing background count level can extend the "infinite age" limit up to the vicinity of 50,000 C-14 years (detection level about 1/400 of the contemporary reference level) using scintillation and gas discharge (geiger tube) counting techniques.

The recently developed Accelerator Mass Spectrometry technique for counting individual C-14 atoms, rather than only C-14 atom disintegrations, holds prospects for extending the "infinite age" limit to the vicinity of 70,000 C-14 years (1/5000 of the contemporary reference level). A major advantage of this technique is a reduction by a factor of about 1000 in the sample size required (Bennett, 1979; Hedges and Gowelett, 1986).

Since carbon from limestone, anthracite coal, natural petroleum, and natural gas has been used for determining the "infinite age" sample background count level in laboratories using gas discharge and scintillation counting techniques, accelerator mass spectrometer C-14 age determinations in the 40,000 year range for such material have been surprising (Brown, et al., 1983; Linnick, et al., in press; Beukens, et al., in press; Farwell et al., in press; Jull, et al., in press; Nelson, et al., in press; Wolfli, in press). The Washington U. AMS group has reported that an anthracite coal, corrected to 46,000 on the basis of background level obtained from unprocessed geological (natural) graphite (Farwell, et al., in press). The University of Toronto group has reported an AMS C-14 age of 45,200 ± 700 for anthracite (Beukens, et al., in press).

The ready explanation for these finite C-14 ages of samples with a putative geologic age greater than one million years is contamination by modern carbon. This explanation is supported by the tendency for repeated AMS determinations on a limestone sample to yield progressively younger C-14 age (Brown, et al., 1983), and for the AMS-determined C-14 age of processed geologic graphite to be less than that for an unprocessed sample (Farwell, et al., in press; Beukens, et al., in press). On the other hand, since C-14 in Earth's biosphere is a consequence of galactic cosmic rays and atmospheric nitrogen, there should have been C-14 in the biosphere prior to the catastrophic events described in Genesis 7 and 8. Since Biblical chronologic data place this catastrophe only about 5000 years ago, fossil material (coal, petroleum, shell, calcereous sediment) that was emplaced at that time should now have slightly more than half its initial C-14 concentration. If one assumes an AMS C-14 age in the vicinity of 50,000 years to represent residual C-14, rather than contamination from modern carbon, and allows 5000 years since the formation of coal, petroleum, natural gas, fossil shell, and calcareous sediment as a consequence of the Noachian Flood, specimens from the biosphere at the time of the Flood (45,000 year C-14 age at that time) would have had an initial C-14 concentration about 1/230 as great as the modern zero-age level. At present there is no experimental basis for asserting that the 40-50 thousand year range for AMS C-14 ages of "infinitely old" samples is not attributable entirely to contamination. Within a Biblical scientific creation model there is a basis for expecting that these characteristics are due, in part at least, to residual C-14 from the pre-Flood biosphere.

A BIBLICAL CARBON-14 AGE MODEL

According to the two criteria that have been established in the foregoing discussion, viz. constancy of the C-14/C-12 ratio in the upper biosphere within ± 3% over the past 3500 years, and initial C-14/C-12 ratio equal to or less than 1/200 of the contemporary reference ratio, one can postulate that following the Noachian Flood the biosphere experienced a readjustment according to Model C of Figure 7.

The descending portion of the Model C curve in Figure 7 (ascending with increasing real time) could be accounted for by increased C-14 production and/or diminished C-12 reservoir in which the post-Flood C-14 production was distributed. Increased C-14 production could have been a consequence of an increase in the intensity of galactic cosmic radiation, a decrease in the intensity of the geomagnetic field, and a decrease
In shielding by water vapor in the upper atmosphere. A diminished C-12 reservoir would be the result of organisms and sediments that were removed from the carbon exchange system by burial.

COSMIC RAY INTENSITY AND CARBON-14 PRODUCTION RATE

After exposure of a meteoroid or a moon rock to a constant cosmic ray intensity for a time equal to about four half-lives, a cosmogenic radioactive nuclide formed therein reaches an equilibrium concentration at which the number of new atoms formed within a given period of time is equal to the number that experience radioactive decay during the same time. The half-lives for the more than twenty cosmogenic radionuclides found in meteorites and moon rocks cover the range from 5.7 days to 3.7 million years. (Shedlovsky, et al., 1967; Trivedi and Goel, 1973). Within the uncertainty of experimental determinations these nuclides (manganese-52, aluminum-26, beryllium-10, manganese-53, e.g.) are found to be in equilibrium with the present intensity of cosmic radiation.

