SEARCH FOR ACCELERATED NUCLEAR DECAY WITH SPONTANEOUS FISSION OF ^{238}U

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ABSTRACT

A growing number of recent-creationists propose an accelerated nuclear decay event in the past to account for the observations of 'old age' based on constant decay rates. This is a period in time in which radioactive decay rates increase. The proponents of the theory place an event of increased nuclear decay rates during the Creation and/or Flood event. If such an event happened, post-Flood strata should possess a radioactive signature that indicates constant nuclear decay on the order of 10,000 yr. (an approximate date for the Flood). This means that layers of the pre-Flood and Flood era should possess large amounts of radioactive decay. Furthermore, if these layers are radioisotope dated assuming constant decay rates they will give erroneously old ages.

The accelerated nuclear decay theory is tested based on spontaneous fission track densities of ^{238}U in various strata in the post-Flood era. Spontaneous fission track densities are shown to be consistent in historically dated samples, but inconsistent with predictions based on theory for older post-Flood rock (Miocene to Pleistocene). Objections to these results are discussed. This study shows that ^{238}U spontaneous fission tracks are a natural dosimeter which cannot be overlooked in critiquing radioisotopic data and in locating the Flood/post-Flood boundary in the geological column.

INTRODUCTION

Even before the twentieth century, the evolutionary view of earth history required the earth's age to be far older than thousands of years. In this century, the application of nuclear physics into geological dating based on the phenomenon of radioactivity has convinced many that the age of the earth is on the order of billions of years [21]. Recent-creationists are persuaded that macro-evolution is impossible no matter how much time is available. As well, the age of the earth should conform to the Biblical narrative which, if taken literally, implies an age of the earth no greater than several ten thousands of years [42].

Most creationists who have attempted to discredit radioisotope dating studies have done so by showing that at least one of the three common assumptions required in the technique is flawed [5 p. 111-131, 17, 44, 59]. These three assumptions are:

1. Contamination and purging of the parent and daughter isotopes has not occurred or if it has occurred it is well understood.
2. The initial daughter and parent isotope amounts are known.
3. The nuclear decay rate of the parent isotope into the daughter isotope is a constant for all time.

Creationists have criticized the first two assumptions which deal with geological environment and conditions. Methods to avoid the first two assumptions have been implemented which rely on the specimen's homogeneity. The shortcomings of these methods have also been raised by some. Far fewer studies have been made to address the third assumption seemingly because of, if not true, the implication it has to major physical laws and constants. In addition, repeated radioactive experiments in this century prove nuclear decay rates are constant today [22, 38].

Within the last 10 years, a number of prominent recent-creationists strongly suggest or even theoretically require that accelerated nuclear decay has occurred during a time (during the Flood, Creation week, or a time between these events) in the past [7, 9, 18, 35, 39, 58]. These creationists acknowledge that correcting only the first two assumptions is not enough to reconcile all radioisotope data with a recent-creation. In fact, a dating technique using spontaneous fission of ^{238}U can be constructed to avoid having to make such geological environment assumptions.

If accelerated nuclear decay has occurred in the pre-Flood or Flood era, post-Flood strata should contain signatures of radioactivity consistent with ages not older than the date of the Flood. As a post-Flood marker for this study, nuclear decay amounts which would be produced for an age of 10,000 yr. will be considered consistent with post-Flood for two reasons. First, the proposal of an accelerated nuclear decay event theory is to explain how large amounts of nuclear decay (which give ages on the order of 10^6 yr. and older assuming constant decay rates) were produced in a time of about 10^4 yr. Therefore, there is at least 2 orders of magnitude difference expected to be produced by an accelerated nuclear decay event. Thus, an uncertainty of ±5,000 yr. on the date of the Flood has little bearing in this study. Secondly, though some creationists are content with accepting an Usher-like earth chronology with a world-wide deluge about 5,000 yr. ago [57], others have claimed a date of the world-wide flood slightly older than 10,000 yr. [1, 2].

A growing community of creationists believe that strata from the Holocene to the epoch of Miocene are post-Flood for geological reasons [5 p. 58 p. 79-80, 6 p. 3, 7, 33, 34, 51]. Therefore, this study focuses on fission track data from this location in the geologic column. This paper uses data from previous fission track studies with volcanic glass of the Cenozoic era back to the Miocene epoch. The viability of the accelerated nuclear decay theory is discussed based on these spontaneous fission track densities and the overall recent-creation model.

