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A Review of Creation Research Regarding The Earth's Magnetic Field Along With A Thorough Statistical Analysis Of The Data And Suggestions For Future Research

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A REVIEW OF CREATION RESEARCH REGARDING THE EARTH'S MAGNETIC FIELD ALONG WITH A THOROUGH STATISTICAL ANALYSIS OF THE DATA AND SUGGESTIONS FOR FUTURE RESEARCH

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ABSTRACT

This paper updates Humphreys' (2002) compilation of energy in various components of the earth's magnetic field from 1900 to 2000. It extends Humphreys' curve fits from the period 1970-2000 to the full period covered by available data, 1900-2010, and it allows for possible sinusoidal components similar to the one Humphreys (2011) found in the dipole magnetic moment. This paper finds a sinusoidal component not only in the energy in the dipole component, but in energies in higher-order components as well.

INTRODUCTION

In 2011, Humphreys' analysis of the earth's magnetic field revealed a small oscillation in the dipole magnetic moment , superposed on a large exponential decay (Humphreys, 2011). In 2002 Humphreys had calculated the energy in various components from data covering 1900 to 2000. (Dipole energy should be proportional to the square of dipole moment, etc.) But not knowing about a sinusoidal component in dipole moment then, his curve fits used only an exponential decay and covered only the period 1970-2000. The purpose of this paper is to extend Humphreys' energy analysis into higher order spherical harmonics of the earth's magnetic fields, and extend the curve fits to the full period 1900-2010, looking for oscillations in those components.

The development of the ideas of the earth's magnetic field within a creationary context shows that creationists are doing good science. Good creation science is just as dynamic and changing as good secular science. Good science does model building that makes predictions that can be compared to observations. These models often get modified as more observations are compared to predictions. These models and the data also cause the scientist to ask new questions. Good creation science does all of these. A good example of this is the development of the creationist understanding of the earth's magnetic field over time.

The evolutionary models of the earth's magnetic field are based on the dynamo idea. The combined motions of the earth's rotation and the motion of the matter within the core and mantle produce the earth's magnetic field which is self-sustaining over billions of years.

The first attempt at a creation model for the earth's magnetic field was based on the work of Horace Lamb from the nineteenth century. This model was revived in the early years of the modern creation movement by Thomas Barnes (Barnes, 1971, 1973). This model has been called the Free Decay Theory.

The basics of the Free Decay Theory can be summarized by five basic ideas. First, the earth started with an initial value of net electric current deep inside the earth. Second, this electric current is what produces the earth's magnetic field. Third, this electric current encounters electric resistance as charge moves through earth materials. Fourth, this electric current decreases in strength due to this electric resistance. The reduced electrical energy from the current is dissipated as heat. Fifth, the weaker electric current then produces a weaker magnetic field. The magnetic dipole moment of the earth should then decrease exponentially with time.

Observations since the nineteenth century of the earth's dipole moment show a consistent decrease. The data shows a reasonable fit to an exponential decay with a half-life of around two thousand years. Creationists quickly realized the implications of this exponential decay. It has been claimed by creationists that tens of thousands of years ago, the power required to generate the magnetic field would melt the crust of the earth. They used this as evidence that the earth must be younger than tens of thousands of years old.

Evolutionists did not agree with this interpretation of the magnetic dipole moment evidence. One of the most vocal critics of the creationist interpretation was G. Brent Dalrymple. He claimed that the Free Decay Theory had problems because it only focused on the magnetic dipole moment (Dalrymple, 1983a, 1983b). The earth does have higher order magnetic field poles. Therefore, the Free Decay Theory was incomplete. He claimed that current decrease in the earth's dipole moment was offset by increasing higher order components. He also claimed that the reversals of the earth's magnetic field recorded in the rock data showed that the Free Decay Theory was incomplete. Therefore, projecting current trends of the magnetic dipole moment into the past are invalid.

