Cause of Large Post-Flood Jump in Earth's Carbon 14

D Russell Humphreys
Creation Research Society

Follow this and additional works at: https://digitalcommons.cedarville.edu/icc_proceedings

DigitalCommons@Cedarville provides a publication platform for fully open access journals, which means that all articles are available on the Internet to all users immediately upon publication. However, the opinions and sentiments expressed by the authors of articles published in our journals do not necessarily indicate the endorsement or reflect the views of DigitalCommons@Cedarville, the Centennial Library, or Cedarville University and its employees. The authors are solely responsible for the content of their work. Please address questions to dc@cedarville.edu.

Browse the contents of this volume of Proceedings of the International Conference on Creationism.

Recommended Citation
Humphreys, D Russell (2023) "Cause of Large Post-Flood Jump in Earth's Carbon 14," Proceedings of the International Conference on Creationism: Vol. 9, Article 16.
DOI: 10.15385/jpicc.2023.9.1.17
Available at: https://digitalcommons.cedarville.edu/icc_proceedings/vol9/iss1/16
D. Russell Humphreys, Creation Research Society, 8125 Elizabethton Lane, Chattanooga, TN 37421, drhumph@swcp.com

ABSTRACT

There is a need to have a large increase in Earth’s $^{14}$C/C ratio during the post-flood Ice Age (Oard, 2021a). Cosmic-ray-generated neutrons in the atmosphere produce most of the $^{14}$C, but today’s influx of extrasolar cosmic rays would take too long to build the radiocarbon inventory of Earth up to today’s level (Aardsma 1990). Ordinarily, the Sun does not emit particles of high enough energies, but it occasionally does so during bursts of solar activity. I propose that the same phenomenon which accelerated nuclear decay in the Solar System during the Genesis flood (Humphreys 2014) accelerated nuclear fusion in the Sun’s core during the flood year. The increased heat would increase solar activity greatly. That would cause the Sun to emit particles of high energies during the post-flood Ice Age, in enough quantity to produce the necessary jump in $^{14}$C/C. During the centuries afterward, full convection from core to surface would slow and stop, and energetic particle emission from the Sun would nearly stop, leaving extrasolar cosmic rays to generate more $^{14}$C at today’s low rate.

KEY WORDS

Carbon 14, cosmic rays, Sun’s interior, accelerated nuclear fusion, Ice Age.

INTRODUCTION

Creationists studying carbon-14 dating are generally aware of the need to have a large increase in Earth’s $^{14}$C/C ratio during the post-flood Ice Age (Oard 2021a), from about 0.5% of today’s ratio in fossils (Baumgardner 2005) to more than 90% of today’s ratio by the time of Moses, 1500 B.C. (Faure and Mensing 2005). Without such an increase, $^{14}$C ages from the post-flood Ice Age would stretch back tens of millennia earlier than the Biblical date for the flood. See the Conclusion section, particularly Fig. 9. Today, cosmic-ray-generated neutrons hitting $^{4}$N nuclei in the atmosphere produce most of the $^{14}$C. With today’s influx of extrasolar high-energy cosmic rays, it would take about 14,000 years to build the radiocarbon inventory of Earth up to today’s level (Aardsma 1990). That is of course much greater than the roughly 4,500 years the Hebrew-text Bible chronology (with no gaps) gives since the Genesis flood.

The energy of the cosmic rays (mainly protons) must be high, on the order of a GeV, in order to make the neutrons by blowing apart upper-air nuclei (Overholt et al. 2013). Cosmic rays of that energy are not affected strongly by the earth’s magnetic field, so even the large past variations in the field (Humphreys 1986) cannot be the main explanation for a great burst of high-energy cosmic rays during the Ice Age. Ordinarily the Sun does not emit particles with the necessary energy, but occasional bursts of solar activity appear to have caused jumps of several percent in the $^{14}$C/C ratio recorded in tree rings (Brehm et al. 2022).

