CRITICAL ANALYSIS OF THEORIES ON THE ORIGINS OF GEOMAGNETISM

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ABSTRACT: The origins of geomagnetism, to the present day, are not sufficiently well explained. The various theories already presented, for more than a century, none of them attend to all geomagnetic phenomena and behaviors observed in time, whether in units of seconds (s); of hours (h); of days (d); years (a); centuries (100 years); millennia (ka) or millions of years (Ma). The most scientifically accepted theory is the one presented on November 15, 1919, by Joseph Larmor – that of the geodynamo, which would also justify solar magnetism and which, under no circumstances, justifies all the geomagnetic behaviors already verified experimentally. For lack of a better theory, this one has been accepted, until a better one appears on the scientific scene. The dynamo theory was also proposed by the German-born American physicist Walter M. Elsasser and the British geophysicist Edward Bullard in the mid-20th century. The present work will critically discuss the main published theories to justify the spectacular and mysterious appearance of the terrestrial magnetic field that, certainly, would justify, in the same way, the magnetic field existing in other celestial bodies.
KEYWORDS: geomagnetism; origin; theory; analysis; criticism; geodynamo.

1 | INTRODUCTION

The origins of geomagnetism are far from being justified through mathematical simulations based on electromagnetism. Likewise, despite an exhaustive search, no scientific experiments are found, on any scale, capable of proving any of the numerous hypotheses already raised for the origin of terrestrial magnetism. The great difficulties encountered in proving experimentally are not in the means of generating the magnetic fields themselves, but in the justification for all the numerous behaviors of geomagnetism over time, including the proven reversals of polarities.

The most scientifically accepted theory to date, to justify the origin of geomagnetism, is the geodynamo theory [1].

2 | MOTIVATION

The intention of this work is to show and encourage new studies and scientific experiments that are able to better explain the origins and variations of geomagnetism over time, emphasizing that to date there has been no success in these objectives, thus constituting one of the great scientific enigmas.

3 | METHODOLOGY

Bibliographic surveys were carried out on the main hypotheses already found and published on the justifications and theories for the emergence and existence of terrestrial magnetism. Each hypothesis was carefully and scientifically evaluated for judgment of validation or invalidation.

For the present expert analysis, the following assumptions are assumed to be very likely to be true:

3.1 The geomagnetic pole is the position on the surface of the terrestrial ellipsoid where the magnetic field is perpendicular to it;

3.2 The north and south geomagnetic poles are not currently antipodes, that is, they are not located diametrically opposite the terrestrial globe;

3.3 The geomagnetic axis is currently not aligned with the Earth's axis and rotation;

3.4 The North and South geomagnetic poles are currently close to the South and North geographic poles, respectively. That is, the south geomagnetic pole is located in the Arctic and the north in Antarctica;

3.5 The Earth's core contains a solid part in the center, called the inner core;

3.6 The inner solid core is floating in a liquid medium, called the core;

3.7 The solid core is currently rotating in the same direction as planet Earth, but not necessarily in sync;

3.8 The Earth's inner core is at extremely high temperatures, incandescent, around 5000 ºC [2];

3.9 The geomagnetic poles undergo inversions and excursions, but not periodically, only sporadically;

3.10 The direction and sense of the magnetic field generated by the electric current in a loop, ring or coil, meets the rule of the right hand, where the fingers follow the direction and sense of the current and the thumb indicates the direction and sense of the magnetic field generated;

3.11 The conventional direction of electric current in a material is contrary to the movement of electrons, or negative charges, and favorable to the pseudo movement of protons;

3.12 The direction and sense of the magnetic field generated by the movement of electrons, or negative ions, meet the left hand rule.

It is estimated that an electric current of the order of 3 GA around the core, or 17.4 GA around the inner core, could generate the Earth's existing magnetic field. **Figure 1** illustrates and demonstrates, through the equations of electromagnetism, the possibility of developing geomagnetism. However, that current would not be flowing in superconductors; therefore it would cause heat dissipation and would not have the eternal quasi-stability.

