

Much Greater Cosmic Rays During the Ice Age and Before

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Abstract

The RATE project was a huge breakthrough for creation scientists. It especially explained why secular scientists get millions and billions of years from radiometric dating. Quaternary dating methods also need evaluating. One of these dating methods is cosmogenic nuclide dating caused by the bombardment of the Earth by cosmic rays. Production rates of cosmogenic nuclides vary by location on the Earth, altitude, and time and depend upon many variables. They have many geological applications, such as inferring erosion rates and the burial rates of sediments. Carbon-14 is the most well-known cosmogenic dating method, but it has a practical age limit to only 50 ka. In situ beryllium-10 (^{10}Be or Be-10) can be easier to use and can ‘date’ the rest of the Quaternary. Another cosmogenic dating method calculates the ratio of Al-26/Be-10 in sediment, which can determine the time since burial. Seven Be-10 measurements are used as showcases for an old Earth. They produce tens to hundreds of thousands of years in the uniformitarian timescale. When transforming the Be-10 values into Biblical earth history, creation scientists run into four complications which make it impossible to be accurate. In spite of this, it appears that the cosmic rays were very high during the Flood and tailed off rapidly during the Ice Age. These measurements have four implications: 1) high cosmic rays could be due to a nearby supernova or supernovae that may also be a cause for accelerated radiometric decay during the Flood and Ice Age; 2) it accounts for the rapid increase in C-14 after the Flood; 3) accelerated radiometric decay after the Flood telescopes other Quaternary dating methods to the time after the Flood; and 4) finally, we can account for the Be-10 measurements in ice cores.

Keywords: Accelerated radiometric decay, Aluminum-26, Beryllium-10, Carbon-14, cosmic rays, cosmogenic isotope dating, geomagnetic field, Quaternary dating methods, supernovas

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Introduction

Deep time challenges Biblical young-Earth history (Oard, 2019). Creation scientists have been working on understanding why some dating methods calculate millions of years ever since the late Drs. John C. Whitcomb and Henry M. Morris published *The Genesis Flood* (Whitcomb and Morris, 1961). Great progress was made with the completion of the RATE project (Vardiman et al, 2000; 2005; DeYoung, 2005). Humphreys discovered there was a period or periods of accelerated radiometric decay sometime in the past 6,000 years (Humphreys, 2005). Just when accelerated radiometric decay took place in Biblical history is still being debated among creation scientists, although most creation scientists favor just before or during the Genesis Flood. Many more dating questions and challenges are still in the process of being answered. One is how Quaternary dating methods also produce old ages of hundreds of thousands to a few million years.

Quaternary Dating Methods

The Quaternary is the past 2.6 million years (Ma) in the uniformitarian time scale, and is divided up into the Pleistocene from 2.6 Ma to 11,700 years ago (11.7 ka) and the Holocene from 11.7 ka until the present (Figure 1). There are numerous Quaternary dating methods (Noller et al., 2000), which often extend into the Pliocene Epoch (2.6–5.3 Ma) or even “older.” The Quaternary is considered the general period of ice ages in the uniformitarian system of which there are now about 50 ice ages, separated by interglacials (Walker and Lowe, 2007). These ice ages are claimed to have cycled either every 40 ka more than a million years ago (40 ice ages) or every 100,000 years during the past 1 million years (10 ice ages). The post-Flood Ice Age corresponds primarily with the ‘last’ uniformitarian ice age. Terrestrial evidence for previous ice ages is skimpy

with the main evidence coming from wiggles of certain variables, primarily the oxygen isotope ratio, down deep-sea cores. These wiggles can be due to other mechanisms that occurred during the Flood and/or the Ice Age.

Quaternary dating methods are used to anchor deep-sea core oxygen isotope variations. The isotopic variations in the cores are then used to ‘validate’ the Milankovitch mechanism (cyclostratigraphy) that causes cyclical changes in the Earth’s orbital geometry. Changes in the orbital geometry cause changes in the seasonal and latitudinal distribution of solar radiation, but not the total amount of sunlight striking the Earth. The Milankovitch mechanism is why scientists claim that ice ages cycle every 40,000 years, matching the tilt cycle, and every 100,000 years, matching the ec-

centricity cycle, for the past 2.6 Ma. The Milankovitch mechanism is assumed to be proven and now is used to ‘date’ other climatic data sets, such as other deep-sea cores, ice cores, pollen cores, lake sediment cores, etc., at a finer scale (Oard and Reed, 2020b). However, the Milankovitch mechanism is too small to cause glacial/interglacial oscillations (Oard and Reed, 2020a).

The deep-sea cores that supposedly validated the Milankovitch mechanism depend upon Quaternary dating methods, one of which is paleomagnetism. Jake Hebert of the Institute for Creation Research noticed that the date of the transition from the Matuyama Reversal to the Brunhes Normal was changed from 700,000 years ago to 780,000 years ago (Hebert, 2017a, 2017b). This change affected all the other dates of the

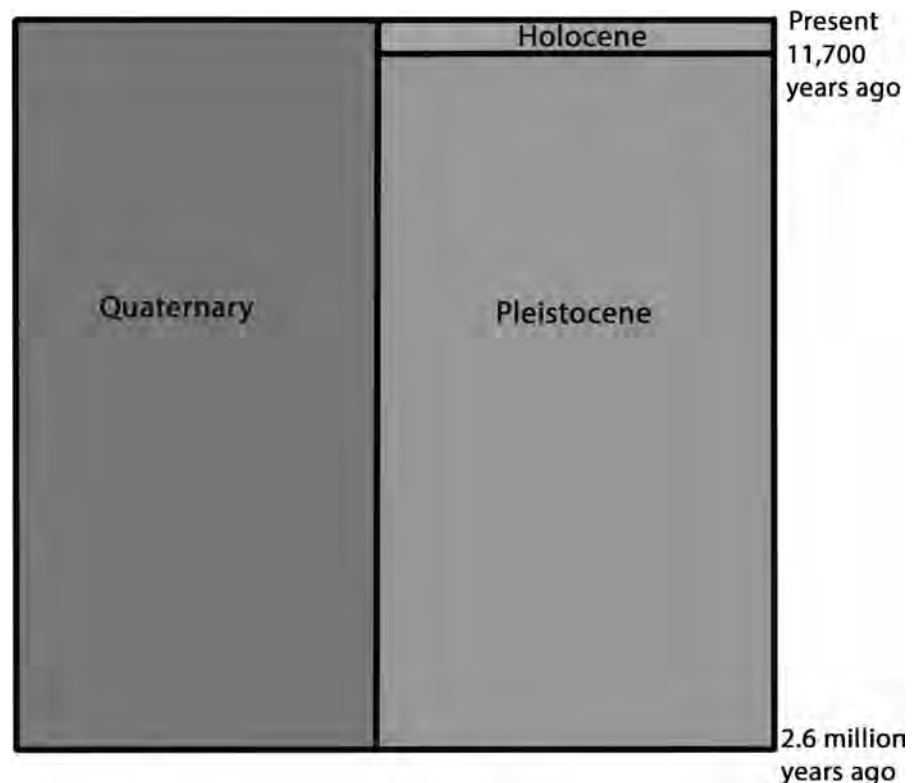


Figure 1. The “Quaternary Period” subdivided into the “Holocene” ‘interglacial’ and the “Pleistocene,” the general time for the secular ice age cycles (drawn by Mrs. Melanie Richard).

cores and threw off the cycles. Under the assumption of uniformitarianism, Hebert reran the spectrum analysis, which determines major frequencies in a time series, using the new date for the paleomagnetic transition. The Milankovitch cycles no longer showed up, which means that the Milankovitch mechanism has *not* really been proven! Secular scientists have attempted to rescue the *Pacemaker of the Ice Ages* paper, but Hebert (2019) shows that this “rescue” may be influenced by “selection bias” and requires arbitrary, capricious handling of seafloor sediment data, which is not convincing. It also means that thousands of papers that assume the Milankovitch mechanism to be true are suspect, even by uniformitarian reckoning.