I am proposing that during the post-flood Ice Age, the Sun emitted a pulse of high-energy protons in enough quantity to produce the necessary jump in $^{14}$C/C. If the pulse decayed exponentially with a thousand-year time constant, its initial intensity would have to be roughly six times more than today’s influx of extrasolar cosmic rays (Aardsma 1990, p. 13).

The cause of the Sun’s burst of energetic particles, I suggest, was the same phenomenon that accelerated nuclear decay in the Earth (Vardiman et al. 2005) and in the Solar System (Humphreys 2014) during the Genesis flood. A weakening of the strong nuclear force would make the nuclear radius larger, allowing increased tunneling through the coulomb barrier (Chaffin 2005). Tunneling can take place in both directions, outward and inward. The latter would increase the rate of nuclear fusion in the Sun’s core. Convection, now confined to the outer third of the Sun, would take place all the way from the core to the surface. That could increase the differential rotation in the upper layers (Kitchatinov 2005) and would increase the duration of the solar magnetic cycle (Humphreys 1990). In turn, that would wrap the Sun’s magnetic lines of force many more times around the Sun than happens in today’s sunspot cycle (Babcock 1961). That would greatly increase solar activity, including the emission of high-energy particles. During the centuries afterward, full convection from core to surface would slow down and stop, reverting to only the outer third. Then particle emission from the Sun would decrease in energy and intensity to today’s levels. I explain the above chain of events in more detail below.

ACCELERATED NUCLEAR FUSION IN THE SUN

The Radioisotopes and the Age of the Earth (RATE) research initiative (Vardiman et al. 2005) found multiple lines of evidence indicating that nuclear decay in the earth was accelerated by a factor of about half a billion during the year of the Genesis flood. I and others in the group felt that the acceleration had also occurred simultane-
ously throughout the Solar System, because of the evidence for similar large amounts of nuclear decay having occurred on other planets, the Moon, and in meteorites (Humphreys 2014). Early in the project, noting that “thermonuclear fusion is like α–decay in reverse,” I suggested that nuclear fusion may have been accelerated in the Sun and stars during the flood year. In turn, that would mean that “after the Flood cosmic ray bombardment of the earth may have been more intense than today, generating $^{14}$C in the earth’s atmosphere faster than now” (Humphreys 2000, p. 374).

Fig. 1 shows a typical potential “well” for α–particles in a heavy nucleus. It is a plot of an alpha particle’s potential energy versus radius out from the center of the nucleus (Humphreys 2000, p. 358). The slope of the well inside the peak potential gives the inward force on the particle, mainly due to the strong nuclear force. The slope of the well outside the peak gives the outward force on the particle, mainly due to the electric field. The highest energy α–particles in the nucleus bounce off the inner walls of the well back and forth repeatedly along the horizontal dashed line. Occasionally one of them will quantum-mechanically tunnel through the coulomb barrier at the edge and escape from the nucleus. Then the nucleus has decayed by emitting an alpha particle. The rate at which tunneling happens is very sensitive to the height and width of the barrier, in particular to the size of the yellow area shown in the figure.

It seems likely that God accelerated α–decay by weakening the nuclear force. Such a change would only affect the tiny regions in and around the nuclei of atoms; it would let processes outside the nuclei proceed unchanged. The weakening would increase the radius of the well, decrease its depth, and decrease the slope of the inside of the well. The yellow area of the barrier would decrease.

Fig. 2 shows the simplified case of a square well, with no rounding at the peak potential. For that case, the probability for the transmission of a particle is $\exp(-\gamma)$, where Evans (1955) gives $\gamma$ as:

$$\gamma \approx \frac{4Zzc}{137v} \left[ \arccos \left( \frac{T}{B} \right) - \sqrt{\frac{T}{B}} \sqrt{1 - \frac{T}{B}} \right]$$

(1)

Here $Z$ and $z$ are the atomic numbers of the nucleus and particle, respectively, $B$ and $T$ are the barrier height and particle kinetic energy, respectively, $v$ is the relative velocity of the particle and nucleus, and $c$ is the speed of light. In terms of the masses of the particle and nucleus, $m_1$ and $m_2$, the relative velocity $v$ is:

$$v = \sqrt{\frac{2T(m_1+m_2)}{m_1m_2}}$$

(2)