The author is aware of claims from some creationists that the geologic column must be relabeled from a more catastrophic framework. A major criticism of the conventional labels is strata not physically connected and in different geographic locations labeled to be of the same era or epoch maybe incorrect because the association is based on uniformitarian assumptions [31]. Note that this paper uses the conventional strata labels loosely for primarily identification purpose.

PRINCIPLES

Radioisotopic dating methods are based on the radioactive decay of the nucleus. This process means the nucleus spontaneously emits a particle (an electron/positron (beta decay) or ionized helium atom (alpha decay)) or fission's. (Nuclear decay is observed also to occur by electron capture.) Rutherford and Soddy [48, 49] observed that for experimental time the rate of radioactive decay is directly proportional to the number of parent atoms remaining at time *t* later. In differential form, one can represent this decay as

$$-\frac{dN}{dt} \propto N \tag{1}$$

where N is the number of parent atoms. This implies that a proportionality constant can equate the two quantities.

$$-\frac{dN}{dt} = \lambda N \tag{2}$$

Lambda (λ) is commonly referred to as the decay rate or constant. By integrating equation (2) and using initial and final conditions, one can obtain the relation

$$N = N_o e^{-\lambda t} \tag{3}$$

which is generally given to describe all radioactive decay. N_o is the number of parent atoms initially.

One can define the radiogenic daughter amount from a decay process of parent atoms as:

$$D^* = N_o - N \tag{4}$$

By substituting what N_o is from equation (3), D^* becomes

$$D^* = N(e^{\lambda t} - 1) \tag{5}$$

In actual experiments, if a specimen is suspected to have original daughter isotope amounts that are not radiogenic a term must be added to the right side of equation (5).

$$D^{*} = D_{o} + N(e^{\lambda t} - 1) \tag{6}$$

N and D are the present measurable parent and daughter isotope amounts and D_O must be assumed, if not measured at time t = 0. This relation is called the radioisotope age equation [24 p. 40]. Starting with equation (6), a formula will be derived for determining the amount of fission that will occur in a specimen containing uranium.

Since 1940, the isotope ^{238}U is known to spontaneously fission [30]. Spontaneous fission is possible only for nuclides of atomic mass near 100 and above. This is because these heavy nuclei are in a less stable state compared with the states of the daughter nuclei. Put another way, the parent nuclide has a binding energy per nucleon that is less than the binding energy per nucleon of the daughter isotopes. The product nuclides are approximately one half the mass of the original uranium isotope.

Nineteen years after the discovery, Silk and Barnes [52] observed spontaneous fission tracks on a polished specimen surface of a mica using an electron microscope. Later in 1962, Price and Walker [46] showed that by preparing the surface after polishing with the proper etching agent and amount of time the fission track widths could be enlarged for viewing with 500X to 1500X magnification. Fission tracks have been observed in mica, natural glass, man-made glass, zircon, apatite, and other materials [26, 29, 47]. The track surface density obtained by counting tracks per area can be directly related to the amount of nuclear decay that has occurred in the sample or to a time the specimen solidified given a constant rate of decay (commonly referred to as the fission track dating method) [16, 24 p. 341-353, 29 p. 159-231].

Spontaneous fission tracks are a convenient natural dosimeter. Most radioisotope dating methods depend on measuring the amount of daughter isotope at time *t*. The observation of the density of fission tracks representing nuclear decay in the specimen eliminates the necessity to measure the daughter isotope amount and thus, the assumptions associated with daughter isotope (initial amount, contamination or purgation). Before and at solidification, the rock has no fission tracks and the amount of original daughter isotope is independent. The removal or entrance of daughter isotope does not effect the spontaneous fission track density which is the nuclear decay signature. Parent contamination or purgation may have occurred, but this could be detected by observing an inhomogeneous fission track distribution if the rock sample chosen is one characterized by homogeneity (e.g. natural or man-made glass). Note that for the present study, only contamination of uranium could account for higher spontaneous fission track densities than expected.