Cosmogenic Isotope Dating

Another Quaternary dating method is cosmogenic nuclide dating. Cosmogenic nuclides are formed by the bombardment of primary, energetic cosmic rays from space on the atmosphere, causing a cascade of numerous particles as ‘secondary cosmic rays’ (Figure 2). Primary cosmic rays are very high energy particles and consist of about 90% protons, about 8% alpha particles (He nuclei), and the remainder heavier nuclei and electrons with an extremely minute proportion of positrons and antiprotons (Lifton et al., 2005). The latter likely were made by recent energetic processes. Cosmic rays vary significantly in energy. The cascade of particles and energy result in neutrons that penetrate the atmosphere to the surface. The fast neutrons and ‘thermal’ neutrons (those that have slowed to the temperature of the surrounding molecules) mostly form the in situ cosmogenic nuclides (Gosse and Phillips, 2001; Desilets and Zreda, 2003; Balco et al., 2008).

The origin of cosmic rays is a mystery. Very-high-energy cosmic rays are believed to have formed mostly in the Milky Way Galaxy, but extra-high-energy

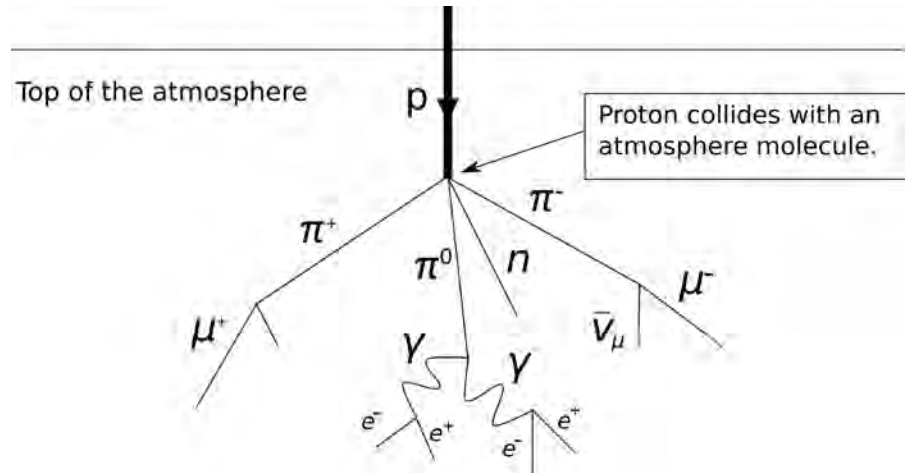


Figure 2. Primary cosmic-ray particle (a high energy proton) collides with a molecule in the atmosphere (User:SyntaxError555, Wikimedia Commons CC-BY-SA-3.0 mitigated).

cosmic rays are believed to have come from outside our galaxy (Cockburn and Summerfield, 2004). Scientists mostly think cosmic rays are from supernova remnants (SNRs), which have somehow accelerated the cosmic rays to relativistic speeds (Ackermann et al., 2013; Morlino, 2017). Others think that such very high accelerations come from supermassive black holes, such as the one believed to be in the center of the Milky Way Galaxy (Hess Collaboration, 2016).

The secondary cosmic rays start forming high in the atmosphere and continue to react with the atmosphere below with some eventually striking the Earth’s surface in their downward trek (Zreda and Phillips, 2000). Numerous interactions with the atmosphere and many different particles, of various energies, are produced. The cosmogenic nuclides are formed especially by high-energy neutrons from these secondary cosmic rays, mostly by spallation. Spallation takes place when a cosmic ray particle collides with matter and dislodges protons and neutrons from the atoms, forming new atoms and

residual particles. High energy protons account for 5% of the in situ cosmogenic nuclides (Reedy, 2013). Around 2% of in situ cosmogenic nuclides, those formed at the surface, are formed by negative muon capture and fast muon interactions and are usually ignored (Granger et al., 2013; Balco, 2017a). A muon is an elementary particle similar to an electron with a charge of -1 but with a much greater mass. Neutrons in the atmosphere are difficult to measure, and the physics of the production of cosmogenic nuclides, except for carbon-14, has not been worked out (Argento et al., 2015; Phillips et al. 2016). Each cosmogenic nuclide has its own unique production from nuclear reactions, with the energy of the cosmic rays important (Reedy, 2013). The pathway and molecular bombardment are different for the various cosmogenic nuclides (Gosse and Phillips, 2001).

Because cosmic rays are predominantly electrically charged, their fluxes into Earth’s atmosphere are influenced by the interplanetary magnetic field (the part of the solar magnetic field that

extends into the interplanetary region), whose strength depends on the level of solar activity, which produces low-energy cosmic rays (Lal, 1987). Because solar activity is cyclical and averages out, the effect of solar cosmic rays will not be considered further. However, once in a while, coronal mass ejections occur that increase the flux of solar cosmic rays, but these are rare enough to also ignore (Argento et al, 2015).

Thus, production rates of cosmogenic nuclides vary in latitude, longitude, altitude, and time and depend upon many variables: “Cosmic-ray produced production is a complex process that is affected by many variables” (Argento et al., 2015, p. 40). Numerous cosmogenic nuclides are generated, but only the stable atoms, ^3He and ^{21}Ne , and the radioactive isotopes, ^{10}Be , ^{14}C , ^{26}Al , ^{36}Cl , ^{39}Ar , and ^{60}Fe are considered significant for geological work (Lal, 1991).

One of the main variables that affects the production rate of cosmogenic nuclides is altitude and geomagnetic latitude. Because cosmic rays are predominantly charged particles, they often get caught up in the geomagnetic field. Because the geomagnetic field tends to funnel these charged particles to higher latitudes, the low to mid geomagnetic latitudes are shielded to a certain extent. The high energy cosmic rays can better penetrate the geomagnetic field at high latitudes. There is little geomagnetic blocking poleward of about 60° geomagnetic latitude in a dipole field. Researchers use “scaling factors” from one or several locations, primarily at high latitude and sea level, to determine the production rate of cosmogenic nuclides globally and at all altitudes.

The production rate of cosmogenic nuclides is especially high in the upper atmosphere with most of them produced in the stratosphere (Adolphi and Muscheler, 2016). Production decreases downward to the surface, which is believed to produce only several atoms per gram of quartz per year. Quartz,

being a ubiquitous molecule on Earth, is the standard substance used to measure cosmogenic nuclides. Cosmogenic nuclides increase greatly with altitude by a factor of about 1,000 in the upper atmosphere. These nuclides usually reach the Earth’s surface, for instance adhering to aerosol particles that sink through the atmosphere. As a rule of thumb, for every 10 m increase in elevation gain from sea level, the production rate goes up about 1% (Stone, 2000). But, it is questionable whether this rule of thumb applies for moderate to high altitudes (see below).

Cosmogenic nuclides have a number of applications in geology. They are primarily used to determine the length of time a surface has been exposed, such as a large boulder in a terminal moraine or a polished, striated surface left over from the Ice Age. Cosmogenic nuclides can be used to estimate the rate of erosion and the rate of burial of a surface (Portenga and Bierman, 2011). However, many complications enter into the procedures (Gosse and Phillips, 2001). For instance, in measuring surface exposure, the researchers must assume that the surface or the top of a boulder did not have any previous exposure, called inheritance. Previous exposure would presumably be ruled out if the boulder was dislodged from a depth below 3 m, since secondary neutrons generally cannot penetrate more than three meters of ground. However, it is commonly found that striated surfaces have a component of inheritance, which usually is not known until the measurements turn out different from the ‘known’ age (Balco, 2017b). Researchers usually choose the top of large boulders, since they are believed to have little inheritance, and it is unlikely they have moved since emplacement, been covered by soil, or slowly weathered and eroded. A long deep snow cover can also shield the boulder for a while, but this is commonly factored in during the interpretation of the measurements.