From these observations it is apparent that the present cosmic ray intensity is essentially the same as the average that has been maintained for longer than any time period that can be covered by radiocarbon dating. The experimental data also indicate that any variation of the galactic cosmic ray intensity averaged over ten or more years has been within a factor of two of the long-time average.

A change in the C-14 concentration by a factor of two would shift the radiocarbon time scale by only 5730 years--one half-life. Therefore fluctuations that may have occurred in the cosmic ray intensity cannot be expected to have produced a discrepancy of more than about 6000 years between any radiocarbon age and equivalent real time. In my judgment there is not a sound basis for assigning any major C-14 age discrepancy to the cosmic ray intensity factor.

FIGURE 7. Models for Biosphere Carbon-14 level. The idealized contemporary reference level is specified as "100%." A- Strictly uniform conditions model. B- First approximation for the current Bristlecone Pine dendrochronology model (linear ordinate scale). C- First approximation for Biblical chronology requirements (logarithmic ordinate scale). Horizontal bars designated FLOOD and CREATION give the range of uncertainty for the dates of these events. Cross-hatched area indicates approximate range of uncertainty for the dates for the pre-Flood biosphere C-14 concentration.
GEOMAGNETIC FIELD INTENSITY AND CARBON-14 PRODUCTION RATE

Only the cosmic ray particles that reach Earth's atmosphere are effective in producing C-14 in the biosphere. The magnetic field of the Earth deflects a large portion of the incoming cosmic ray particles so that they do not interact with the atmosphere. It has been reliably estimated that if the present geomagnetic field were to completely disappear the C-14 production rate would double (Kigoshi and Hasegawa, 1966; Lingenfelter and Ramaty, 1970). An eleven-fold increase in the geomagnetic field would reduce the C-14 production rate to one-fourth its present value. An increase in the order of 100-fold would be required to bring the production rate near zero.

One can postulate that prior to the Flood the geomagnetic field was strong enough to hold the production of C-14 in the atmosphere to a negligible level. Since the mechanism by which the geomagnetic field is maintained is not understood, there is little restraint against postulating that this field may have been 100-fold greater than it is presently. The geomagnetic field was probably greater before the Flood than it is at present, but the available paleomagnetic intensity data place an upper limit of 3-6 times the present intensity (Barbetti and Flude, 1979). A six-fold increase would restrict the world-wide C-14 production rate to about one-third its present value. A factor of one-third would account for only about 9000 years of the radiocarbon time scale.

STRATOSPHERE MOISTURE CONTENT AND CARBON-14 PRODUCTION RATE

A magnetic field is not the only means by which the biosphere could have been shielded from the harmful effects of cosmic radiation. Water absorbs the cosmic-ray generated neutrons that produce C-14. Throughout the region of the atmosphere in which C-14 is produced the water content is now typically less than five parts per million (Harris, et al., 1976; Scholz, et al., 1970; Evans, 1974). The destruction of post Creation Week surface features of our planet in the Flood experience could have been accompanied by a reduction in the water content of the outer atmosphere. Genesis 1:6,7 has been interpreted by many Bible students to indicate that in the pre-Flood world a large quantity of water was located above the troposphere. Removal of this water might be expected to produce conditions more favorable to the production of cosmogenic C-14.

At sea level and 100% relative humidity one out of every 29 molecules in the atmosphere is water (3.5%). In atmosphere of this composition 95% of cosmic-ray-generated neutrons produce C-14 and nearly 0.8% are captured by the hydrogen in water molecules. In dry air such as now exists in the stratosphere 96% of cosmic-ray-generated neutrons produce C-14. Suppose that in the pre-Flood world the stratosphere contained an average of six times as many water molecules as oxygen and nitrogen molecules combined. In such an atmosphere 40% of cosmic-ray generated neutrons would produce C-14, and 58% would be captured by the hydrogen in water molecules. A stratosphere containing as much as 78% water (six water molecules for every nitrogen or oxygen molecule) requires unreasonable values of temperature and total atmospheric pressure, and represents an extreme upper limit for water content (Brown, 1979). For further consideration of water canopy models the treatments by Kofahl (1977) and Morton (1979) should be consulted.