Chaffin (2005, pp. 529-533, Fig. 3) found that for alpha decay, eq. (1) should be modified by a factor which can change greatly for small changes in the nuclear radius. It has to do with an abrupt change in the resonant nodes of the quantum-mechanical wave function for an alpha particle in the nucleus. But for fusion, with particles going into nuclei from outside them, there should be no such resonance. So, during the year of the Flood, fusion processes would not have been accelerated nearly as much as alpha decay. Here is an estimate of the relative rates:

For fusion processes in the Sun’s core, the nuclei and the impinging particles are lighter than in alpha decay, being mostly nuclei of hydrogen, deuterium, tritium, helium 3, and helium 4. Barrier penetration goes from outside the nucleus to inside it. The energies of the penetrating particles are less, several keV instead of several MeV as for the case of alpha decay. Taking deuteron-deuteron fusion as an example, $Z = z = 1$ and $m_1 = m_2 = \text{mass of deuteron}$. In the solar core the temperature is about 15.5 million Kelvin (Allen 1981), giving us a mean kinetic energy of about 2.0 keV, amidst a Maxwellian distribution of lower and higher energies. Fig. 3 shows how the resulting probability of fusion for a single collision depends on the nuclear radius $R$. It suggests that fusion rates increased by a factor between 1 and 2, whereas alpha decay rates appear to have been roughly a half-billion times greater than normal (Vardiman et al. 2005).

The next section and following ones will constrain how much fusion took place during the flood year, and they will show the main consequences of the increase.

**CONVECTION IN THE SUN**

Fig. 4 shows a cross-section of the Sun today. The convection zone is
where a gas bubble can rise (or fall) far and rapidly due to being hotter, less dense, and more buoyant (or cooler, denser, and less buoyant) than its surroundings. Helioseismology, the study of the Sun’s vibrations, has determined the thickness today of the convection zone, \( l \), in Fig. 4, as 0.287 ± 0.003 of the solar radius (Phillips 1999, p. 97). In the convection zone, the temperature gradient (the change of temperature \( T \) with radius \( r \)) is slightly steeper than the adiabatic (no heat exchange) temperature gradient:

\[
\left. \frac{dT}{dr} \right|_{ad} = \left( \frac{\gamma-1}{\gamma} \right) \frac{\mu}{k} g
\]

where \( g \) is the local acceleration of gravity, \( g = \frac{Gm(r)}{r^2} \), \( m(r) \) is the mass within radius \( r \), \( G \) is Newton’s gravitational constant, \( \gamma \) is usually 5/3 (but nearer the surface it approaches 1), \( \mu \) is the average atomic mass of the solar plasma (counting free electrons), 0.61 a. m. u., and \( k \) is Boltzmann’s constant. (All the temperature gradients are negative, so I am using absolute values for clarity.) With the gradient of the medium slightly steeper than adiabatic, a rising and adiabatically expanding bubble will always find the surrounding gas slightly cooler than it, so it will continue to rise. For more details on these things, see Phillips (1999).

In the steady-state conditions of the Sun today, the temperature gradients in the core and radiation zone are shallower than the adiabatic gradient. That means a rising bubble expanding adiabatically will immediately find itself cooler and denser than its surroundings, and it will stop rising. In that zone, radiation transfers heat upward by diffusion with a flux \( J \) proportional to the temperature gradient:

\[
J = \frac{4\sigma c T^4}{3 \rho k} \left| \frac{dT}{dr} \right|
\]

where \( \sigma \) is the Stefan-Boltzmann constant, \( c \) is the speed of light, \( \rho \) is the mass density, and \( k \) is the opacity. This process is much slower than convection; heat generated in the core today would take about ten million years to rise to the bottom of the convection zone (Noyes 1982). From that height, convection bubbles carry heat upwards at more than several km/s (Stein and Nordlund 1998), reaching the surface in a day or less and making the granulation in Fig. 5. By setting the radiative temperature gradient of eq. (4) equal to the adiabatic temperature gradient of eq. (3), Phillips (1999, pp. 97-98) shows that there is a critical value of the power generated per unit mass in a core of radius \( r \):

\[
\left[ \frac{L(r)}{m(r)} \right]_{crit} = \left( \frac{\gamma-1}{\gamma} \right) \frac{16\pi Gc \rho}{k \kappa \rho}
\]