Moreover, researchers must be careful not to measure atmospheric produced nuclides (Bierman, 1994), a problem for unconsolidated sediments. With an “understanding of the secular history” of the environment, cosmogenic nuclides have been used to estimate surface erosion rates and burial times for sediments and soils (Balco and Rovey II, 2008), although several uniformitarian assumptions go into the calculations.

Carbon-14 Dating

Carbon-14 is one of the cosmogenic nuclides which many people recognize. In the upper atmosphere, it forms from nitrogen-14 and quickly combines with oxygen creating carbon dioxide. The carbon dioxide spreads through many carbon reservoirs: the atmosphere, the biosphere, and the ocean, so it is simpler to use Be-10 (Adolphi and Muscheler, 2016). Most people mistakenly think that carbon-14 dates the Earth as old, but it is primarily used to date the remains of once-living organisms (Oard, 2019). Also, with a half-life of 5,730 years, its practical dating limit is 50,000 years, since after that time the sample of carbon-14 becomes too small to measure with current technology, making contamination more of a problem.

Carbon-14 was the first Quaternary dating method developed in the 1950s and 1960s. It has been used to date numerous archeology sites, Late Quaternary animals, etc. Scientists discovered that carbon-14 is not particularly accurate, so it needs to be “calibrated” to dates of “known” age, produced by other, presumably more accurate dating methods. It is assumed that counting of tree rings, dendrochronology, is one of the most accurate dating methods and can date to nearly the precise year by counting rings of living and *dead* trees. The rings in dead trees are supposedly cross matched to each other and “connected” to the end of the living trees. Secular scientists have only been able to compare

tree rings to around 14 ka years BP (before the present or 1950), by correlating dead trees often found in river terraces (Muscheler et al., 2014). How tree ring chronologies are developed, and why they extend to beyond the Flood dated at about 4,500 BP (Thomas, 2017) is beyond the scope of this article. However, it has been addressed by other creation researchers (i.e., Woodmorappe, 2018). The assumption of old age plays a large part. Secular scientists also correlate the carbon-14 method beyond tree-rings to 50 ka by using “varves,” speleothems, corals, ice cores, etc. (Reimers et al., 2013) with deep time assumed in all of these systems.

The Beryllium-10 Dating Method

Because carbon-14 dates reach a practical limit of only 50,000 years, and the Quaternary is said to be 52 times this length, secular scientists have been actively searching for dating methods that provide ages well beyond the limit of carbon-14. They have developed many such dating methods (Noller et al., 2000). Beryllium-10 (Be-10) is one.

The formation of Be-10

Cosmogenic Be-10 is one of the main cosmogenic nuclides that is used in geology because of its long half-life. Once formed in the atmosphere, it is absorbed by aerosol particles that fall to the Earth's surface or become absorbed into precipitation. Its atmospheric life is about 2 years, but it is complicated in that the stratosphere has a higher concentration of Be-10 than the troposphere, and so the variable air exchange between the stratosphere and troposphere must be taken into consideration (Adolphi and Muscheler, 2016). A slight amount of Be-10 is formed at the surface (in situ Be-10) from bombardment of oxygen and silicon in quartz (Gosse and Phillips, 2001), which can be measured by sensitive mass spectrometers.

The cosmic rays will penetrate slightly into matter, generally within about 3 m of rock, except for the secondary cosmic ray muons, high energy neutrons, and gamma rays that penetrate much deeper (Balco, 2017a). The production of Be-10 decreases exponentially with depth with an e-folding depth of 60 cm in rock and 1.5 m in ice (Schaefer et al., 2016). The e-folding depth is the depth at which production is decreased by a factor of $1/2.71828$, or 0.37. The depth of penetration depends upon the density.

Be-10 is radioactive with a half-life that has been variously estimated between 2.9 Ma to 1.386 Ma, but recently researchers have settled on the lowest half-life of 1.386 Ma (Chmeleff et al., 2010) based on a measurement of the $^{10}\text{Be}/^{9}\text{Be}$ isotope ratios. Thus, the Be-10 dating method has the potential to date to around 3 half-lives or well into the Pliocene.

Be-10 is commonly measured in ice cores and its oscillations are correlated with various Quaternary events, such as the Laschamp polarity excursion about 40 ka. A polarity excursion is like a reversal but represents a dramatic deviation of the axial dipole of around 45° , or sometimes more, with a decrease in intensity to 0 to 20% of normal that lasts tens to hundreds of thousands of years in geological time (Neuendorf et al., 2005, p. 504). However, the Be-10 values in ice cores depend upon the amount of wet versus dry deposition of aerosols on the ice sheets and atmospheric circulation processes (Adolphi and Muscheler, 2016), which are difficult to estimate in the present and especially for the past. So, I will use the much simpler dating method developed from in situ Be-10.

As already stated, little in situ Be-10, as well as other cosmogenic nuclides, is formed on the Earth's surface by secondary cosmic rays. The geomagnetic field at low to mid latitudes deflects some of the cosmic rays with about 50% shielding near the equator. Geomagnetic shielding does not take place at latitudes

higher than 60° assuming a dipole field. So, it is claimed that at sea level only about 4 atoms/gm/yr. are formed at high geomagnetic latitudes (Young et al., 2013) and about 2 atoms/gm/yr. at low geomagnetic latitude (Blard et al., 2019). These are rough estimates.

Be-10 calibrated to surfaces of 'known' age

In the past, observed production rates have been estimated from physics (Masarik and Reedy, 1995), but the physics is so complex that researchers estimate the production rate based on surfaces of “known” age (Balco et al., 2009; Balco, 2017b; Blard et al., 2019). Such a procedure is in fact circular reasoning and adds an old-age bias to the measurements. One of the problems in using physics to calculate production rates is that it is difficult to measure the flux of neutrons (Reedy, 2013). Some other complications are that there are eight reactions with matter that form Be-10 (Gosse and Phillips, 2001), and objects such as trees, buildings, and even distant mountains in the field of view cut down the production rate (Cerling and Craig, 1994), but usually only slightly. So, it has been difficult to determine the production rate, with different models yielding estimates varying by a factor of two (Kovaltsov and Usoskin, 2010).

In reference to calibrations to ‘known’ age surfaces, Balco (2017a, p. 151) states:

Here ‘geological calibration data’ means measurements of concentrations of naturally occurring cosmic-ray produced nuclides in settings where independent knowledge of the geological history of the site allows one to infer nuclide production rates from the concentration measurements.

This specifically refers to muons but it also applies to all in situ cosmogenic nuclides. Borchers et al. (2016, p. 189) further state:

The production rate parameter is calibrated by finding the value that

best fits measured concentrations from a collection of sites for which independent age measurements are available.

This of course is how deep time automatically enters into the calculations, and why production rates are assumed to be particularly low.

Scientists commonly measure the amount of Be-10 on surfaces to about 10^4 to 10^6 atoms/gm, and with low production rates, they arrive at ages of tens of thousands to millions of years within the uniformitarian paradigm. This is way beyond the timescale of the young Earth, based on the genealogies in Genesis 1–11.

Aluminum-26 (Al-26)

Aluminum-26 (Al-26) is also another cosmogenic nuclide that scientists work with. It has a shorter half-life of 7.17×10^5 years, about half that of Be-10. But more atoms of Al-26 are formed in situ than Be-10, but the ratio varies by altitude, latitude, depth below the surface, and other variables (Luo et al., 2020). Although the ratio has been measured up to 7.3 (Corbett et al., 2017), the ratio of $^{26}\text{Al}/^{10}\text{Be}$ used today is about 6.8 (Luo et al., 2020).

Secular scientists have developed another dating method using these cosmogenic nuclides. Since Al-26 decays faster than Be-10, the $^{26}\text{Al}/^{10}\text{Be}$ ratio will decrease with time. Since both isotopes are generally formed the same way, when they measure Be-10, it is rather simple to also measure Al-26. Any system that changes with time is a potential dating method, although the further back in “time,” the more “iffy” the results. Different values of the half-life of this dating method have been published, probably because the production rates are difficult to determine. One value from the literature for the half-life of the $^{26}\text{Al}/^{10}\text{Be}$ ratio is 1.4 Ma (Schaefer et al., 2016) and another value is 2.08 Ma (Granger et al., 2015).