A change from a C-14 production rate of 40% to 96% of cosmic-ray generated neutrons is an increase of 2.4 fold or 21.26. A 1.26 half-life compression in the real-time range of the C-14 age scale is only about 7200 years. Consequently any reasonable proposal concerning water vapor in the pre-Flood stratosphere is ineffective toward complete harmonization of a 50,000 year C-14 date with a Biblically-based chronology.

CARBON EXCHANGE SYSTEM INVENTORY AND THE CARBON-14 AGE RANGE

The C-14/C-12 ratio in the biosphere is a function of both the C-14 production rate and the inventory of C-12 in which C-14 is distributed. The pre-Industrial-Revolution C-14/C-12 ratio has been estimated to be about 1/(848 billion). Since the beginning of the Industrial Revolution this ratio has progressively increased as a result of burning fossil fuels (Wilson, 1978; Nozaki et al., 1978). The combustion of fossil fuel introduces into the atmosphere CO2 that contains less than 0.5% of the 1/(848 billion) reference C-14/C-12 ratio, restoring to the carbon exchange system carbon from a more luxuriant period in the past.
Estimates that have been made of the world carbon inventory are in general agreement (Borchert, 1951; Rubey, 1951; Revelle and Suess, 1957; Bolin, 1970; Fairhall and Young, 1970; Reiners, 1973; Woodwell, et al., 1978; Hall, 1979; Broecker, et al., 1980; Olson, in press). The estimate that developed out of the 24th Brookhaven Symposium in Biology in 1972 (Reiners, 1973) is utilized in Table 5. The estimate for the total "fossil" organic carbon given in Table 5 is taken from Jerry S. Olson (in press). The term fossil is here used within quotation marks to indicate that some of the buried organic carbon may be primordial rather than associated with organisms. According to the data given by Reiners, the total carbon inventory in the present biosphere is less than 1/600 of the total "fossil" carbon inventory. On the basis of the estimate given by Olson, the ratio of total carbon inventory in the present biosphere to the total "fossil" organic carbon inventory is 1/265.

Presuming that the fossil carbon was removed from the biosphere by the Flood, one could postulate that the pre-Flood biosphere contained in the order of 600 times more carbon than does the contemporary biosphere. If the same world inventory of C-14 as is now maintained were distributed in this pre-Flood biosphere the level of C-14 activity would have been about 1/600 the contemporary reference level. Since 600=29.23, approximately nine C-14 half-lives or 52,000 years of the radiocarbon time scale might be accounted for in this way.

Even if one assumes that no sedimentary carbonates were formed during and after the Flood, and that all present "fossil" organic carbon was buried by the Flood, the reduction in the active biosphere carbon inventory resulting from Flood burials would be 265-fold, according to Item No. 17 of Table 5. On this basis the apparent age of terrestrial plant and animal material at the time of the Flood would be close to 46,000 years (8.05 x 5730), assuming that the world C-14 inventory at that time was the same as has been characteristic of recent times. Since the chronologic data in the Bible places the Flood approximately 5000 years ago, at the present time this material would have a C-14 age of about 51,000 years.

If specimens presumed to be "infinitely old" have C-14 ages in the vicinity of 50,000 years, as indicated by AMS C-14 dating, and if these specimens were actually removed from the biosphere carbon exchange system in a world-wide catastrophe approximately 5000 years ago, their present C-14 age might be accounted for as follows:

- Real time since termination of carbon exchange with the biosphere: 5,000
- Reduction in geomagnetic field intensity to about 1/4 the pre-Flood level: 6,000
- Accumulation of 1/5 total "fossil" carbon (Table 5, Item 15) as a consequence of the Flood: 40,000
- Total Apparent C-14 age: 50,000

The approximate 4700x10^{12} metric ton accumulation of "fossil" carbon required by this scheme could be postulated in any combination between about half the "fossil" organic material (Table 5, Item 13) and about one-third the sedimentary carbonate (Table 5, Item 14).