Initially creationists responded to criticisms of the Free Decay Theory by claiming the alternative explanations were based on noisy data (Barnes, 1984).

D. Russell Humphreys began developing the Dynamic Decay Theory for a Creationist model of the earth's magnetic field (Humphreys, 1986, 1990). This was presented at the International Conference on Creationism in 1986 and further amplified at the International Conference on Creationism in 1990. Humphreys included evidence from archaeomagnetic data as well magnetic reversals in his model.

The basics of Humphreys model has five key components. First, the earth's magnetic field was produced by the initial electric currents that God put in place during the Creation week. Second, the earth's magnetic field decayed according to the Free Decay Theory until the Flood. Third, at the flood dynamic decay of the Earth's magnetic field took place. This dynamic decay is due to the motion of the mantle dragging current with it. Humphreys developed this ideas using magnetohydrodynamics. During the flood magnetic higher order components of the earth's magnetic field came into play. Fourth, after the Flood the earth's magnetic field fluctuated due to the interplay of the dipole and the higher order terms of the earth's magnetic field. As time went on the earth's magnetic field settled down to primarily dipole components around the time of Christ. Fifth, after the dipole component of the earth's magnetic field became dominant the earth's magnetic field behaved as the Free Decay Theory predicts.

The Dynamic Decay Theory predicts rapid magnetic reversals. This is an example of good science because scientific models change to accommodate new data. The Dynamic Decay Theory also predicts that the total magnetic energy of the earth is decreasing with time. In fact, the Dynamic Decay theory predicts an even younger earth than the Free Decay Theory

In the aforementioned article in the *Creation Research Society Quarterly* (2011) Dr. Humphreys used data from the International Geomagnetic Reference Field (IGRF-11) to examine more carefully the energy in the earth's magnetic field. He found the existence of a sinusoidal oscillation around the exponential decay in the dipole field.

This paper re-examines the historical data for the earth's magnetic field. First, this magnetic dipole moment trend with time is examined in more detail than has been published before. Curve fitting was done with linear, quadratic, and exponential fits. The fitted parameters are reported along with uncertainties in the fitted parameters. The root mean square error for each fit is reported as well. The purpose of the multiple fits was to examine whether the exponential decay fit that Creationists have used for many years is actually the best fit for the data. The half-life of the exponential decay is reported. The uncertainty in the half-life is also reported.

This paper extends the work of Humphreys' research using IGRF-11, using the same mathematical procedures that he used to analyze the IGRF-11 coefficients. Magnetic dipole energy is examined over time. Curve fitting was performed using linear, quadratic, and exponential fits.

METHOD

The IGRF-11 coefficients were downloaded as an Excel spreadsheet from the International Geomagnetic Reference Field website (IGRF-11, 2010). Then the energy of each harmonic was calculated using Equations 10 and 11 from Humphreys (2002).

$$E_n = \left(\frac{a}{b}\right)^{2n+1} \left(\frac{2\pi a^3}{\mu_o}\right)\left(\frac{n+1}{2n+1}\right) G_n^2 \tag{1}$$

and

$$G_n^2 = \sum_{m=0}^{n} \left[\left(g_n^m\right)^2 + \left(h_n^m\right)^2 \right] \tag{2}$$

where:

E_n	= the magnetic energy for the nth harmonic
a	= radius of the earth's surface
b	= radius of the earth's core
μ_o	= magnetic permeability of free space

g_n^m and h_n^m = Gauss coefficients for the nth harmonic

Notice that in eq. (1) the energy in each component is proportional to the sum of the squares of the Gauss coefficients (moments) for each component. Curves were then fitted to the magnetic energy vs. time graphs using Logger Pro 3.5 from Vernier Software and Technology (http://www.vernier.com/). This program also provides uncertainties of the fitted parameters. Root Mean Square Error, RMSE, was used to determine the goodness of fit. Linear and exponential fits were performed on all of the harmonic energies unless stated otherwise.