Figure 3. View of the divide of Unaweep Canyon through the Uncompahgre Mountains of west-central Colorado, USA (view west).

Examples of Be-10 Measurements

Numerous Be-10 measurements have been made, especially on glacial features or deposits (Balco, 2017b). Assuming a dipole field, high geomagnetic latitude measurements do not need correction for the changing geomagnetic field in the past, but lower latitude measurements do (Lifton et al., 2008). I will provide some representative samples from the secular literature starting from likely Flood-formed features, to early Ice Age, and then late Ice Age.

Be-10 in Unaweep Canyon fill

Unaweep Canyon is a wind gap carved through the Uncompahgre Mountains (Figure 3). In the process, thin-bedded sediments, interpreted as lacustrine by secular scientists, collected in the canyon west of the rock divide. After the ‘lacustrine’ sediments were laid down, the top was covered by alluvium/colluvium mostly from the canyon sides.

The total depth of this amazing canyon fill is about 350 m (1,150 ft.) (Figure 4). Uniformitarian scientists have difficulty explaining the sediments of the canyon fill. They suggest a landslide dam at the western end of the canyon. It would have had to be several hundred meters high, of which there is no evidence of such a landslide dam, as far as I know.

The scientists dated the ‘lacustrine’ sediments with Be-10 (Balco et al., 2013). At several levels in the core, they found Be-10 concentrations that ranged from 1.12×10^5 atoms/gm at 112.7 m (370 ft.) to 3.42×10^5 atoms/gm at 243.6 m (800 ft.) depth down the core. Based on these concentrations, uniformitarian scientists derived dates of 0.71 to 1.69 Ma.

Granite inselbergs in Southern Australia

Granite inselbergs in Southern Australia are believed to be very slowly eroding, as slow as 0.6 m/Ma (Bierman and Turner,

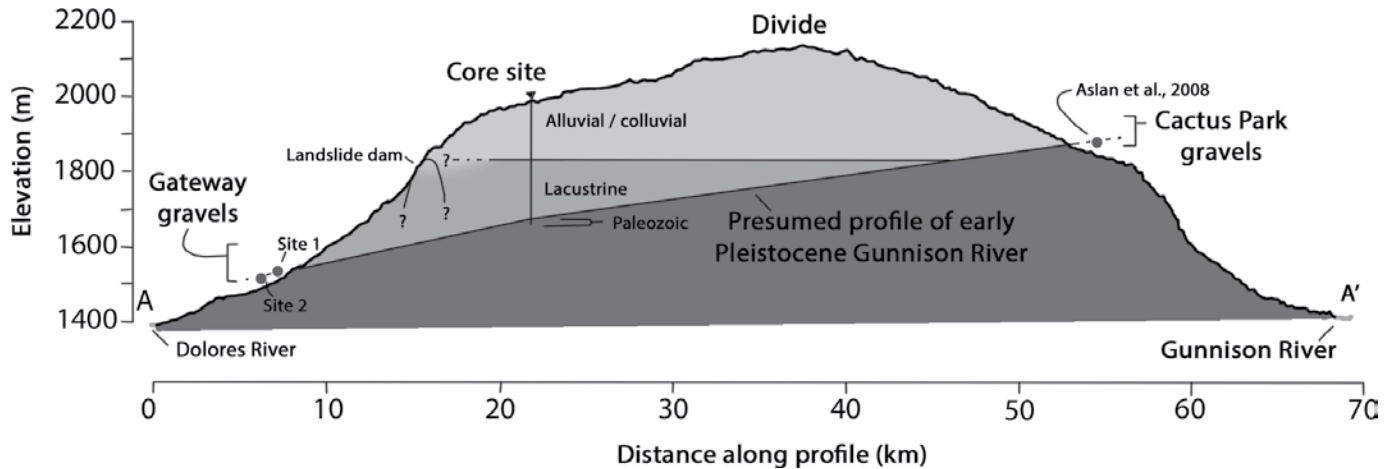


Figure 4. Longitudinal Unaweep Canyon profile (from Balco et al., 2013, p. 150, Figure 2, used in accordance with federal copyright (fair use doctrine) law. Usage by CRSQ does not imply endorsement of copyright holder). The mountains around the wind gap are not shown.

1995). Be-10 values on these inselbergs range from 0.71 to 4.43×10^6 atoms/gm for minimum uniformitarian ages of 114 to 628 ka. For uniformitarian ages this old, the decay of Be-10 must be taken into account. The figures are minimums because a little erosion would have already taken place between the time of formation and today.

Hickory Run boulder field

Numerous boulder fields worldwide have been dated with an age range of 70–600 ka. For instance, Hickory Run boulder field in east-central Pennsylvania in the northern Appalachian Mountains, the largest in North America, is 120 by 550 m (400 by 1,800 ft.) (Figure 5). These sandstone and conglomerate boulders are large, less than 1 m (3.25 ft.) to more than 10 m (32.5 ft.) in long axis. The secular scientists dated the boulders that they assumed have not moved for a long time and whose tops were assumed not to be significantly eroded. The boulders have a Be-10 accumulation of 0.44 to 3.26×10^6 atoms/gm equivalent of 70 to 600 ka of surface exposure (Deen et al., 2017). The vari-



Figure 5. Hickory Run boulder field, east-central Pennsylvania (Mtruch, Wikimedia Commons CC-BY-SA-3.0 mitigated). Note the people in the background for scale.

ability is attributed to boulders moving and flipping. The production rate for that altitude and latitude is believed to be about 6 atoms/gm/yr.

Beryllium-10 in bedrock below the Greenland Ice Sheet

Just recently scientists dated 1.55 m of granite bedrock penetrated by the

GISP2 ice core drilled at the top of the Greenland Ice Sheet (Schaefer et al., 2016). The scientists applied the Be-10 method and discovered that the Be-10 bedrock concentration varied from 9,800 atoms/gm at 1.55 m to 24,800 atoms/gm at the surface. The researchers assumed a production rate of 4.1 atoms/gm/yr. at the latitude of GISP2. If there was no rock or soil above the current bedrock surface, the age would be 6,049 years. Erosion of bedrock and/or soil may have occurred during exposure, so that the measurements represent Be-10 occurring at depth. Although there are various scenarios, the researchers assumed the best fit of the data meant that 1.3 meters of rock or 1.7 m of soil had been eroded. Thus, the secular scientists came up with an age of exposure of 280 ka for the current bedrock surface. So, the current top of the bedrock was not the original surface, and it would have received much fewer cosmic rays.

It is interesting that these results are causing controversy among uniformitarians. Climate models have shown that the Greenland Ice Sheet should have existed throughout the whole Quaternary, for more than 2.6 Ma (Schaefer et al., 2016). Because of their age of 280 ka at the bottom of the ice sheet, it means that the ice sheet must have been totally or almost totally melted, for a total length of time of at least 280 ka during the past 2.6 million years. They think that since exposure is additive, this 280 ka of Be-10 exposure could have come in 10,000-year increments during the numerous 'interglacials.'

Furthermore, Camp century may also have been ice-free 400 kyr. ago (Voosen, 2019), but should have been ice covered for 2.6 Ma, according to climate models. DNA at the bottom of several ice cores came from plants that would thrive with summer temperatures averaging 10°C.