**BIBLICAL CARBON-14 TRANSIENT MODEL**

Carbon-14 is presently produced in the upper atmosphere at an average rate of 8.2 ± 1.5 kilograms per year (Lingenfelter and Ramaty, 1970, p. 524). The 8.2 kg average gain per year is balanced by an 8.2 kg average loss per year due to radioactive transformation to nitrogen-14 and to net transfer from the mixed surface layer of the ocean to the deep ocean, principally the latter. If this production had been maintained indefinitely (at least four half-lives, or 23,000 years), the present world inventory of C-14 would be about 68,000 kg (8.2 kg/yr x 8267 yrs). The total accumulation over 5000 years would be only 30,800 kg [8.2 x 8267 (1 - 2^{-5000/5730})].

With the data from Table 5, Items 6, 7, 8 and 10, and the knowledge that the C-14/C-12 ratio in the mixed surface layer of the ocean is about 95% of the ratio value for air, and that the corresponding value for the deep ocean averages about 84% (Siegenthaler, et al., 1980), the modern biosphere C-14 inventory can be estimated to be about 46,000 kg [(2.53 + 0.95 x 1.50 + 0.84 x 36) x 10^{15} x 1.18 x 10^{-12} x 14/12]. If the world carbon inventory is in equilibrium with production at 8.2 kg/yr, there would be an additional 22,000 kg of C-14 in sediments (68,000-46,000). Consequently production at a uniform 8.2 kg/yr over 5000 years accounts for only about half to two-thirds of the present world C-14 inventory. This observation requires a model for C-14 age
### TABLE 5. WORLD CARBON INVENTORY

Primary data as given by Reiners (1973), excepting that for total "fossil" organic carbon inventory which is taken from Olson (in press). Estimates are presented in units of 10^12 metric tons.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Value (10^12 metric tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Atmosphere</td>
<td>0.670</td>
</tr>
<tr>
<td>2</td>
<td>Freshwater</td>
<td>0.330</td>
</tr>
<tr>
<td>3</td>
<td>Living organisms on land</td>
<td>0.833</td>
</tr>
<tr>
<td>4</td>
<td>Dead organic material on land</td>
<td>0.700</td>
</tr>
<tr>
<td>5</td>
<td>Living organisms in the ocean</td>
<td>0.001</td>
</tr>
<tr>
<td>6</td>
<td>Dead organic material in the ocean</td>
<td>1.000</td>
</tr>
<tr>
<td>7</td>
<td>Atmosphere, freshwater, and organic material</td>
<td>3.53</td>
</tr>
<tr>
<td>8</td>
<td>Dissolved in the ocean surface layer</td>
<td>0.500</td>
</tr>
<tr>
<td>9</td>
<td>Primary contemporary biosphere</td>
<td>4.03</td>
</tr>
<tr>
<td>10</td>
<td>Dissolved in deep ocean</td>
<td>35.000</td>
</tr>
<tr>
<td>11</td>
<td>Total contemporary biosphere</td>
<td>39.03</td>
</tr>
<tr>
<td>12</td>
<td>Available coal, oil and natural gas</td>
<td>10.000</td>
</tr>
<tr>
<td>13</td>
<td>Total &quot;fossil&quot; organic</td>
<td>10,300</td>
</tr>
<tr>
<td>14</td>
<td>Sedimentary carbonates</td>
<td>13,180</td>
</tr>
<tr>
<td>15</td>
<td>Total &quot;fossil&quot; carbon (Sum of Items 13 and 14)</td>
<td>23,480</td>
</tr>
<tr>
<td>16</td>
<td>*Ratio (23,480 + 39.03)/39.03</td>
<td>602±29.24</td>
</tr>
<tr>
<td>17</td>
<td>*Ratio (10,300 + 39.03)/39.03</td>
<td>265±28.05</td>
</tr>
</tbody>
</table>

*Uncertainties in the inventory estimates make the exponents of 2 uncertain by as much as ±1, and possibly more (9.24±1, 8.05±1).

Interpretation that incorporates the Biblical chronologic data to also incorporate the hypothesis that the world production rate of C-14 over a significant period of time following the Flood was greater than it has been in recent years.

A model that incorporates all the C-14 features that have been discussed in this paper is presented in Figure 8. The modern total carbon inventory value in Figure 8 is that given for the upper biosphere in Table 5, Item 9. The suggested C-14 production rate variations are presumed to be due principally to changes in the geomagnetic field intensity, although variation in the primary cosmic ray intensity could be a contributing factor.