The fitted parameters were then used to determine other quantities, such as half-life, etc. The theory of propagation of errors was used to estimate the uncertainties of the calculated quantities.

The exponential function used for harmonics greater than dipole had the following form, $E = Ae^{Ct} + B$. The form used for the dipole data was $E = Ae^{Ct}$. This was to compare the dipole results with previous studies.

Once a good fit was found, a graph of the residuals was produced. A sinusoidal function was fitted to the residuals graph and the period of the oscillation was determined using the fitted parameters.

DATA AND ANALYSIS

Dipole Energy

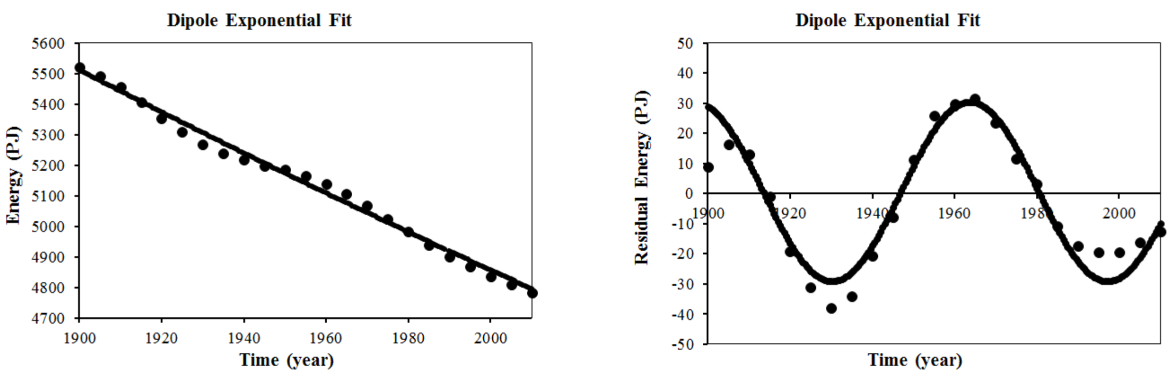


Figure 1. Dipole energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the exponential fit. The graph on the right shows the sinusoidal fit to the residuals from the exponential fit.

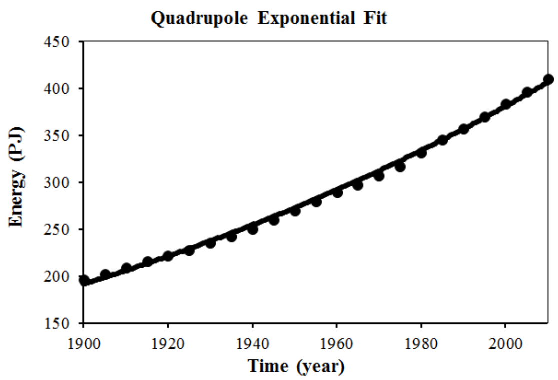
Figure 1 shows the trend of the dipole magnetic energy as a function of time. The linear fit and the corresponding sinusoidal fit to the residuals is very similar to the exponential fit.

A line or an exponential function fits the dipole energy data quite well. The root mean squared error for a linear fit is 21, while the root mean squared error for an exponential fit is 22. The statistical analysis cannot determine if the data should be described by a linear function or an exponential function. The results are consistent with the theory developed by Horace Lamb and advocated by Thomas Barnes.

The half-life of the dipole energy is 548±7 years. This result disagrees with Humphreys (2002) result of 437±11 years. The difference between the two analyses is probably for several reasons. First, Humphreys did not try to allow for a sinusoidal component. Second, Humphreys used data from 1970 to 2000, while this study uses data from 1900 to 2010.

The sinusoidal fit to the exponential residuals is a reasonable fit, as the root mean squared error was 5.3. The oscillation period is 67 ± 1 years. This result is consistent with Humphreys (2011) analysis. The residuals to the linear fit to the dipole energy also produced a good sinusoidal fit with an oscillation period of 64 ± 2 years, which is very close to the results from an exponential fit.