A relationship between spontaneous fission track density of ^{238}U and the elapsed time will now be derived based on what is known from fission track analysis and radioactivity from equation (6). ^{238}U is prone to two radioactive decays: Alpha decay and spontaneous fission. Alpha decay is predominant. Equation (6) can be applied to obtain the radiogenic daughter by alpha decay which looks like

$$D = {}^{238}U(e^{\lambda_{\alpha} t} - 1) \tag{7}$$

where N is replaced by ^{238}U the number of uranium 238 atoms per volume, D is the number of product atoms per volume, and λ_{α} is the alpha decay rate for ^{238}U. ($\lambda_{\alpha} = 1.55125 \times 10^{-10}$ yr.$^{-1}$) ^{238}U also spontaneously fissions, but at a rate about 10^{7} times slower than alpha ($\lambda_f = 8.46\ (\pm 0.06) \times 10^{-17}$ yr.$^{-1}$ [11, 32]). Therefore, the decays given to spontaneous fission (F_S) per volume can be written as

$$F_s = \frac{\lambda_f}{\lambda_{\alpha}} {}^{238}U(e^{\lambda_{\alpha} t} - 1) \tag{8}$$

The approximation ($e^{\lambda_{\alpha} t} - 1 \cong \lambda_{\alpha} t$) is introduced when using this equation for time less than 500,000,000 yr. (500 Ma). The above equation becomes

$$F_s = \lambda_f {}^{238}U t \tag{9}$$

The correct method to obtain ^{238}U from a measurement of the amount of uranium (U) in the sample in ppm is

$${}^{238}U = \frac{U \rho N_A}{A_w}(1 - I) \tag{10}$$

where ρ is density of the glass, N_A is Avogadro's number, A_W is the atomic weight of uranium, and I is the fraction of the natural abundance of ^{235}U to ^{238}U isotopes (1/137.88).

Combining equations (9) and (10),

$$F_s = \frac{\lambda_f U \rho N_A (1-I) t}{A_w} \tag{11}$$

This allows a prediction of F_S given a known age and measurements associated with a homogeneous sample (i.e. U content and mass density). Figure 1 displays how F_S depends on uranium content of a natural glass sample of age *t* and $\rho = 2.5\ g/cm^3$. (This density which has an estimated uncertainty of 10% is representative for the glass samples in this study.)

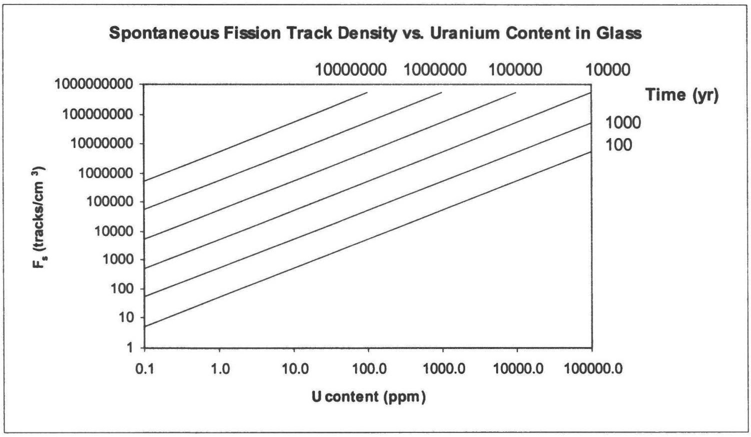

Figure 1. A plot of F_S vs. U content for different glass sample ages (t). For instance, a sample of age 10,000 yr rests on the line of 10,000 yr. If it contains 1 ppm of uranium it has about 5,000 tracks/cm^3.

METHOD

Experimentally, F_S is determined by an areal spontaneous fission track density (ρ_S) of a prepared surface of the specimen. I have shown that the conversion between area and volume fission track densities is

$$F_s = \frac{\rho_s 2}{L} \tag{12}$$

where L is the fission track length [10 p. 34-35]. This length is considered constant because the energy per nucleon of the products in the fission process is consistently about 1 MeV/nucleon. The length of the fission tracks in a glass of $\rho = 2.5\ g/cm^3$ is determined to be 15 (±1) μm [10 p. 36-39 p. 47-48]. The fission track length can be found by solving the Bethe-Bloch equation semi-empirically [45] or by more experimental data of ions traversing through material. This calculation is verified by measurement on glass samples.