Above this value, convection must occur. \( L(r) \) is the power flowing out of the core (today equaling the luminosity at the Sun’s surface), \( m(r) \) is the mass of the core, \( P \) is the hydrostatic pressure, and the
radiation pressure is \( P_r = \sigma T^4 \). Phillips shows that the critical value for the Sun’s core today is 1.5 milliwatts per kg, whereas the estimated actual power generated is a bit less, 1.35 milliwatts per kg. So, if the actual power generated were increased by more than 11%, the core would become convective. Thus, my proposal is that during the flood the luminosity of the Sun increased by at least 11%. Later I will offer a reason to think that its luminosity gradually decreased during the Ice Age back down to today’s level.

Convection in the core would send bubbles of hotter gas up into the radiation zone. They would penetrate a short distance, then slow down and break up. That would heat up the penetrated region. Because the bubble temperatures would be adiabatic as they rise, the temperature gradient in the newly heated region would steepen to about the adiabatic gradient. The steeper gradient would allow the following bubbles to rise further into the zone and heat up a higher region, making its temperature gradient steeper to the adiabatic slope also, as Fig. 6 shows. In this way, the pulse of heat in the solar core during the year of the flood would travel rapidly (at convective speeds, km/s) to the surface and make the Sun fully convective. That is, the thickness of the convection zone, would become about 3.5 times larger, extending all the way from the center to the surface. Then heat could travel rapidly from the core to the surface in a matter of days.

**DIFFERENTIAL ROTATION IN THE SUN**

The Sun rotates faster at its equator than at higher latitudes (Howe 2009). The observed difference in angular velocity from pole to equator, \( \Delta \Omega \), is 3.0 degrees per earth day. The rotation period at medium latitude is about 27 days. In one year, the equator rotates 14.6 times, while the poles rotate only 11.6 times (Allen 1976, p. 180). So, every year, the equator rotates three more times than the poles. This differential rotation is very important to the Sun’s magnetic cycle, but how it happens is not well understood. It seems to result from turbulence in the convection, from eddies that add to the eastward flow of gas more near the equator than near the poles. Kitchatinov (2005, p.

Figure 6. Wave of convection rising through the diffusive radiation zone.

\[
\Delta \Omega \approx \left( \frac{2}{\delta} \right)^{1/2} \left( \frac{v}{\delta} \right)^{3/2}
\]

(6)

Apparently because turbulent fluid flows are still mostly a mystery, Kitchatinov gives no way to calculate \( \Delta \Omega \) from first principles, which leaves us not knowing how that ratio would have changed when the Sun went fully convective. If conservation of angular momentum is involved, the larger value of \( l \) could mean that \( v \) was larger. But \( \delta \) may have increased also. I am assuming that the differential rotation was either about the same as now, or somewhat faster.