The scientists of course have related this result to global warming by claiming that since the Greenland Ice Sheet

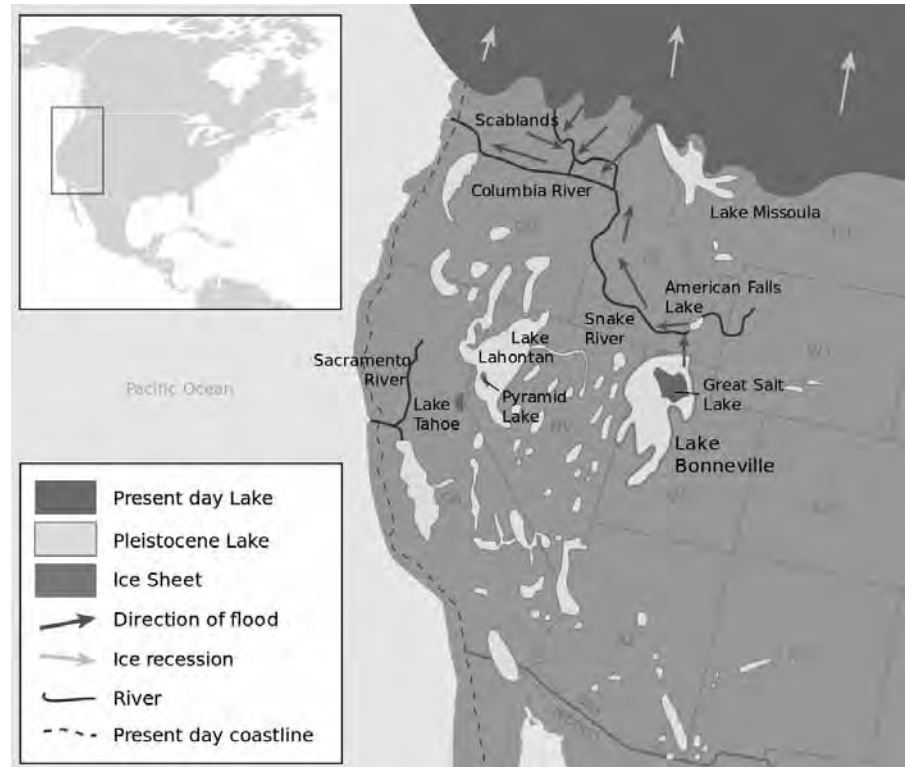


Figure 6. Ice Age lakes in the western United States, including glacial Lake Missoula in western Montana. The arrows show the path of the Bonneville flood and the later Lake Missoula flood (Fallschirmjäger, Wikimedia Commons CC-BY-SA-3.0).

melted during presumed, previous interglacials, it can melt today (Voosen, 2019), reinforcing global warming hysteria.

Be-10 associated with the Bonneville flood

Based on C-14, the Bonneville shoreline of pluvial Lake Bonneville in Utah is believed to be 18.5 ka old and the Provo shoreline 18.5 to about 15 ka old due to a long stillstand at the Provo level after the Bonneville flood (Lifton et al, 2015). Lake Bonneville at its maximum depth was about 350 m (1,150 ft.) deep, compared with 3.7 m (12 ft.) average depth today (Figure 6). It was 12 times larger than the Great Salt Lake. Uniformitarian scientists have difficulty explaining the filling of this pluvial lake. When the lake rose to the level of a wind

gap in southeast Idaho, the Bonneville flood happened. It lasted about 8 weeks (O'Connor, 1993) causing pluvial Lake Bonneville to drop about 100 m (330 ft.) from the Bonneville to the Provo shoreline. By assuming the carbon-14 date of 18.3 ka for the two shorelines, and the measured amount of Be-10 of 2.75×10^5 atoms/gm at Promontory Point, they calculated a production rate of 15.1 atoms/gm/yr. They recognize some shielding due to its mid latitude location and higher production at an altitude of about 1,280 m (4,200 ft.). However, according to the rule of 1% more Be-10 per 10 m altitude increase, the production rate should have been about 128% of the sea level production at this latitude, which is in the neighborhood of about 3 atoms/gm/yr. The production



Figure 7. A striated and polished granite surface from the glaciation in the Sierra Nevada Mountains.

rate should have been about 6.8 atoms/gm, if this rule of thumb applies to this altitude. Regardless, the uniformitarian procedures are crude at best.

Dating boulders from a moraine in the Scottish Highlands

Boulders, assumed to be continuously exposed since deglaciation in a glacial moraine in the Scottish Highlands, were measured for Be-10, which turned out to be 6.93×10^4 atoms/gm (Putnam et al., 2019). Based on C-14 dates of organic matter associated with the moraine, they arrived at a date of 12,480 BP for the moraine. Thus, the Be-10 production rate turned out to be 5.50 atoms/gm/yr. at the altitude of 320 m (1,050 ft.). For sea level, the production rate was estimated at 3.95 atoms/gm/yr. The rule of thumb works out well in this situation.

Sierra Nevada glaciation measurements

Many Be-10 dates have been measured on glaciated Sierra Nevada granite sur-

faces and moraine boulders. Nishiizumi et al., (1989) were probably the first to measure Be-10 on glacially polished rocks (Figure 7) to calibrate production rates with measurements on this 'known' age surface, based on their assumed ice age paradigm (Gosse and Phillips, 2001). It was assumed that Be-10 started at zero when the ice melted, and no erosion has occurred since then, which is reasonable since the surface is still polished and striated. They measured Be-10 at about 5.0×10^5 atoms/gm. Based on the 'age' of deglaciation of about 11,000 years BP, they estimated a production rate at that altitude of 3,340 m (10,950 ft.) of about 60 atoms/gm/yr. Lal (1991) also calibrated his well-used global production rates to these Sierra Nevada surfaces: "Accurate estimations of production rates are generally not possible because of lack of knowledge of the probabilities of formation of nuclides in the different reactions" (Lal, 1991, p. 25). This is one reason why they do not use physics to directly calculate the production rates.

Using the rule of thumb and a sea level production rate of 3 atoms/gm/yr. results in a production rate of only 13 atoms/gm/yr. at the high altitude of the Sierra Mountains. Something seems wrong with their assumptions, the rule of thumb, or both.

Creation Science Explanation

Creation scientists have a lot of research to do when it comes to Quaternary dating methods. We also have several extra complications to consider when examining and translating Be-10 concentrations on a surface into the Biblical timeframe (Table I).

Four complicating variables

In translating the raw bedrock measurements, creation scientists have four major complicating variables. The uniformitarian scientists infer a production rate based on an assumed age, but ages in Biblical Earth history are much younger. To find a production rate in Biblical Earth history, we must adjust for Biblical ages. Since, the Sierra Nevada Mountains are complicated by high elevations, I will use the low-altitude Scottish moraine to adjust the production rate based on Biblical ages. Deglaciation and exposure of this site in Scotland likely occurred at about 4,000 BP. This compares to the uniformitarian age of 12,480 BP. This is about three times the Biblical age, suggesting the production rate in the Biblical timescale would be roughly three times that of the secular timescale. We can probably apply this correction factor worldwide for all the measurements. This is the first complicating variable in transforming measured values of Be-10 into the Biblical timeframe (Table I).

But even at three times today's production rate, Be-10 measurements are still usually calculated to be much older than the Biblical timescale, especially those of Hickory Run boulder field and the Australian inselberg. There seems

Table I. The effects of four variables that must be considered in translating Be-10 concentration measurements from uniformitarian sources into the Biblical time scale.

Variable	Effects on Be-10 production rate in Biblical timescale
1. Uniformitarian production rates	Production rate at surface increased by three times.
2. Accelerated radiometric decay	Unknown but will assume small
3. Geomagnetic quadrupole and/or non-dipole field	Decreased production at high latitude and increased production at lower latitudes. Effect likely small
4. Oscillating magnetic field	Increase production rate, mostly at lower latitudes

to be only one way to explain such old dates within Biblical history, and that is by assuming *cosmic rays were much greater during the Flood and Ice Age*.

A second complicating factor is that the Al-26/Be-10 ratio turns out less than its present-day formation ratio of about seven, because there should not have been enough time in 4,500 years for this ratio to measurably change. But, secular scientists find values around three or four. Such a ratio implies hundreds of thousands to a few million years of age. This means that *much accelerated radiometric decay has taken place after the Flood*. Snelling (2005) found very few radiohaloes in Tertiary-aged granites, interpreted as post-Flood, suggesting that accelerated radiometric decay had ended. But this result could be due to the lack of enough radioactive nuclides settling in one precise spot to form a halo, since halos first appear after 10^8 atoms have collected in that one spot. Besides, the Tertiary likely is mostly from the Flood (Oard, 2014). Therefore, *accelerated radiometric decay continued for a while after the Flood* (Table I).