The above equation assumes that 100% of the fission tracks at the surface are revealed. In practice, this is not the case. Track ratio methods have been employed to avoid the necessity for a revealing fission track efficiency [24 p. 341-353]. For this study, a revealing fission track efficiency (ε) can be defined as

$$\varepsilon = \frac{\rho_{sm}}{\rho_s} \tag{13}$$

where ρ_S is the actual or ideal area fission track density and ρ_{sm} is the measured area density. Given a glass sample that has been exposed to a thermal neutron flux which induces fission of ^{235}U, the sample's U content, and a subsequent determination of the induced area fission track density (ρ_{im}), a fission track revealing efficiency can be obtained from

$$\varepsilon = \frac{\rho_{im} 2}{L\, {}^{235}U \phi \sigma} \tag{14}$$

where ^{235}U is in atoms/cm^3, ϕ is the thermal neutron flux in neutrons/cm^2, and σ is the cross section of the ^{235}U for thermal neutron induced fission (σ = 580.2 X 10^{-24} cm^2). Using data from Westgate [57] and a sample of Libyan glass prepared for fission track observation (provided by Dr. John Westgate of the University of Toronto) ε was determined to be overall 0.83 (±0.02) [10 p. 39-41 p. 47-48]. Therefore, F_S is experimentally obtained by

$$F_s = \frac{\rho_s 2}{\varepsilon L} \qquad (15)$$

and can be compared to F_S predicted by principles of radioactivity and characteristics of the sample.

Historically dated glass will now be utilized setting a foundation for the reliability of F_S obtained from principles of radioactivity and F_S observed in a particular sample. These results and eventually others progressively older in age are described and plotted superimposed onto Figure 1. Two of the glasses analyzed by Brill, *et. al.* were known to be manufactured (based on stylistic basis (sb)) in the last half of the 19th century [14, 15]. The results with uncertainties are in Table 1. Notice the location of these data points plotted on the calibrated graph of F_S vs. U content for glass in Figure 2.

Table 1. Data for historical man-made glass sample approximately 100 yr. old.

Known date	U content in %	ρ_s (cm^{-2}){F_s}(cm^{-3})
1850-1860 (sb)	0.51	190 {2.52X10^7} ±22%
last quarter of 19th century (sb)	0.37	108 {1.44X10^7} ±25%

The second set of data is fission track studies of natural glass flows (or objects annealed) historically dated to approximately 1,000 yr. ago [12, 43, 54]. These data came from Italy and Japan. See Table 2 and Figure 2 for the data and plot. Again, notice the agreement between these data plotted in Figure 2 with theory.

Table 2. Data for historical natural glass samples approximately 1,000 B.P. (B.P. means the number of years before present which is taken to be 1950 A.D.)

Sample	Date(BP)/evidence	U content in ppm	ρ_s (cm^{-2}){F_s}(cm^{-3})
Rocche Rosse Flow	1400 - 1450	6.2	3.2 {4.3X10^5} ±32%
	historic volcanic event		
Forgia Vecchia Flow	1220 - 4800	7.1	4.2 {5.6X10^5} ±24%
	^{14}C dated strata below		
Obsidian Arrowhead	990 - 1420	3.1	0.92 {1.2X10^5} ±19%
Obsidian Flake	same as above	3.1	1.0 {1.3X10^5} ±47%
	near ^{14}C dated pottery		

Now that the relationship between time and spontaneous fission track density is established back to 1,000 B.P., the third set of data to superimpose on the figure 1 calibration curve is spontaneous fission track densities from strata designated as Pleistocene, Pliocene, and Miocene. Strata at this level in the geological column are considered post-Flood based on the environment in which they were formed, their local to regional extent, and the characteristics of the layers above and below them [5, 7]. Westgate, *et. al.* have observed spontaneous fission track densities in Cenozoic volcanic glass from tephras for use in fission track dating [3, 50, 53, 55, 56]. This data provides enough information to construct our last set of data to plot. (See Table 3.)

Table 3. Data for fission track analysis of glass samples from Pleistocene to Miocene. In some cases, equation 14 was used to determine the uranium content.

Sample/ Locality	Φ (X1015n/cm2)	ρ_i (X105 cm-2)	U content in ppm	ρ_s (X102 cm-2) {F_s} (cm-3)
Ester Ash Beds (UA743) Fairbanks, Alaska	3.96	1.46	2.2	3.95 {5300} (±16%)
Fort Selkirk Tephra (UT82), Yukon	3.79	1.20	1.9	6.33 {8440} (±9.1%)
Borchers Ash (UA598) Meade County, Kansas	2.42	2.86	7.1	2.28 {3040} (±5.8%)
Lake Tapps Tephra (UT462), Algona, Wash.	2.02	1.22	2.1	6.53 {8700} (±12%)
Rockland Tephra (RPT(L)15)*, N. Calif.	3.45	2.34	4.3	5.90 {7900} (±13%)
Bishop Tuff (UT35) Bishop, Calif.	2.04	2.58	7.6	11.4{15200}(±8.7%)
Old Crow Tephra (UT613), Holitna, Alaska	1.88	1.12	3.7	1.47 {1960} (±13%)
Same as above (UT501) Halfway House, Alaska	1.88	1.20	4.2	1.25 {1700} (±19%)
Davis Creek B (UT776)* Cypress Hills, Saskatch	3.83	3.00	4.9	120{160000}(±3.7%)