**INCREASE IN MAGNETIC ACTIVITY OF THE SUN**

Fig. 7 shows how the differential rotation affects the Sun’s magnetic field, according to a well-known theory by Babcock (1961), supported by spectroscopic observations of the magnetic field in the gas at the surface. The observations show that the Sun reverses the polarity.
of its overall magnetic field every eleven years, in synchronism with its sunspot cycle. When the number of sunspots is at a minimum, the observed field is mainly dipolar, with the magnetic lines of force going mainly north and south. Then the strength of the north-south part of the field starts to diminish, the number of sunspots begins to increase, and an east-west part of the field begins to appear. Magnetohydrodynamics (Jackson 1975) explains that the electrically conductive ionized gas in the Sun sweeps the lines of force eastward as the differential rotation pulls the gas eastward (Shercliff 1965). The magnetic field intensity, $B$, increases as the lines of force are bunched together, and the tension (Jackson 1975, p. 474-475, eqs. 10.21 and 10.22) and energy in them increases as $B^2$, very much like rubber bands being stretched. It appears that turbulent roiling of the ionized gas around the east-west lines of force twists them, like stretched rubber bands being wound up. Tight enough winding produces kinking, with loops of magnetic field lines erupting out of the photosphere. Sunspots appear at the bases of such loops. Overlapping lines of force in opposite directions produce magnetic reconnections, where the lines break and form new shapes, propelling plasma violently in several directions (Biskamp 1993).

As the east-west magnetic field intensity increases, the tangling, writhing, and breaking of the lines of force increases in proportion to the square of the magnetic field intensity. This greatly increases solar activity, such as sunspots, flares, coronal mass ejections, solar wind, and, of particular importance here, energetic particle emission, i.e., energetic cosmic rays leading to $^{14}$C production. In about 5.5 years, the north-south component has diminished to zero, the number of sunspots is at a maximum, and the east-west lines of force have been wound around the Sun like a ball of twine, about fifteen times. The field intensity in the east-west part is thus about 15 times the original north-south intensity (Humphreys 2013).

Then things begin to happen in reverse. A south-north part of the field appears, in the opposite direction of its predecessor. The number of sunspots begins to diminish, and the east-west part of the field begins to unwind. After another 5.5 years, the number of sunspots is at a minimum, the east-west component has disappeared, and the field again has a dipole shape, just as it did eleven years previously. Now, however, the north and south poles of the field have switched places. In another 11 years the field reverses again, making a total of 22 years for the complete cycle.

As far as I can tell, if the Sun today had no differential rotation, its magnetic field would be nearly dipolar throughout its cycle, reversing itself every eleven years. It would be very much like the earth’s field when it was reversing itself during the year of the Genesis flood. According to the theory I proposed for the physical mechanism for the earth’s reversals, the controlling factor for the period of the reversals was the thickness of the convection layer, which I am calling $l$ here (Humphreys 1990, p. 9, eq. (16)). The period of the reversals would be proportional to $l$, and inversely proportional to convection velocities.

Assuming that convection velocities were not changed much, then if $l$ in the Sun after the flood was 3.5 times greater than now, it would take 3.5 times longer for a reversal to go through its cycle. The half-period would have been nearly 40 years instead of the 11 years it is now. Differential rotation would have more time to wrap up lines of force more tightly. If differential rotation then were at the same rate as now, it would have wrapped the lines of force 3.5 more times around the Sun than occurs now. The magnetic tension and energy in the lines would have been about 12 times greater than at the peak of the sunspot cycle now. If the differential rotation were faster than now, the tension and energy would have been even greater. So solar activity, particularly emission of high-energy protons, would have been much more than now. Fig. 8 shows a spectacular example of

**Figure 8.** Coronal mass ejection.
solar activity, a coronal mass ejection.

**EFFECTS AND DURATION OF ENHANCED LUMINOSITY**

During the Ice Age, the climate was quite different. The oceans were warmer and evaporating much more water (Oard 1986), so there was more rain, and cloudy weather (Vardiman 2013). Clouds are very efficient in reflecting light, as are glacial ice and volcanic dust, so the earth’s albedo (percentage of sunlight reflected back into space) must have been greater than the 30% it now is (Goode et al. 2001).

Having the Sun be more luminous would have been compensated for by the greater albedo, leaving the average temperature of the earth roughly the same, which apparently was what God intended.