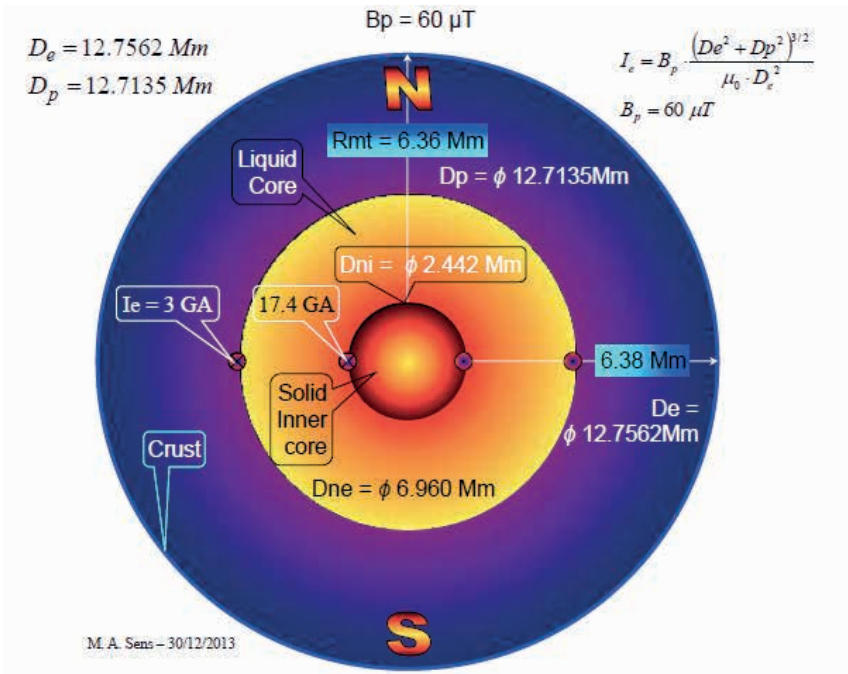

Figure 1 - Geomagnetism Generated By Electric Current in the Core

4 I HYPOTHESES FOUND TO JUSTIFY GEOMAGNETISM

4.1 Natural Magnets in the Earth's Crust

4.2 Natural Magnets in the Earth's Solid Core

4.3 Water Present on the Planet

4.4 Water in Rotation Movement

4.5 Natural Dynamo in the Fusing Nucleus

4.6 Relative Motion between Core and Crust

4.7 Rotational Motion of the Incandescent Solid Inner Core

4.8 Turbulent Movement of the Fusing Nucleus

4.9 External Plasmatic Belt to the Planet

4.10 Electric Current in the Core that Arose in Creation

4.11 Metals Rotating in the Crust

4.12 Flux Metals Rotating in the Core

Judicious analysis can only be effected because generations of investigators, anonymous or public, have been able to strictly follow a set of simple rules for verifying ideas through experiments and observations; development of the ideas that passed the preliminary evaluations; reject those that do not meet the minimum requirements; continuing to study the evidence wherever it leads and, above all, questioning everything and every hypothesis raised to justify a phenomenon.

5 | EXPERT ANALYSIS OF HYPOTHESES ABOUT THE ORIGIN OF GEOMAGNETISM

5.1 Geomagnetism is generated by Natural Magnets in the Earth's Crust.

Although ferromagnetic materials in the Earth's crust can retain magnetism in orientation with declining orientation between axes of rotation and magnetic alignment, and yet, with the movement of the crust, cause inconstant decay - the angle of phase shift between axes is inconsistent, exhibit eccentricity - not passing through the center rotation of the Earth and does not change with the rotation of the Planet, under no circumstances could the reversal of polarity occur. In this way, the hypothesis that the origin of the geomagnetic field is due to natural magnets in the Earth's crust can be discarded.

5.2 Geomagnetism is generated by Natural Magnets in the Earth's Core.

It seems widespread that the interior of planet Earth is very hot, very hot, incandescent[2]. Hundreds of released images reveal the temperature gradient of the Earth's core compared to other layers.

Thus, at such high temperatures, even the terrestrial core being composed of iron and nickel, as is supposed, it would not present any magnetic property. It has been proven that such metals, as well as other ferromagnetics, at temperatures above 1400 ºC lose any remanent magnetism[3],[4]. Temperatures of the order of 5430 ºC have been indicated to represent the innermost environment of planet Earth[5]. In this way, the hypothesis that geomagnetism would originate in the ferromagnetic materials of the core can be discarded.

5.3 Geomagnetism is generated by the Water Present on the Planet

This hypothesis, to justify the geomagnetism, was registered in a notary in the Center of Rio de Janeiro – RJ, Brazil. According to the author's opinion, only celestial cups containing water are provided with magnetism. Water does not have the capacity to generate magnetic

fields, either in static or dynamic condition and it constitutes a diamagnetic material. Furthermore, even if there were the possibility of generating magnetic fields, there would be no possibility of polarity reversals occurring. In this way, the hypothesis that geomagnetism is generated by the water present on the Planet can be discarded.