If there has been a period of increase in the C-14/C-12 ratio in the upper biosphere as portrayed in Figure 8, and Figure 7-C, some direct evidence for such change should be available. Such evidence is provided by the anomalous C-14 ages associated with the Chekurovka mammoth—26,000 for hair and 5,610 for overlying peat (Radiocarbon 8:320, 321); the Fairbanks Creek musk ox—24,000 for scalp muscle tissue and 17,200 for hair (Radiocarbon 12:203); the Union Pacific mammoth—11,300 for most recently formed ivory and 5,000 for wood fragments in the surrounding gravel (Radiocarbon 8:172, 173); and the Ferguson Farm mastodon—8,900 for bone collagen and 6,200 for gyttja within the skull cavity (Radiocarbon 10:216).

Additional supportive evidence is provided by the C-14 age profile for the 137 cm of animal dung accumulation on the floor of Rampart Cave in the western end of Grand Canyon (Long and Martin, 1974; Martin, 1975; Hansen, 1978), as shown in Figure 9. The dung accumulation rate in the 20-40 thousand C-14 year range amounts to less than one sloth bowel movement in the cave every three years, an unrealistic value for the occupation of the surrounding area by a viable population of animals. If one assumes that the entire dung deposit on the floor of this cave accumulated within only one thousand real-time years, the average accumulation rate is only a bit more than 20 bowel movements per year.
TOTAL CARBON

1.18 x 10^21 kgf/yr

FLOOD C. 2000 A.F.

TIME

FIGURE 8. SPECULATIVE MODEL FOR C-14 PRODUCTION AND RELATIVE CONCENTRATION TRENDS ASSOCIATED WITH THE FLOOD. Vertical scales are arbitrary and have no quantitative significance. Lines are drawn to indicate hypothetical changes only in the first approximation of trend, not magnitude. Horizontal scale is solar years before (B.F.) and after (A.F.) the Flood. Total carbon is that in the atmosphere, fresh water, ocean surface, organisms, and undecomposed organic material.

EPILOGUE

It is important for individuals who maintain confidence in the historical validity of the first eleven chapters of Genesis to recognize that there is no process of inductive reasoning by which one can with sound logic proceed from radioisotope data to the concept of a flat creation within the past 10,000 years, or to a world-wide destruction of planet Earth's surface about 5000 years ago. These are essentially religious concepts that must be accepted on the same basis of faith as are the Biblical concepts associated with the Fall and the Redemption of man. But this faith viewpoint gives the advantage of eyewitness testimony in addition to the scientific data regarding after-the-event consequences. In seeking for an interpretation that is compatible with these two sources of information, great care must be exercised to keep the search within the boundaries of good science and sound logic. In this search one can expect success or lack of success, but should never anticipate arriving at proof or disproof. The spectrum of bias based on past experience and on personal preference regarding the future will produce a wide range of judgment concerning the success or lack of success achieved by any particular model for harmonizing radioisotope data with Scripture. In seeking for continued improvement in our models for harmonization we can be guided by confidence that revelation of the Creator and His ways through inspired testimony should be consistent with the revelation of the Creator and His ways through data obtained in the pursuits of natural science. Where consistency is not apparent we should seek for improved understanding of either or both revelations.
FIGURE 9. Rampart Cave Animal Dung C-14 Age Profile.
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DISCUSSION

Dr. Brown gives a good summary of options in interpreting radiometric data. Balanced coverage is given to concordancy, isochron problems, and sample contamination. Several additional questions arise from the study:

1) What part does the biblical curse play in nuclear decay; was there a change in nuclear reactions after the Fall?

2) The preferential concentration of either C-12 or C-14 by plants and animals is well known (CRSQ, June 1974, pp. 32-36). Could such isotope fractionation be a substantial correction in age determinations?

3) Is the geologic column really dated radiometrically? The rock layers themselves are not subject to such analysis, having formed from pre-existing rock.

4) Can a possible historical variation in nuclear half-life be so quickly discounted? A strong pulse of space radiation, for example, could have temporarily "speeded up" nuclear decay.