In the Ice Age, the weather oscillated between sunny/warm and cloudy/cool/rainy many times during the year (Oard 2021b). The brighter sunlight, plus warmth and wet ground, would have accelerated tree growth in the first phase of a sunny period. A dry spell in the last phase would slow growth. The two phases would produce a tree ring (Lammerts 1983), which the following cloudy and cool period of little growth would accentuate. The 14,000-ring history that dendrochronologists have put together from living and dead trees (Van der Plicht et al. 2020) indicates that the weather oscillations stimulated an average of about nine additional rings per year during the first thousand years after the flood, about one ring every five weeks.

The Sun’s contribution to this God-designed period of extraordinary plant growth would have come to an end when its luminosity diminished to the normal level, presumably near the end of the Ice Age. Could the Sun have cooled naturally, during the full-convection period, enough to have restored it to its present condition? It looks like the answer is “no.” If we divide the amount of heat in the Sun by its present luminosity, we get the rate of decrease in the average temperature (several million Kelvin) as about 300 Kelvin per millennium. That is not enough. I suggest that God cooled the Sun by its great albedo, leaving the average temperature of the earth roughly the same, which apparently was what God intended.

**CONCLUSION: EFFECTS ON CARBON 14 DATING**

Fig. 9 shows the quantities we need to understand how the step of a creature’s death is calculated. The conventionally used calibration curve \( B(t) \), the dashed green line in Fig. 9, gives the amount of \( ^{14}C/C \) we would need to have in the air to get \( T \) to agree with the uniformitarian tree-ring chronology, which assumes only one tree ring formed every year. \( B(t) \) differs from the horizontal black dashed line, today’s ratio, by an amount called \( \delta^{14}C/C \). I am ignoring all the fluctuations in \( B(t) \) and simply approximating it as an exponential with a small rate constant \( \beta \). To match the uniformitarian calibration curve, a \( \beta \) of about 1/70,000 years works well. Writing \( B \) in terms of \( T \) gives us:

\[
B(T) = A(p) e^{\beta(p-T)}
\]  

(9)

Using (9) to express \( B(T) \), \( C(p) \) is related to \( T \) by an exponential decay with rate constant \( \lambda \), shown by the dashed red curve in Fig. 9:

\[
C(p) = A(p) e^{-\lambda(p-T)} e^{-\beta(p-T)}
\]  

(10)

Equating the right-hand sides of eqs. (8) and (10) gives us a relation between \( t \) and \( x = t - T \), the excess age of the uniformitarian date:

\[
x = \frac{-1}{\lambda - \beta} \ln[1 - e^{-\alpha(t-f)}] + \frac{\beta}{\lambda - \beta} (p - t)
\]  

(11)

Notice that when \( t \) approaches \( f \), the excess age \( x \) becomes large. For example, a tree that died a hundred years after the flood would give an excess age of about 17,400 years. So, ignoring the large step in \(^{14}C/C \) that occurred in the Ice Age, plus assuming only one tree ring per year, results in large errors in radiocarbon ages.
The sensitivity of $x$ to small values of $t - f$ comes from the argument of the logarithm in eq. (11), the dependence I arbitrarily assumed in eq. (7). To be more general, let us replace the argument with a not-yet-known function, $F(t)$, so that in eq. (11), $[1 - e^{-(t-f)/p}]$ becomes $F(t)$. $F(t)$ would resemble eq. (7) in its large-scale features, such as rising monotonically from near zero in the region of $t = f$ and approaching 1.0 at $t = p$. The slope of the $^{14}$C/$^{12}$C ratio in the last millennium has been positive and non-zero due to extrasolar cosmic rays, so $F(t)$ should account for that also. To account for the $^{14}$C/$^{12}$C ratio shown in fossils (see Introduction), $F(f)$ should be on the order of 0.005. That value would give an excess age $x$ of a little over 50,000 years for samples of real age 4,500 years. For half that value, $F(f) = 0.0025$, the uniformitarian age (the excess age plus real age) would be about 60,000 years.

$F(t)$ should also include a series of small, smooth steps upward after time $f$ due to the solar magnetic cycles. The width of each step would be the half-period of the cycle at the corresponding time. I have estimated the half-period as about 40 years (not 11 years as now), but it may have varied considerably from that for the first few cycles. The resulting value of the excess age will depend greatly on the exact details of $F(t)$ in those centuries. Future research should concentrate on determining $F(t)$ better.