5.4 Geomagnetism is generated by Water in Rotation Movement.

Water does not have the capacity to generate magnetic fields, either in static or dynamic condition and it constitutes a diamagnetic material. If there were the possibility of generating magnetic fields with the movement of the planet's waters, there could also be a shift angle between the axes that is inconstant, due to the movement of the crust. Even so, there would be no possibility of polarity reversals occurring without the reversal of the Planet's rotation. In this way, the hypothesis that geomagnetism is generated by water in rotation can be discarded.

5.5 Geomagnetism is generated by the Natural Geodynamo in the Fusing Nucleus.

The idea of a geodynamo attributes the generation of the magnetic field to the existence of electrical currents in the liquid medium of the Earth's core[1],[6],[7],[8]. However, this hypothesis does not even meet the current laws of physics. In order to induce currents, according to Faraday's Law, it is necessary to have a time-varying magnetic field on an electrical conductor.

This hypothesis of the emergence of the geomagnetic phenomenon is usually justified in comparison with the dynamo called Faraday disk, whose operation requires the existence of a static magnetic field and a rotating disk, that is, the existence of relative movements. Currents cannot be induced in a coil or ring using the magnetic field generated by the coil or ring itself. Considering that the conductor, not a good one, for being incandescent, would be the liquid core of the Earth, the magnetic field would have to be caused by magnetic poles external to the Planet. Or, the poles fixed in the crust and the core moving relative to it. One can imagine that the planet's melting core is made up of infinite conducting rings, concentric, with axes almost aligned with the Earth's axis.

If these rings move upwards and downwards and there is, by hypothesis, a fixed magnetic field in the crust, there would be an induction of electric currents in the rings, with the generation of magnetic fields in the opposite direction, according to Lens' Law of Physics. And, in this case, the fields would tend to cancel each other out and braking would occur, a dampened movement of the rings.

Such imaginary rings, evidently would all be in short circuit, would not be isolated and, obviously, could not form turns or coils. In the event that there are electrical currents

in the melting core, these would be of great magnitude and would cause high thermal dissipation. In the upward movement, the currents would be in one direction and in the downward movement in the opposite direction. That is, the magnetic fields would oscillate.

Even if there were the possibility of such geomagnetic generation, the poles could not reverse unless a reversal of rotation of the Planet, never reported, occurred. In the same way, this type of generation would not justify any excursion, or alignment of the magnetic axis with the Planet's Equator, very well verified the occurrence.

In this way, the hypothesis that geomagnetism is generated by the natural geodynamo in the planet's melting core can be discarded.

5.6 Geomagnetism is generated by Relative Motion between Nucleus and Crust.

The relative movement of the melting core with the Earth's crust could somehow generate electric currents, either by friction or by thermionic emission and, such currents, would cause the existing geomagnetism[9],[10]. Or, such friction when hot, it could simply cause an ionic layer on the periphery of the nucleus which, with the spin, would cause the magnetic field, even without current. However, these currents or movements of ions would have to be in the direction of the movement of the Planet, which would be quite possible, but for the occurrence of reversal one would have to invert the direction of rotation of the liquid mass, very unlikely.

In this way, the hypothesis that geomagnetism is generated by the relative movement between Earth's core and crust can be discarded.

5.7 Geomagnetism is generated by the Rotation of the Incandescent Solid Inner Core.

The inner core is understood as the central core, solid, and that it is incandescent[2]. There are plenty of indications that the positioning of the north magnetic pole has gradually migrated and lodged at different angles from West to East, in longitudes comprising an angle of 90 degrees in the last hundred years[11],[12], that is, a quarter back in the attic ice cap.

When publishing his geomagnetic map of 1701, E. Halley recorded his opinion about the origins of the geomagnetic fiel[13],[14],[15],[16],[17],[18].

Halley devoted much of his time to modeling and mapping the behavior of the Earth's magnetic field. His great ambition was to solve the age-old problem of longitude through a better understanding of the Earth's magnetic field.