* Indicates that these samples were partially annealed by heating in the laboratory giving a slightly lower spontaneous fission track density than before laboratory annealing.
Note that error in the uranium content values is at most ±10% based on some neutron flux variations [24 p. 343]. Error in the spontaneous fission track densities is determined by poisson counting error [19].

These previously published data are now placed on the plot of F_S vs. U content. This set represents observed spontaneous fission track densities in natural glass of the Cenozoic back to middle Miocene. Notice their deviation from predicted densities based on a post-Flood era of 10,000 yr. ago. For a further verification, the author plans to check the reproducibility of these observations on a chosen natural glass of the post-Flood era not yet fission track analyzed to be published elsewhere.

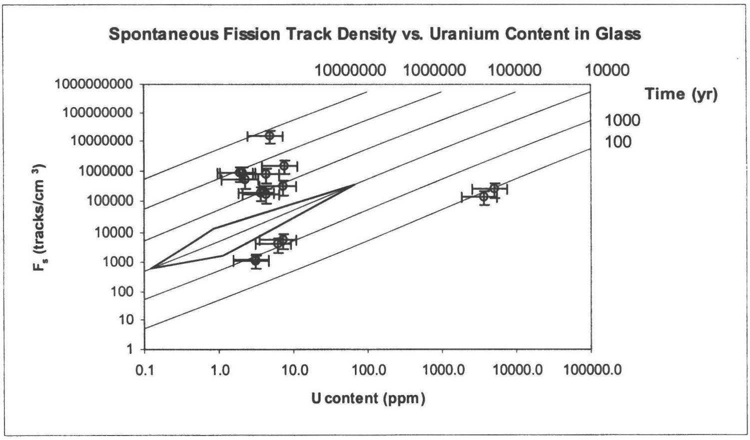

Figure 2. A plot of F_S vs. U content for glass of density 2.5 g/cm^3 with lines showing order of magnitude of time required for a particular F_S to accumulate. This graph shows the observed spontaneous fission track densities for the specimens cited in the text. The polygon shows where a 10,000 yr. sample should plot. Exaggerated error bars of 50% in both directions are applied to emphasize the clear difference between theory and experiment.

DISCUSSION

The spontaneous fission track densities previously observed and published for strata between Miocene to Pleistocene epochs are not consistent with nuclear decay predictions from a post-Flood era of 10,000 yr. in length. As part of the previous study to obtain a spontaneous fission track density of the Resting Spring Range Obsidian, the author dedicated a chapter to addressing alternative explanations for these results [10].

The first explanation may be to claim non-^{238}U fission track sources in terrestrial materials. This claim can be divided into track sources which are nuclear in origin and track sources which a non-nuclear in nature. The radioisotope candidates for spontaneous fission are few, but a candidate that is observed to spontaneous fission, at a faster rate than ^{238}U and maybe naturally present in substantial terrestrial amounts is the isotope ^{244}Pu. The validity of this argument can be checked by an experimental search for the natural terrestrial abundance of plutonium. One such experiment was completed in the 1960's [25]. They found a terrestrial abundance ratio in a test sample to be $3X10^{-22}$ ((g of ^{244}Pu)/(g of sample)). By comparison, knowing the terrestrial abundance ratio of ^{238}U to be $1X10^{-6}$ and that spontaneous fission is 10^5 times more likely for a ^{244}Pu isotope, it can be shown that if the ^{244}Pu abundance ratio is $1X10^{-11}$ in a sample, a substantial amount of tracks are not from ^{238}U. Thus, the ^{244}Pu abundance ratio necessary to affect observed spontaneous fission track densities is almost $1X10^{-11}$ larger than observed by Fields *et. al.* Other isotopes susceptible to spontaneous fission must first be observed to have a terrestrial abundance and fission rate that together is comparable to ^{238}U. Thorium, neptunium, californium, and a few other elements have potential isotopes if significant terrestrial abundance can be observed which to date has not been proven. The fission sources such as cosmic rays and thermal neutron induced fission of ^{235}U in nature are observed at present to be rare [27, 29 p. 161, 35, 47]. Cosmic ray exposure effects on terrestrial materials are another dimension to the study of an abrupt change in nuclear decay rates which cannot be overlooked. Only by assuming the cosmic ray exposure rate has drastically changed, possibly simultaneously, in connection to a nuclear decay rate change can an attempt be made to mesh processes that would oppositely affect cosmogenic radioactive isotope quantities in terrestrial materials. Observed terrestrial cosmic ray exposure data will discussed later in more detail.