REFERENCES


Baumgardner, J.R. 2005. $^{14}$C evidence for a recent global flood. In L. Vardiman, A.A. Snelling, and E.F. Chaffin (editors), Radioisotopes and the Age of the Earth: Results of a Young-Earth Creationist Research Initiative, vol. 2, p. 595, Fig. 3(b). El Cajon, California: Institute for Creation Research; Chino Valley, Arizona: Creation Research Society.


Vardiman, L. 2013. Numerical simulations of winter storms, tropical cyclones, and Nor’easters during the Ice Age using the NCAWRF model with a warm ocean, Proceedings of the International Conference on Creationism: Vol. 7, Article 22.

APPENDIX (HELPFUL NOTES ON THE REFERENCES)

Aardsma, G.E. 1990. See https://digitalcommons.cedarville.edu/icc_proceedings/vol2/iss1/37/. Discussion by D. R. Humphreys on p. 13. Change the “1” in the first term of the equation to “exp (–λ t)”. That changes my estimate of $Q_0$ from 3.2 to about 6.

esp. Fig. 3, p. 579.

Baumgardner, J.R. 2005. See https://www.icr.org/i/pdf/technical/Carbon-14-Evidence-for-a-Recent-Global-Flood-and-a-Young-Earth.pdf. Multiply pMC numbers in Fig. 3(b) by 1.724 to get the percent of the ratio in modern carbon at the time of the flood.


Evans, R.D. 1955. Rewrite eq. (95) in terms of the fine structure constant, which I am taking as exactly 1/137. Evans’ $M$ is reduced mass, $m_1 m_2 / (m_1 + m_2)$, as in my eq. (2).

Humphreys, D.R. 1986. See https://digitalcommons.cedarville.edu/icc_proceedings/vol1/iss1/52/, pp. 118-121, for the fluctuations in the field after the flood. Also see p.116 for a description of the Sun’s magnetic cycle.

Humphreys, D.R. 1990. See https://digitalcommons.cedarville.edu/icc_proceedings/vol2/iss1/47/, pp. 134-136, Figs. 8-9, and eqs. (16) and (17).


Humphreys, D.R. 2013. See https://digitalcommons.cedarville.edu/icc_proceedings/vol7/iss1/9/.

Humphreys, D.R. 2014. See https://dl0.creation.com/articles/p098/c09866/j28_3_51-60.pdf.

Humphreys, D.R. 2018. See https://digitalcommons.cedarville.edu/icc_proceedings/vol8/iss1/21/.

Kitchatinov, L.L. 2010. See https://www.researchgate.net/publication/225174957_The_differential_rotation_of_stars. Put into eq. (48), p. 462, eq. (25) with his definitions of $\tau$ and $l$ in the first two lines below eq. (23). I have changed his notation, making $l \rightarrow \delta$ and $<u^2>^{1/2} \rightarrow v$.


Oard, M.J. 2021a. See https://www.creationresearch.org/much-greater-cosmic-rays-during-the-ice-age-and-before-featured-article, esp. Fig. 13, p. 44.


Phillips, A. C. 1999, p. 95. To get my eq. (1) from Phillips eq. (3.23), insert his eq. (3.25) and $(T/P) = (\mu/\rho k)$ from the ideal gas law.


Vardiman, L. 2013. See https://digitalcommons.cedarville.edu/icc_proceedings/vol7/iss1/22.

THE AUTHOR

D. Russell Humphreys has a Ph.D. in physics from Louisiana State University and is now retired after working 22 years as a physicist for Sandia National Laboratories in Albuquerque, New Mexico, USA. He is an author of Starlight and Time, Radioisotopes and the Age of the Earth, Earth’s Mysterious Magnetism, and numerous technical articles. He is a Fellow of the Creation Research Society and retired from its board of directors in 2019 after 26 years of service.