In 1683, Halley produced the first of many papers on the Earth's magnetic field. In 1696, he argued that the Earth was made up of an outer layer and a separate inner core. Each would produce its own magnetic dipole. The movement of the inner core would

be responsible for the observed behavior of terrestrial magnetism[17],[18]. Although Halley's model was eventually proven wrong, his belief that the behavior of the planet's magnetic field had its origins deep in the Earth's core resonated with explanations that emerged in the 1950s. The core is molten and is in motion. Complex magnetohydrodynamic processes deep in the Earth, which are still not fully understood, may be responsible for the observed magnetic field behavior at the Earth's surface and above.

A decade ago Columbia University's Lamont-Doherty Earth Observatory announced that it had found that the Earth's inner core is rotating faster than the planet itself.

The inner core rotates in the same direction as the Earth and slightly faster, completing its rotation once a day, about two-thirds of a second less than the Planet.

It has been found that over the past 100 years the speed of the Earth's core has gained an extra quarter of a turn relative to the planet as a whole[19],[20]. Interestingly, this finding fits with the records given by NASA and Columbia University regarding the movement of the North magnetic pole position[11],[12].

Such movement is extremely fast for geological movements - about 100,000 times faster than the drift of continents, it has been observed.

Such conclusions were drawn after measurements of changes in the speed of seismic waves generated by earthquakes passing through the inner core.

The latest study builds on that research, linking the way the inner core rotates to the behavior of the outer core.

On the other hand, British studies answered the question about which direction the center of our Planet turns. The inner core, made up of massive iron, is super-rotated towards the East (where the sun rises, like the Earth's surface) - which means it spins faster than the rest of the planet - while the outer core, made up of mostly cast iron, rotates westward (where the Sun hides) at a slower pace[21].

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hypothesis, yet confirmed nor discarded.

5.8 Geomagnetism Is Generated by the Turbulent Movement of the Fusing Nucleus.

It is conjectured that the swirling flow of molten iron and nickel around the Earth's solid core causes an electric current, which generates the planet's magnetic field[22],[23]. Such a hypothesis does not find any basis if any of the facts and findings on geomagnetism. The very stability of geomagnetisms would not be possible by a turbulent, chaotic generator. Much less could a reversal in geomagnetism be justified by such a generating system.

In this way, the hypothesis that geomagnetism is generated by the swirling flow of molten iron and nickel around the solid core of the Earth can be ruled out.

5.9 Geomagnetism is generated by the Plasmatic Belt External to the Planet.

A plasmatic belt, external to the Planet, in the same way as the incandescent core, could behave like an electric current. And these clouds can generate magnetic fields in the direction of the belt's axis of rotation. Such a hypothesis does not find any foundation if we consider many of the facts and observations about geomagnetism, as detailed in 3. To name one, there could not and could not be a justification for a reversal in geomagnetism by such a generation system.

Thus, the hypothesis that geomagnetism is generated by the outer plasmatic belt of the Planet can be discarded.

5.10 Geomagnetism Is Generated By Electric Current In The Nucleus That Arose In Creation.

It is estimated that an electric current of the order of 3 GA could generate the current magnetic field existing on Earth. Figure 1 illustrates and demonstrates, using electromagnetism equations, this possibility of generating geomagnetism. However, this current would not be flowing in superconductors, therefore, it would cause heat dissipation and would not have the eternal quasi-stability. There is no way to justify the maintenance of this electric current, nor a reversal, to mention just one of the facts and findings about geomagnetism, described in **3**.

A scheme different from the schemes called geodynamos, was published in Brazil in 1999[24]. It is even thought that the end of the world could be predicted[25], by the extinction of the terrestrial magnetic field, obtained by linear extrapolation.

In this way, the hypothesis that the current geomagnetism is generated by an electric current in the core that arose in creation can be discarded.

5.11 Geomagnetism is generated by Rotating Metals in the Crust.

This hypothesis is not supported by concrete evidence that rotating, non-incandescent metals can cause magnetic fields and cannot meet the facts and findings on geomagnetism, described in 3. Thus, the hypothesis that geomagnetism is generated by metals rotating in the crust can be ruled out.

5.12 Geomagnetism is generated by Flux Metals Rotating in the Core.

This hypothesis, raised in a fiction film[26], has been tested, in an attempt at an experimental reproduction, without success, by different researchers[8],[27]. The experiments, however, used hot but not incandescent liquid metals, both spinning and in turbulence. The results cannot meet the facts and findings on geomagnetism, described in **3**. There could be some decline, due to the movement of the crust, but never a reversal, to mention just two findings. In this way, the hypothesis that current geomagnetism is generated by molten metals rotating in the core can be discarded.