Such accelerated radiometric decay has two implications for Be-10 dating. It

means the measurements of the amount of Be-10 and Al-26 have been decreased compared to what they would have been in the absence of accelerated decay. However, it is possible that accelerated radiometric decay is less for low atomic number nuclides (Vardiman et al., 2005). On the other hand, accelerated radiometric decay could cause an increase in these isotopes, because of an increase in neutrons from the rapid fission of ^{238}U and the alpha decay of ^{235}U , ^{238}U , and ^{232}Th (Heisinger et al., 2002). It is the neutrons that mostly cause in situ Be-10 and Al-26. It is difficult to know the outcome of these two competing processes for cosmogenic nuclide dating. It could be they cancel each other and the net effect would be small.

A third modification that must be considered is that cosmogenic nuclide measurements assume a geomagnetic axial dipole field, but secular scientists often recognize a significant non-dipole contribution of 10 to 25% (Dunai, 2001). These non-dipole contributions could be because the Earth could have had a quadrupole pattern for a while after the Flood (Humphreys, personal communication, 2020) (Figure 8).

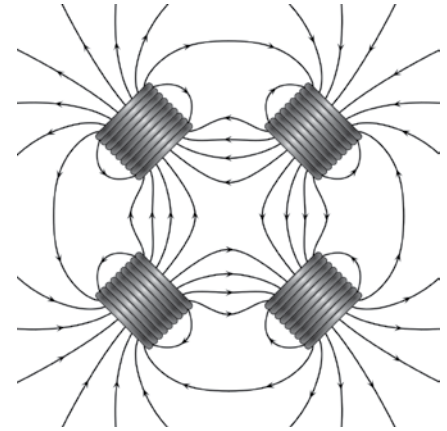


Figure 8. Quadrupole magnetic field generated by four coils (Geek3, Wikimedia Commons CC-BY-SA-3.0).

Since a dipole field has no effect poleward beyond about 60° latitude and about a 50% reduction at the equator, a more complicated field would tend to even out the geomagnetic shielding. There would be fewer cosmic rays beyond 60° latitude and more south of 60° (Table I). We don't know the net effect of these more complicated magnetic fields, but since the difference between shielding at polar locations and the equator is only 50%, the effect is probably small.

A fourth modifying effect on cosmogenic production rates is that the magnetic field oscillated between north and south polarity for some time after the Flood (Humphreys and De Spain, 2016). During reversals the geomagnetic field would have been low intensity. More cosmic rays would penetrate the surface of the Earth at low to mid latitude. But since reversals in the Biblical timescale were quick, the net effect likely was small (Table I).

Because of these variables, it seems impossible to translate the measurements on surfaces, or in the case of Unaweep Canyon in sediments, into Biblical Earth history. Therefore, I will

give some rough qualitative estimates using the examples above and assuming variables 2 through 4 are small. Thus, the uniformitarian estimated production rate, assumed to be the same as today for millions of years, will be multiplied by a factor of three.

Unaweep Canyon formed during the Flood

Within the Flood model, Unaweep Canyon is a wind gap (Oard, 2014) and abandonment of the canyon cutting likely occurred when the Floodwater was still high and was diverted from cutting the Unaweep wind gap deeper by flowing north through Grand Valley and around the north end of the Uncompahgre Mountains. It is likely that as this happened, the flow through Unaweep Canyon became sluggish and fine-grained sediments were deposited. A landslide dam is not needed. Then, alluvial/colluvial sediments filled on top of the fine-grained sediments within the canyon as the water level declined. When driving through this amazing wind gap, it is impossible to tell that the fill below the pass (Figure 3) is 350 m (1,150 ft.) thick.

It is difficult to interpret the Be-10 results within Biblical Earth history. The fine-grained sediments have been buried since the end of the Flood and would not accumulate any significant Be-10 in the post-Flood period. Then how did this sediment gain such high concentrations of Be-10?

One way would be if the sediments were at or near the surface during the pre-Flood or Flood period and then were eroded or re-eroded ending up as canyon fill in the Unaweep Canyon. The Be-10 concentrations would imply a very large flux of cosmic rays. Another possibility is that abundant accelerated radiometric decay of uranium and thorium and the fission of ^{238}U during the Flood caused the high values of Be-10. It would appear that a large flux of cosmic rays occurred during the Flood.

Australian Inselbergs

The values of Be-10 of quartz on southern Australian inselbergs vary from 0.71 to 4.43×10^6 atoms/gm. These are considered minimums by secular scientists, since they believe these inselbergs are millions of years old and would have experienced variable, but slow erosion with much radiometric decay. Inselbergs are Flood features (Oard, 2014), and erosion since the end of the Flood 4,500 years ago would have been slight. Thus, the secular values should be a reasonably good estimate since the end of the Flood.

The estimated production rate for this middle latitude site is about 3 atoms/gm/yr. at sea level, interpolating between 4 atoms/gm/yr. for high latitudes and 2 atoms/gm/yr. at the equator (Young et al., 2013; Blard et al., 2019). I will take the top of Yarwondutta Rock at 190 m (625 ft.) for my calculation within the Biblical timescale. At a 1% increase in production rate for every 10 m, the production rate would be 19% more than at sea level, or about 3.57 atoms/gm/yr. (Stone, 2000).

Multiplying the production rate by three and applying this production rate for 4,500 years since the Flood would have produced a concentration since the Flood of only 4.8×10^4 atoms/gm, assuming cosmic rays have not changed with time. The measurement for this rock is 3.57×10^6 atoms/gm. This is 74 times the expected concentration, indicating a high flux of cosmic rays since the end of the Flood.

Hickory Run Boulder Field

The Hickory Run boulder field was likely formed at the end of Flood runoff. Be-10 concentrations range widely on the boulders from 0.44 to 3.26×10^6 atoms/gm. This suggests that some, or maybe all, boulders have rotated (or flipped) within the last 4,500 years. The higher value is more representative, but still a minimum since even all boulders may have turned and a little weathering

has occurred in 4,500 years. This boulder field is in east-central Pennsylvania, USA, where freeze-thaw weathering and relatively high precipitation occurs. The present-day production rate was estimated by secular scientists at about 6.3 atoms/gm/yr. for this latitude and altitude. If we multiply this rate by three for 4,500 years of post-Flood exposure, we should have a Be-10 concentration of about 8.5×10^4 atoms/gm. The highest secular value is 38 times the expected Biblical value, implying roughly 38 times the amount of cosmic rays bombarded of the Earth since 4,500 years ago.

The Greenland Ice Sheet Production Rate

In the Biblical Ice Age model, Greenland would have been surrounded by warm ocean water and isostatically uplifted due to lack of an ice sheet (Oard, 2004a). So, the Greenland Ice Sheet would develop slowly. This fits with Greenland having plants at low elevations early in the Ice Age with relatively warm temperatures, while the mountains were starting to collect snow (Oard, 2004a, 2005). It would have begun in the eastern mountains within 50 years (Figure 9), the eastern and western mountains in 100 years (Figure 10), and much of Greenland by 200 years (Figure 11). The location where the GISP2 ice core was drilled was just west of the eastern mountains. So, the location would have been exposed for a while before glaciation. Only 10% of Greenland needs to be covered by ice and mainly in the eastern highlands for GISP2 to be exposed. Thus, it would probably take 100 to 200 years for this low-altitude, high-latitude location to be covered by ice. If we take the average of 150 years, GISP2 would have been covered since about 4,350 years BP. We assume no erosion and no surface sediments originally covered the location, and 24,800 atoms/gm of Be-10 were measured at the surface of the rock. The isostatic altitude correc-



Figure 9. Postulated snow and ice after 50 post-Flood years in the Northern Hemisphere (Drawn by Mrs. Melanie Richard).

tion of about 1,000 m higher right after the Flood (Oard, 2020a) would result in an isostatic corrected production rate of 8.2 atoms/gm/yr. If the production rate for Biblical Earth history (Table I) was three times the uniformitarian production rate for 150 years, there should

be 3,700 atoms/gm on the surface at today's rate. The surface measurement is 24,800 atoms/gm, 6.7 times the rate with Biblical assumptions and isostatic compensation.