Quadrupole Energy



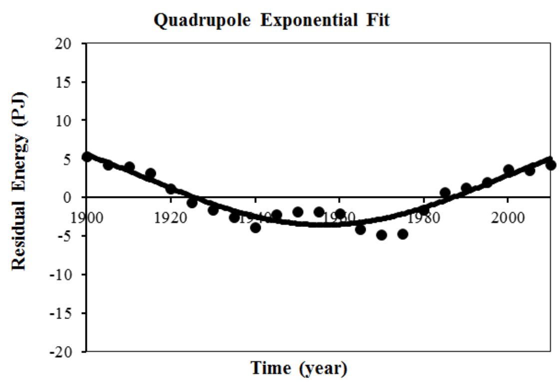


Figure 2. Quadrupole energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the exponential fit. The graph on the right shows the sinusoidal fit to the residuals from the exponential fit.

Figure 2 shows the trend of the quadrupole magnetic energy as a function of time. The linear fit and the corresponding sinusoidal fit to the residuals is very similar to the exponential fit. Consult Tables 1 and 2 for more details of the fits and the calculations based on the fits.

The exponential fit predicts that the quadrupole magnetic energy was zero at 1600 ± 200 AD. These results suggest that the quadrupole magnetic energy began building up only hundreds of years ago. Therefore, the quadrupole magnetic energy began increasing after the Genesis flood. This was not predicted from any creationist theory of the earth's magnetic field.

The residuals to the linear fit to the dipole energy also produced a good sinusoidal fit with an oscillation period of 260 ± 90 years, which is very close to the results from an exponential fit. The quadrupole oscillation has not been predicted but is thought to be consistent with the proposed mechanism Humphreys (2011) offered.

Octupole Energy

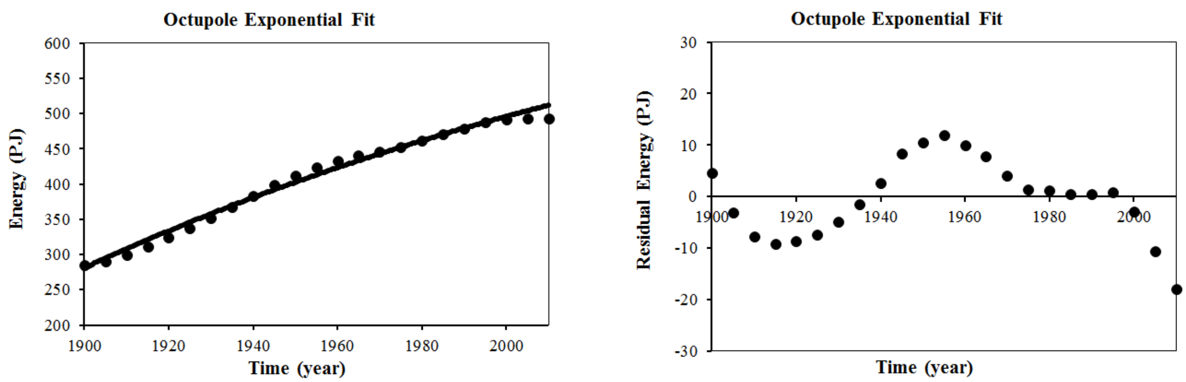


Figure 3. Octupole energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the exponential fit. The graph on the right shows the sinusoidal fit to the residuals from the exponential fit. The sinusoidal fit was performed on data from 1900 to 1990 AD.

The linear fit and the corresponding sinusoidal fit to the residuals is very similar to the exponential fit.

It was difficult to obtain a sinusoidal fit to the residuals when using the full range of data. This was true for both linear and exponential functions. Sinusoidal fits were performed using data from 1900 to 1990 AD. Consult Tables 1 and 2 for more details of the fits and the calculations based on the fits.