Table 1 shows whether or not the various hypotheses raised to justify geomagnetism were met.

Table 1 - Evaluation of the Hypotheses by the Criteria

ITEM	HYPOTHESES TO JUSTIFY GEOMAGNETISM	Meet the observed Geomagnetic Behavior *					
		GMG	DCL	DIN	NAP	REV	EXC
4.1	Natural Magnets in the Earth's Crust	☑	☑	☑	☑	☐	☐
4.2	Natural Magnets in the Earth's Solid Core	☐	☑	☑	☑	☐	☑
4.3	Water Present on the Planet	☐	☑	☑	☑	☐	☐
4.4	Water in Rotation Movement	☐	☑	☑	☑	☐	☐
4.5	Natural Dynamo in the Fusing Nucleus	☑	☑	☑	☑	☐	☐
4.6	Relative motion between core and crust	☐	☑	☑	☑	☐	☐
4.7	Rotational Motion of the Incandescent Solid Inner Core	☑	☑	☑	☑	☑	☑
4.8	Turbulent Movement of the Fusing Nucleus	☑	☑	☑	☐	☐	☐
4.9	External Plasmatic Belt to the Planet	☑	☐	☐	☐	☐	☐
4.10	Electric Current in the Core that Arose in Creation	☑	☑	☐	☐	☐	☐
4.11	Metals Rotating in the Crust	☐	☑	☑	☑	☐	☐
4.12	Flux Metals Rotating in the Core	☑	☑	☐	☐	☐	☐

*GMG	Magnetism Generation – ability to generate magnetic fields.
DCL	Decline, or magnetic decline between axes of rotation and magnetic alignment.
DIN	Inconstant Decline – the offset angle between the axes is inconstant.
NAP	Non-antipode – poles are not diametrically opposite.
REV	Reversals – Hundreds of magnetic pole reversals have occurred.
EXC	Excursion – magnetic axis temporarily aligned with the equator.

Table 2 shows the summary survey of the criteria met by each of the hypotheses raised to justify the presence and behavior of the geomagnetic field.

Table 2 - Table 2 - Summary of Hypothesis Analysis

ITEM	HYPOTHESES TO JUSTIFY GEOMAGNETISM	HYPOTHESIS ANALYSIS *				
		PSC	PSD	NPC	NPD	NCD
4.1	Natural Magnets in the Earth's Crust	☐	☑	☐	☐	☐
4.2	Natural Magnets in the Earth's Solid Core	☐	☑	☐	☐	☐
4.3	Water Present on the Planet	☐	☑	☐	☐	☐
4.4	Water in Rotation Movement	☐	☑	☐	☐	☐
4.5	Natural Dynamo in the Fusing Nucleus	☐	☐	☑	☐	☐
4.6	Relative motion between core and crust	☐	☐	☑	☐	☐
4.7	Rotational Motion of the Incandescent Solid Inner Core	☐	☐	☐	☐	☑
4.8	Turbulent Movement of the Fusing Nucleus	☐	☐	☐	☐	☑
4.9	External Plasmatic Belt to the Planet	☐	☑	☐	☐	☐
4.10	Electric Current in the Core that Arose in Creation	☐	☑	☐	☐	☐
4.11	Metals Rotating in the Crust	☐	☑	☐	☐	☐
4.12	Flux Metals Rotating in the Core	☐	☐	☐	☐	☑
*PSC	Can Be Confirmed					
PSD	Can Be Discarded					
NPC	Cannot Be Confirmed					
NPD	Cannot Be Dismissed					
NCD	It Cannot Be Confirmed nor Discarded					

6 I CONCLUSIONS

Planet Earth was formed together with most of the bodies of the Solar System, in a single instant, from a great explosion and such a hypothesis constitutes acceptance notoriety. From this explosion, the bodies received kinetic energy, in the form of an impulse, which implied rotation and translation movements, among other transitory oscillations. Due to the dimensions, the planets were molded in the shape approximately spherical, by gravitational action and the imposed rotation. Evidently, the rotational movements received by the celestial bodies were unidirectional for their entire mass, although asynchronously, as they were constituted, initially, by liquid and gaseous parts.