Don B. DeYoung
Winona Lake, Indiana

Dr. Brown has done an admirable job in presenting the problems involved in the correlation of "radiogenic time" with a young earth hypothesis. I am disappointed that he ignored so much past writings of creationist scientists on the subject particularly in the Creation Research Society Quarterly (CRSQ). I recommend the 22 references I compiled in the September 1985 Quarterly concerning mainly C-14 dating that have appeared in CRSQ including one of his own papers. (See CRSQ, Sept. 1985, p. 658.)


Would Dr. Brown care to comment?

Emmett L. Williams
Norcross, Georgia

Dr. Brown has done commendable things in this paper, but there are three great difficulties that I believe checkmate his effort. I will refer to these difficulties under the enumerated headings (1) Lack of a Flood Paleontological Model, (2) Lack of a Model of the Power Source of the Flood, and (3) Lack of a Model for Contracting the Greater Bristlecone Pine Ages.

(1) Lack of a Flood Paleontological Model

Although it is gratifying to see Dr. Brown non-destructively shrink the time-scaling of the igneous strata, any creationist who accepts his act is obliged to face the stringent need for a Flood paleontological model, and to face the frightening fact that no credible, decent model of that type exists.

Dr. Brown's contracted radiometric time scale brackets each fossil-bearing sedimentary stratum firmly on a vastly shortened time axis, but a Flood paleontological model is not yet found in the creationists' effort—a model which explains how the Flood of Noah shuffled the taxonomy of a more or less well-balanced (and certainly an ecologically complete) biosphere and dealt it into the sediments in such a way that taxonomy and time are firmly linked together. (By the latter is meant that taxonomic indicators of simplicity and slight specialization are linked to the early phases of the Flood Episode, while indicators of complexity and heavy specialization are linked to the late phases.)

The most difficult challenge of a Flood paleontological model is that it must explain how the erosional and sedimentational processes of the flood produced the neat order depthwise in the marine portions of the geologic column of the subspecies of foraminifera, diatoms, and coccoliths.
(2) Lack of a Model of the Power Source of the Flood

Unless Dr. Brown is willing to reject three major geophysical processes—ocean-floor spreading, continental drift, and geomagnetic perturbations—as major global processes in the Flood Episode, his great contraction of the radiometric time scale introduces the need for a model of the power source of the geophysics of the Flood. These processes, in the best of geophysical theories, involve the entire interior of the planet, because the first two processes are surface manifestations of convection in the core.

In setting up a model of the power source of the Flood, Dr. Brown must ask the following questions:

(1) What form or forms did the power take?

(2) Was the power released from a potential energy form stored by God during Creation Week, and released at the time of the Flood by activation energy briefly injected by God (Baumgardner's concept), or was the power injected ex nihilo by God continuously during the Flood Episode?

To reject the idea of the creation of power ex nihilo by God during the Flood commits the absurd inconsistency of doing it despite accepting the Genesis account of the creation of matter ex nihilo by God during Creation Week. Such a position is horribly ambivalent; one should accept both concepts if he is to stay in creationism, or reject both and clear out. This is especially obvious in view of the universally accepted equivalence of mass and energy.

(3) Lack of a Model for Contracting the Greater Bristlecone Pine Ages

Dr. Brown's treatment of the official Bristlecone Pine time scale (now reaching to nearly 7,000 years, having been extended by a technique called "cross-matching") is unsupported. His simple assertion on page 12 that the method is questionable is not acceptable because he submits no literature citation. (The only critique Dr. Brown could have cited since the 1930's is that of Sorensen, which unfortunately appeared in a Velikovsky-oriented quarterly called Pensee, now fortunately no longer in publication.) Dr. Brown's all-too-easy dismissal of the Bristlecone Pine time scale—which by the way is exactly backed up by similar time-scaling using other species of trees in Ireland and Germany—is a coverup of the fact that the Bristlecone Pine dates are universally regarded as reliable verifiers of the radiocarbon dates. (There is a small systematic disagreement for ages greater than 3,000 years, which has a reasonable explanation, and which has not inhibited the scientists from universally calibrating the radiocarbon time scale by means of the Bristlecone Pine time scale.)