4th Harmonic Energy

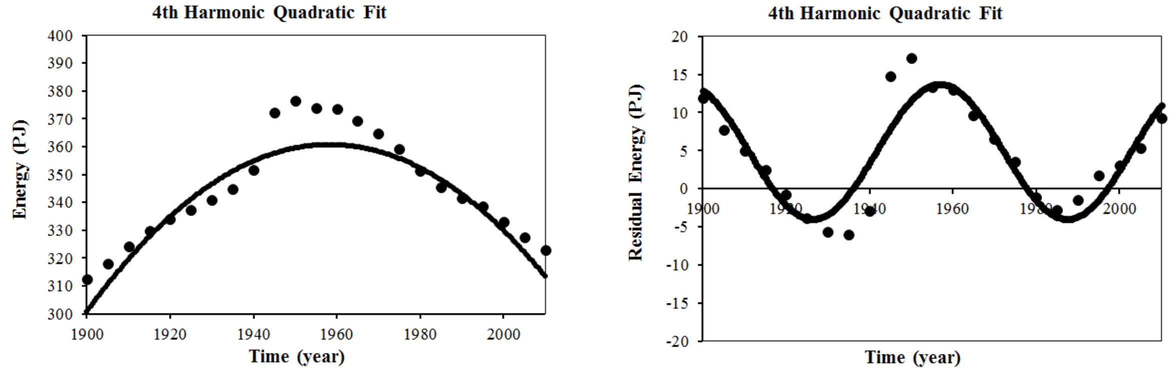


Figure 4. 4th harmonic energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the quadratic fit. The graph on the right shows the sinusoidal fit to the residuals from the quadratic fit.

A linear or exponential fit was not appropriate for the 4th harmonic energy, so a quadratic fit was performed. Consult Table 3 for more details of the fits and the calculations based on the fits.

5th Harmonic Energy

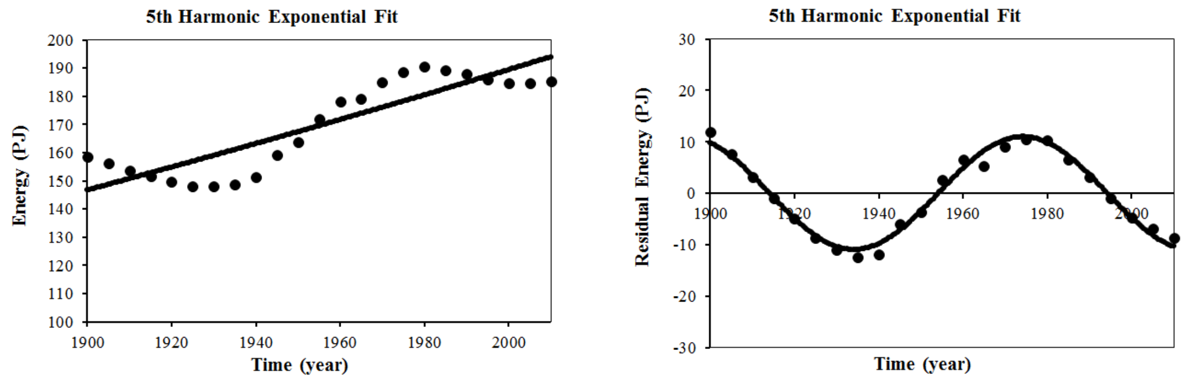


Figure 5. 5th harmonic energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the exponential fit. The graph on the right shows the sinusoidal fit to the residuals from the exponential fit.

The linear fit and the corresponding sinusoidal fit to the residuals is very similar to the exponential fit. The sinusoidal fit was exceptionally good for the 5th harmonic energy. Consult Table1 and 2 for more details of the fits and the calculations based on the fits.