There is no reason to consider the hypothesis that the cores of the planets had a direction or sense of rotation originally different from the main bodies, since the alignment of the axes of rotation constitutes the most stable form. That is, the Earth originally had unidirectional rotation for all mass, solid and liquid. Earth's solid, glowing core floats on a liquid core and rotates inertial and asynchronously with the planet. Such a core, solid and floating, has received impulses of kinetic energy from asteroids that collide with the Earth and grant them transient oscillations and even reversals in the axis of rotation, depending on the magnitude of the impact. The impacts received by the planet Earth by the craters left on the surface are verified, which have already been cataloged in approximately 200 in the last 2000 Ma, with diameters of up to 160 km[28]. It was verified, without an incessant

search on the surface of the Planet Earth, that in 135 reversals, in the last 160 Ma, the normal polarity, like the current one, was present in 67% of the time[29] and that precisely in the periods of smaller frequency of impacts the polarity remained more stable, as shown in **Figure 2**.

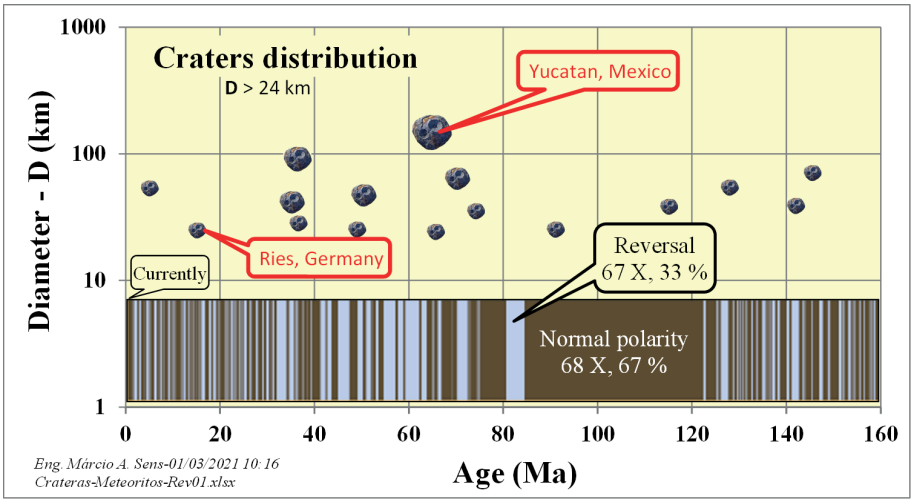

Figure 2 - Correlation of Geomagnetic Reversals with Asteroid Impacts

The hypothesis that geomagnetic reversals are associated with the impacts of extraterrestrial bodies with Planet Earth is not new and was raised in 1996 by Müller[30]. However, the justifications for the foundation of the hypothesis are fanciful and even hilarious. Explanations of how the geomagnetic field would have been neutralized by a large impact, then born again in opposite directions, in the "geodynamo" system, without a fixed remanent magnetic field on the Planet do not seem convincing.

The Earth rotates counterclockwise if viewed from the geographic North Pole, or Arctic Pole.

Geomagnetism probably originates from the rotation of the solid and hot core of the Earth. In this way, the generation of the magnetic field occurs without the energy dissipation predicted in previous hypotheses, where the magnetic field would be generated by electric currents through the liquid core. In this case, there is no reaction or braking torque of the supposed geodynamo.

The Earth's solid inner core is floating in the liquid core, like the yolk floating in the white of an egg. However, the inner core of the Earth is not attached to the Planet, as in the case of the egg yolk, which is attached to the inner membrane of the shell through a cord called chalaza. An egg yolk, although it can rotate on its axis, cannot topple over and reverse poles relative to the shell. The inner core of the Earth, on the other hand, can topple over and invert its polar position, without stopping and without, in fact, reversing the direction of rotation with respect to its own axis. The Earth's solid core can wobble

in all directions and have the axis of rotation in alignment with the Earth's axis. Nothing prevents the Earth's solid core from being, for some time, off-center, displaced downwards, towards Antarctica, as it actually is today. Although such oscillations may have fundamental periods of millions of years, they are not infinite and the tendency, with damping, is that they cease over time and that the solid core remains in a condition of greater stability, that is, in alignment and in centralization with the axis of rotation of the Planet. As the magnetic field at the Antarctic pole is superior to that of the Arctic by 10 μT, the inner core, solid, must be outside the Earth's center, and be displaced towards Antarctica by approximately 320 km.

As it is detected, by superficial measurements of almost 400 years, that the geomagnetic field has been falling over time[25],[31],[32], it is suggested that such behavior is due to two reasons – the decay of the rotation of the solid core and its temperature decay.

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