However, it is likely that erosion occurred before glaciation. As a reasonable

first estimate, the secular researchers estimated 1.3 m of rock or 1.7 m of soil had been eroded before glaciation. With an e-folding depth of 60 cm in rock, the current bedrock would have received about 1/9th the in situ Be-10. So, we would have to multiply 24,800 atoms/



Figure 10. Postulated snow and ice after 100 post-Flood years in the Northern Hemisphere (Drawn by Mrs. Melanie Richard).



Figure 11. Postulated snow and ice after 200 post-Flood years in the Northern Hemisphere (drawn by Mrs. Melanie Richard). Notice that the Sierra Nevada Mountains are glaciated by 200 years after the Flood.

gm by nine and divide by 3,700 atoms/gm. The production of Be-10 is then 60 times the current rate, signifying a high flux of cosmic rays early in the Ice Age.

Lake Bonneville Production Rate

According to the Biblical Ice Age, the Lake Missoula flood occurred at the peak of the Ice Age about 4,000 BP (Oard, 2004b). The Bonneville flood broke just a little before the Lake Missoula flood, since the Missoula flood sediments overlie Bonneville flood sediments downstream in the Lewiston, Idaho, area. Therefore, we can date the Bonneville flood to about 450 years after the Flood, or 4,050 BP. Lake Bonneville and all the other pluvial lakes of the southwestern U.S., were first formed by ponded water during late Flood runoff. The lake levels continued to rise during heavy Ice Age precipitation and cool summer temperatures.

The secular production rate for Lake Bonneville shorelines at this relative

high-altitude location is estimated at 15.1 atoms/gm/yr. If there was three times as much production in the Biblical timescale, there should be 1.83×10^5 atoms/gm on the surface since 4,050 years ago, if there was no inheritance of Be-10 for 450 years. This compares to the measured amount of Be-10 of 2.75×10^5 atoms/gm at Promontory Point, which is only about 1.5 times the Biblical estimate. This value would be a maximum, since there could have been some inheritance before the shoreline formed. It looks like the production rate of Be-10 dropped off dramatically during the Ice Age.

Scottish moraine boulders

The British-Irish Ice Sheet would have developed about midway in the Ice Age, about 300 years after the Flood (Figure 12), starting with the northern mountains, the Scottish Highlands. This is because of onshore flow of warm, moist air early in the Ice Age (Oard, 2004a). The ice would then spread south after 300 years and to lower altitudes by the

end of the Ice Age at 500 years after the Flood. It probably took 100 years to melt the ice in the Scottish Highlands. However, we need to consider the low elevation of the Be-10 measurement, which melted by 550 years after the Flood or 3,950 BP. So, its total exposure time in the Biblical time scale would have been 3,950 years assuming no inheritance. The uniformitarian production rate was estimated at 5.5 atoms/gm/yr. for this latitude and altitude. Multiplying by three and 3,950 years, the Biblical accumulation would be 6.5×10^4 atoms/gm. The secular measurements gave 6.93×10^4 atoms/gm, close to the Biblical measurement. This result is close to that of the Sierra Nevada Mountains and suggests that the production rate was close to the present rate near the end of the Ice Age.

Sierra Nevada production rate

Secular scientists first estimated the production rate of Be-10 on striated pavements in the Sierra Nevada Mountains. Based on other 'age' indicators,



Figure 12. Postulated snow and ice after 300 post-Flood years in the Northern Hemisphere (drawn by Mrs. Melanie Richard). Note that the Scottish Highlands are glaciated by 300 years after the Flood.

the Biblical production rate would be three times the secular value. Because of the high altitude, the secular geologists estimated a production rate of 60 atoms/gm/year. However, for a mid-latitude sea level site, production would be 3 atoms/gm/yr., and if we increase production rates by 1% per 10 m, the uniformitarian production rate should be about 9 atoms/gm/yr. It could be that production rate value increases by more than 1% per 10 m as one goes higher up. Regardless, using the secular estimate of the production rate, we would estimate the production rate of 180 atoms/gm/yr. in the Biblical timescale. These surfaces may not have been glaciated until a little after 100 years after the Flood (Figure 10 and 11), and deglaciation likely was complete at this high altitude about 3,900 years ago. This would mean a total exposure of about 3,900 years if there is no inheritance and 4,000 years if there was inheritance. Thus, the concentration in the Biblical time scale would be

7.0×10^5 atoms/gm. The secular measurement of 5.5×10^5 atoms/gm is fairly close, indicating also there likely was no inheritance for the first 100 years after the Flood. Like the Scottish moraine, these glacial pavements indicate that cosmic rays were today's rates near the end of the Ice Age.

Further Implications

If all Be-10 concentrations were due to cosmic rays, then it appears that the production rate dropped rapidly during the Ice Age. This would imply that the cosmic rays were especially intense during the Flood. However, it is likely that some Be-10 was formed by accelerated radiometric decay, making a Flood estimate difficult. So, the best we can say from the in situ Be-10 measurements is that *cosmic rays were very high during the Flood and decreased rapidly during the Ice Age*. Such an increase in cosmic rays have a least four further implications.

Supernova explosion close to the Earth and accelerated radiometric decay

Since cosmic rays are believed to have been caused by supernovas, increased cosmic rays could be due to a supernova explosion, or more than one, relatively close to the Earth during the Flood. Reedy et al. (1983, p. 133) state: "Rare external events (nearby supernovae) or solar variations (a Maunder minimum) can cause short-term [cosmic ray] flux changes." This would support Chaffin's (2017, 2019) contention that a nearby supernova or supernovae could be a cause of accelerated radiometric decay.

Great increase in carbon-14 after the Flood

Since C-14 is caused by cosmic rays in the upper atmosphere and becomes spread through the carbon reservoirs, including the biosphere, increased cosmic rays would produce much more C-14 after the Flood.