6th Harmonic Energy

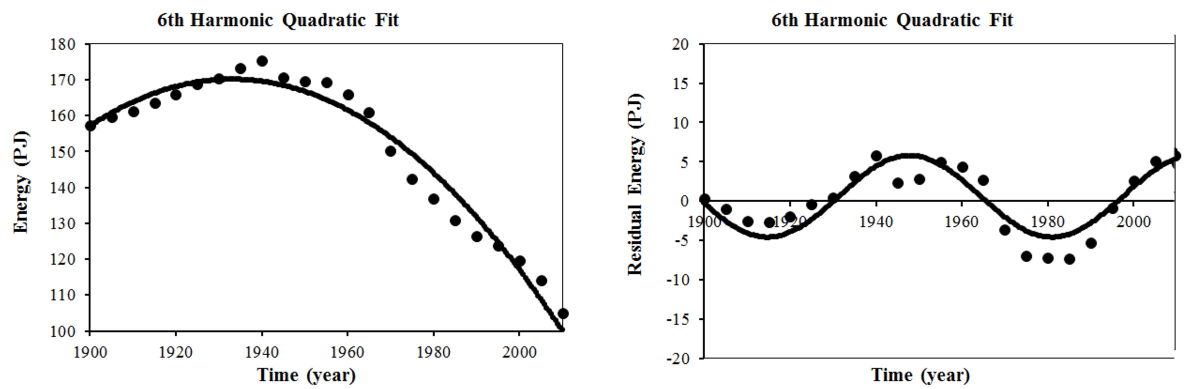


Figure 6. 6th harmonic energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left shows the quadratic fit. The graph on the right shows the sinusoidal fit to the residuals from the quadratic fit.

The best looking fit was quadratic and this is shown in Figure 6. Consult Table 1-3 for more details of the fits and the calculations based on the fits.

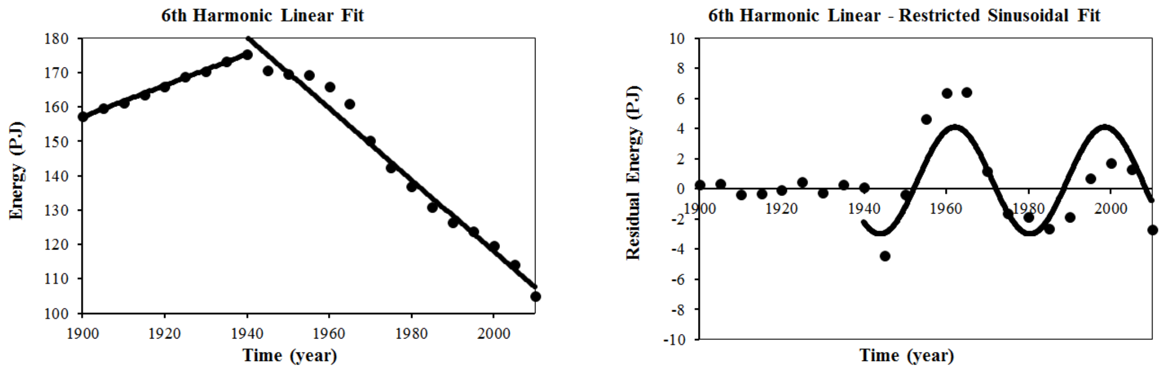


Figure 7. 6th harmonic energy of the earth's magnetic field from 1900 to 2010 AD. The graph on the left uses two lines to fit the data. The graph on the right shows the sinusoidal fit to the residuals from the linear fit from 1940 to 2010 AD.

The 6th harmonic energy can be modeled nicely by treating the data as two linear functions. The left line is from 1900 to 1940 AD. The right line is from 1940 to 2010 AD.

The left line goes to zero energy at 1560 ± 50 AD. This is similar to most of the other non-dipole harmonics. The right line goes to zero energy at 2100 ± 100 AD.

The sinusoidal fit to the right line has an RMSE of 2.3 and has a oscillation period of 34 ± 2 yrs.