For non-nuclear sources, misleading fission track densities have been recorded primarily because of problems with identifying genuine fission tracks from microlite pits, cracks, fractures, or defects. Environmental heating of the rock after solidification can cause track fading and give a misleading low fission track density. Track annealing is not a cause for an over abundance of fission tracks. Bigazzi *et. al.* 13 p. 711] points out that "Proper identification of fission tracks appears to be of prime importance in glass sample; reliable data are the result of experience and careful selection of samples." Thus mistakes have been made, but as was shown spontaneous fission track densities for historically dated specimens are consistent with assuming constant radioactive decay rates.

There are researchers in the recent-creationist community that contend Flood strata includes layers possibly up to the Pleistocene and even the Holocene. [20 p. 74, 37, 57 p. 286]. However, there is good reason to credit these strata possessing the glass shards reported in this study as post-Flood. The dominant recent-creation model places a surge of volcanism activity during and immediately following the Flood [5, 7]. All of the glass analyzed has come from volcanic tuff deposits. Another characteristic to note is that these strata are believed to have been air-fall accumulated, not in water, and portions of the tuff are welded implying a far slower cooling rate than a quench in water. From a more general view, Cenozoic strata tend to cover only a local to regional area in extent, but the geological effects of a global catastrophic Flood are expected to be at least continental in extent. Assuming both a global cataclysmic Flood and a simultaneous event of accelerated nuclear decay, suggests that these middle to early Cenozoic strata have both a pre-Flood/Flood trait (high amounts of nuclear decay) and a post-Flood trait (physical formation and characteristics).

Is it possible that an accelerated nuclear decay event occurred in the post-Flood? If so, the highest amounts of decay (Miocene F_S) are a factor of 1000 higher than a 10,000 yr. post-Flood prediction. One can imagine, this order of increased nuclear decay would result in intense heating of rocks containing radioisotope species. Uranium ore deposits would have possessed harmful effects to the nearby environment as observed in a nuclear blast or nuclear reactor accident. This is not a pleasant environment for life. From another viewpoint, some ages obtained by cosmic ray exposure of rocks are reported to be older than 10,000 yr. [40, 41]. This age depends on the cosmic ray flux and the amount of cosmogenic isotopes produced in the exposed rock surface. After an accelerated nuclear decay event in the post-Flood all materials should be depleted in radioisotopes and the ages of rocks determined by cosmic ray exposure should give misleadingly lower dates, not older than the Flood date. Accelerated nuclear decay in the post-Flood era does not remedy the issue.

CONCLUSION

Spontaneous fission tracks in man-made and natural glasses are a reliable nuclear decay dosimeter for the recent past. Spontaneous fission track densities of glass from volcanic strata throughout western North America below Holocene in the geologic column indicate an over abundance of nuclear decay assuming a Flood/post-Flood boundary near the Miocene epoch and an accelerated nuclear decay event before or during the Flood. Characteristics and formation of these tuffs do not seem to be traits of Flood strata. A proposed accelerated nuclear decay event in the post-Flood era creates more problems than it solves. The Flood/post-Flood boundary is not discernible in the geologic column given the present recent-creation model with both a catastrophic global Flood and an accelerated nuclear decay event (during Creation and/or Flood).

There are a few avenues for future research connected to this study. One research avenue that may provide clues to the theory in question is a creationist lead experimental search for present or evidence of past terrestrial abundance of elements other than uranium known to spontaneously fission. A search for evidence of a change in cosmic ray exposure in earth history independent of, or related to, accelerated nuclear decay is necessary. Another avenue is to conduct a more complete study of spontaneous fission track densities in Holocene strata starting with specimens expected to be slightly older than historical ones confirmed by fission track dates. This will provide vital information in locating the Flood/post-Flood boundary.

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