In concentrating on contracting the greater radiocarbon ages without concentrating equally on contracting the greater Bristlecone Pine ages, Dr. Brown is evading the necessity laid upon all Flood-oriented creationists—to produce a comprehensive geochemical model of the Noachian Flood that will do the following. It must simultaneously and in a dynamically interconnected way show that the greater Bristlecone Pine ages and the greater radiocarbon ages appear to verify each other only because:

(1) Each method exaggerates the tree-ring ages by substantially the same factor $F$ century-by-century after the Flood Year, and

(2) the exaggeration $F$ declines to the value of one by approximately 1,500 years after the Flood Year, and

(3) the decline in $F$ for Bristlecone Pine ages is matched century-by-century to the decline in $F$ for radiocarbon ages (except for the small systematic disagreement for ages exceeding 3,000 years, which itself must be naturally explainable by the model).

Furthermore the Flood model must be detailed enough to explain (even if only in an overall way) why the numerical value and rate of decline of $F$ for the centuries following the Flood Year for the Bristlecone Pines is substantially the same as for radiocarbon dating. In other words, the model must not consist of a pair of ad hoc submodels which produce two identical curves of $F$ versus time without providing an explanation of the dynamical basis of their congruence.

Henry F. Pearl
Glendale, California

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CLOSURE

I appreciate the opportunity Dr. DeYoung's comments have given for elaboration of the concepts that are presented in my paper.

Since nuclear decay rates are related directly to the characteristics of elementary particle interaction, viz., electrical force, nuclear long-range force, and nuclear short-range force, i.e., to the basic parameters of physical phenomena, and since electromagnetic radiation from remote objects in the universe, as well as radiation damage records in meteoric, lunar, and terrestrial minerals, gives no indication of significant change in these parameters during the existence of the physical universe, I do not see any usefulness in an Earth-history model that involves large (multi-order of magnitude) change in nuclear half-lives.

Isotope fractionation affects both the C-13/C-12 and the C-14/C-12 ratios. Since C-13 is stable the C-13/C-12 ratio is preserved while the C-14/C-12 ratio diminishes exponentially to zero. The initial C-14/C-12 ratio change due to fractionation can be determined precisely from the C-13/C-12 ratio. Radiocarbon ages are routinely corrected for this fractionation by use of C-13/C-12 ratio measurements made together with the C-14/C-12 ratio determination. The correction for fractionation is often less than one standard deviation due to the C-14 counting statistics, and is commonly omitted as insignificant or not worth the cost of a C-13/C-14 determination. [See Polach, H.A., et al., ANU Radiocarbon Date List VIII, Radiocarbon, 23 (No. 1, 1981), p. 3 of pp. 1-3; p. 17 of Olsson, Ingrid U., editor, Radiocarbon Variations and Absolute Chronology, Wiley Interscience, 1970; and examples in Liu, Chao Li, et al., Illinois State Geological Survey Radiocarbon Dates, Radiocarbon, 28 (No. 1, 1986): 78-133].

A major thrust of my paper is an effort to demonstrate that inorganic radiometric ages are more likely to indicate source material characteristics than time of placement. Whether or not the geologic column is "really dated radiometrically" depends on whether the question is directed toward data gathering procedures, or toward the validity of an interpretation of those data.

A pulse of radiation sufficiently intense and widespread to produce a major distortion (orders of magnitude) of radiometric age indication would be expected also to destroy all organic life. Furthermore, such a pulse might fortuitously cause two radiometric systems to indicate the same "age," but it would not account for the large number of samples in which three and up to as many as six independent radiometric systems indicate the same "age," within experimental uncertainties.

Readers who are interested in a summary of creationist attempts to deal with radiometric age dating will be grateful for the references Dr. Williams has supplied.

In response to the comments by Henry Pearl, I will elaborate on the Epilogue of my paper and state explicitly that I know of no investigations in the natural sciences that have produced a collection of data adequate to overthrow the currently accepted Bristlecone Pine dendrochronology. Most individuals who prefer to hold a major reservation concerning this chronology must do so on the basis of confidence in the validity and straightforward applicability of the chronological data in the historical books of the Hebrews (specifically the book of Genesis). For a recognition of difficulties with the Bristlecone Pine dendrochronology, see the following:


of the pyramids is 2 to 4 standard deviations older than the corresponding established historical age.] In press, Radiocarbon, 28.

Robert H. Brown, Ph.D.