7th to 10th Harmonic Energy

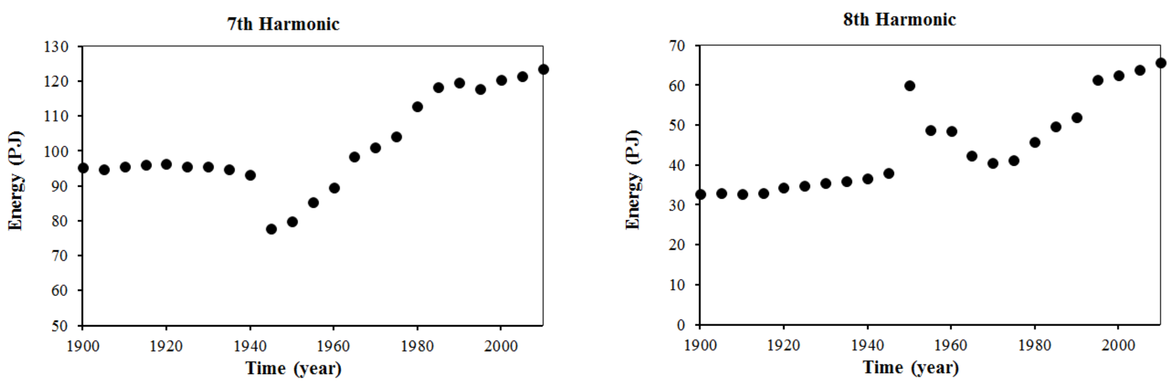


Figure 8. Higher harmonics of the earth's magnetic field from 1900 to 2010 AD. The graph on the left is the 7th harmonic energy. The graph on the right is the 8th harmonic energy.

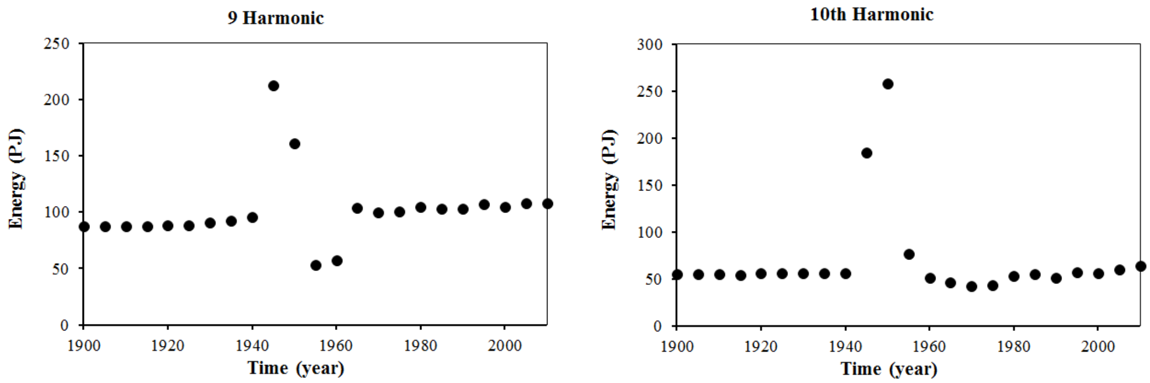


Figure 9. Higher harmonics of the earth's magnetic field from 1900 to 2010 AD. The graph on the left is the 9th harmonic energy. The graph on the right is the 10th harmonic energy.

The harmonics higher than 6th were not modeled because they varied too much.

Harmonic	RMSE of Linear Fit	Extrapolated Date of Zero Energy	RMSE of Sinusoidal Fit to Residuals	Sinusoidal Oscillation Period (yrs)
1st (Dipole)	21.0	2740 ± 70 AD	8.1	64 ± 2
2nd (Quadrupole)	8.9	1800 ± 80 AD	1.2	260 ± 90
3rd (Octupole	12.3	1700 ± 100 AD	2.6	98 ± 4
5th	8.0	1600 ± 300 AD	1.5	80. ± 1
6th	12.9	2200 ± 500 AD	3.2	115 ± 8

Table 1: Linear fit analysis of the earth's magnetic energy.