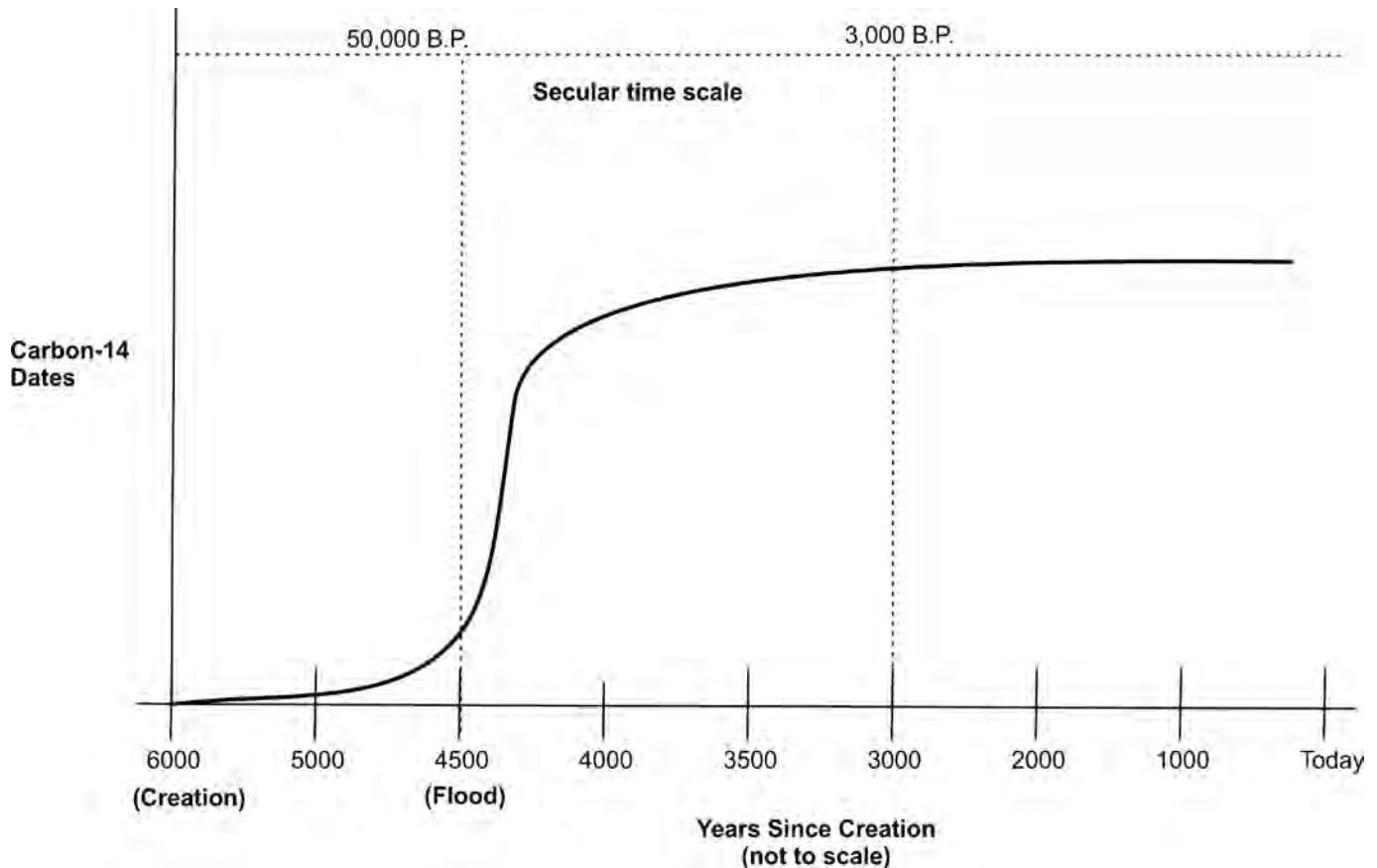


Figure 13. Estimated plot of the increase in carbon-14 dates with time since Creation based on the high cosmic-ray flux early in the Ice Age (plotted by John Reed).

It appears that carbon-14 dates are good for the past 3,000 years, but then 47,000 C-14 years needs to be telescoped into 1,500 years after the Flood (Figure 13) with the greatest increase early in the Ice Age. So, increased cosmic rays during the Flood tailing off early in the Ice Age can explain the telescoping of dates within the Biblical timescale.

Aardsma (1991) recognized that there was too much carbon-14 in the atmosphere, oceans, and biosphere for an Earth about 6,000 years old, but he assumed that the production rate of carbon-14 has been constant. Based on the carbon-14 inventory for the Earth, he pushed back the date of the Flood

to 14,000, plus or minus 7,000 years. He is no longer a young-Earth creation scientist as a result. However, based on this Be-10 research, increased cosmic rays during the Flood, dropping off during the Ice Age, can likely produce the current inventory of carbon-14 in about 6,000 years. This is an example of adding a new variable that changes a result considerably.

Other Quaternary dating systems can be telescoped to within Biblical Earth history

We can now deduce from at least the Al-26/Be-10 ratio being well below 7 that accelerated radiometric decay continued into the post-Flood period. Thus,

other Quaternary dating methods can potentially be telescoped into post-Flood time because of accelerated radiometric decay. For instance, U-series dating on speleothems, which gives dates as old as 500 kyr., can be explained. Contamination from ^{230}Th does not seem to be much of a problem, and the dates are usually consistent from the bottom (the oldest) of a stalagmite to the top (the youngest). Several characteristics of the Ice Age can explain the rapid growth of speleothems (Oard, 2020b,c). However, accelerated radiometric decay presents a problem of too much radiation during the Ice Age, as pointed out by Vardiman et al., 2005, pp. 764–765) for the occupants of the Ark.

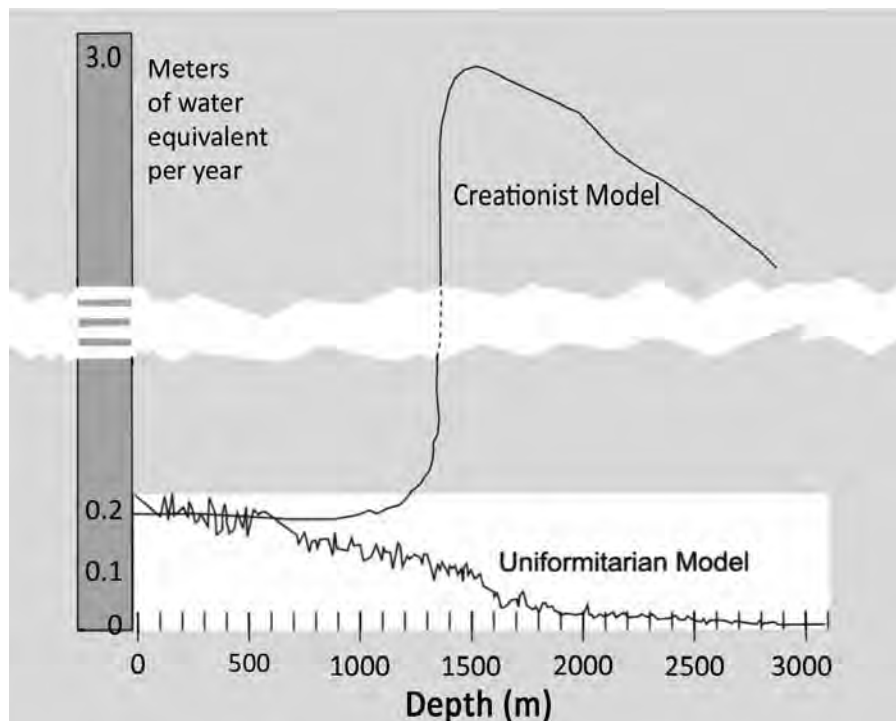


Figure 14. The thickness of annual ice layers down the GRIP ice core on central Greenland, calculated according to the uniformitarian model (from De Angelis et al., 1997, p. 26683) and a rough estimate of annual layers in the Biblical model.

Can explain atmospheric Be-10 in ice sheets

In the Biblical model for the Greenland and Antarctic Ice Sheets, the estimated accumulation rate could be around 3–10 m/yr. for the Ice Age portion of the ice cores, tailing off sharply after the Ice Age. The uniformitarian rate is around cm–mm/yr. (Figure 14). The secular atmospheric Be-10 measurements in the Greenland GRIP ice core show an increase from about $1\text{--}2 \times 10^4$ atoms/gm after the Ice Age to about $3\text{--}5 \times 10^4$ atoms/gm during the Ice Age (Yiou et al., 1997). Because the secular annual layer thickness is much less than the creation science annual layers, these values, especially during the Ice Age, would represent production rates that are much higher than today. This supports the deduction of much higher cosmic rays early in the Ice Age.

Conclusions

I have examined the amount of in situ Be-10 on quartz from Unaweep Canyon formed during the Flood, an inselberg, and several glacial surfaces. It appears that the amounts of cosmic rays that form Be-10 were much higher during the Flood and tailed off rapidly during the Ice Age. The increased cosmic rays have at least four implications. High cosmic rays could be due to a nearby supernova or supernovae during the Flood that may be a cause for accelerated radiometric decay during the Flood and Ice Age. Increased cosmic rays can account for the rapid increase in C-14 during the first 1,500 years after the Flood so that all post-Flood C-14 dates can be telescoped within 4,500 years of post-Flood time. I showed that because many Al-26/Be-10 ratios are less than the current value of around seven, there has

been accelerated radiometric decay after the Flood. Increased cosmic rays also allow us to telescope other Quaternary dating methods into 4,500 years. We can also account for the atmospheric Be-10 values measured in ice cores.

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