Harmonic	RMSE of Exponential Fit	Extrapolated Date of Zero Energy	Half-Life (Doubling Time) for E – C (yrs)	RMSE of Sinusoidal Fit to Residuals	Sinusoidal Oscillation Period (yrs)
1st (Dipole)	22.3	Not Calculated	548 ± 7	5.3	67 ± 1
2nd (Quadrupole)	3.4	1600 ± 200 AD	120 ± 8	1.2	170 ± 50
3rd (Octupole)	8.0	1820 ± 30 AD	130 ± 20	2.7	79.8 ± 0.3
5th	8.2	1,000 ± 100,000 AD	600 ± 2,000	1.4	80. ± 1
6th	7.7	2040 ± 4 AD	25 ± 3	2.5	81 ± 2

Table 2: Exponential fit analysis of the earth's magnetic energy. The exponential function used was $E = Ae^{Ct} + B$, which can cross the horizontal axis with certain ranges of the fitted parameter B.

Harmonic	RMSE of Quadratic	Extrapolated Date of Zero Energy	RMSE of Sinusoidal Fit to Residuals	Sinusoidal Oscillation Period (yrs)
4^{th}	7.2	< 10,000 BC	3.1	61 ± 2
6^{th}	4.4	800 ± 2000 BC	2.1	66 ± 3

Table 3: Quadratic fit analysis of the earth's magnetic energy.

CONCLUSIONS

The third to the six harmonics of the earth's magnetic energy can be modeled as having oscillation periods similar to the value found by Humphreys (2012) analysis of the dipole magnetic moment. Similar oscillation periods were found even when using different fitting equations.

The second to the sixth harmonic energies can also be modeled as having a date when the energy was zero and began increasing since then. Most of the good fits produce starting energies from 1500 AD to 1800 AD. It was hoped that these starting dates would be closer to the Flood. This should be investigated further.

Further work needs to be done to better understand the earth's magnetic field from a creationary perspective.

FUTURE WORK

Pre-Flood

It has been claimed that the earth's magnetic field tens of thousands of years ago would melt the earth's crust. This needs to be shown in more detail. Geophysical calculations should be made using reliable values of variables. The assumptions made in the calculation should also be made explicit.

Humphreys current model claims that free decay of the earth's magnetic field occurred prior to the Flood. This needs to be explored in greater detail. For example, is there any physical evidence that can be used to back up this idea?

Flood

Magnetic reversals during the flood need to be more thoroughly established theoretically. We need a Creation model that can make predictions. The predictions should describe the direction and strength of the earth's magnetic field at a given location as a function of time. The dynamo model for the earth's magnetic field should be explored in this regard. We aren't looking for a model that is self-generating. So, their work may be a good starting place.

The magnetic field data from rocks needs to be compared to the predictions of our future Creation model for magnetic reversals. This study would have many implications for the development of Flood models. It has the potential to lend support to some Flood models and also to eliminate some Flood models.

Post-Flood magnetic fluctuations

We need a quantitative theory to predict strength and direction of the earth's magnetic field as the cause of magnetic reversals dies out. We need to explore the observational evidence for post-Flood magnetic reversals more thoroughly than has been done. Predictions of the future Creation model need to be tested against the observational data.

Post-Flood Free Decay

Theory needs to be developed to predict the beginning of the post-Flood free decay of the earth's magnetic field. Archaeomagnetic evidence needs to be compared with our future model of the post-Flood free decay period.

Polar Wandering Curves

Similar to the issue of magnetic reversals is the issue of polar wandering curves. These need to be examined within a creationary context. One question that needs to be answered is "How firm are the conclusions about direction of the earth's magnetic field being recorded in the rock when it cooled?"

RATE Project

The relationship between the RATE project and magnetic field data needs to be explored more thoroughly. The relationship between Flood models and magnetic field data needs to be explored.

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