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Ocean rift magnetic anomaly

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ABSTRACT

When lava cools in the presence of a magnetic field, such as the Earth's magnetic field, magnetic material in the lava will acquire the magnetic alignment of the applied field. From observation of igneous rock containing magnetic materials, it has been found that some rock beds are magnetized in a direction reverse to the Earth's magnetic field. In order to explain this seeming paradox, a theory was proposed in 1963 by *Vine and Matthews* in which the magnetic poles of the Earth reverse in a non-periodic fashion every 10,000 to 1 million years (approximately).

By exploring the cause of the Earth's Magnetic field, it is discovered that the magnetic field strength of the Earth can and will change over time; however, this change occurs over billions of years and can not explain the short period (10,000 to 1 million years) shown in the geologic record.

Instead, it is possible to show that the magnetic reversals in the geologic record can occur without the Earth's magnetic field changing. In fact, the mystery of the alternating magnetic alignment is demonstrated with a simple experiment that any school child can perform. This phenomenon is simply what magnets do.

We begin our exploration by examining the source of the mystery, the rock created by the separating tectonic plates. One such place of plate spreading is located along a feature in the Atlantic Ocean called the mid-ocean rift. The rift is located along the centerline of the Atlantic Ocean extending from North to South over almost the entire length of the Atlantic. A diagram of a short section of the mid-ocean rift is shown in (Figure 1).

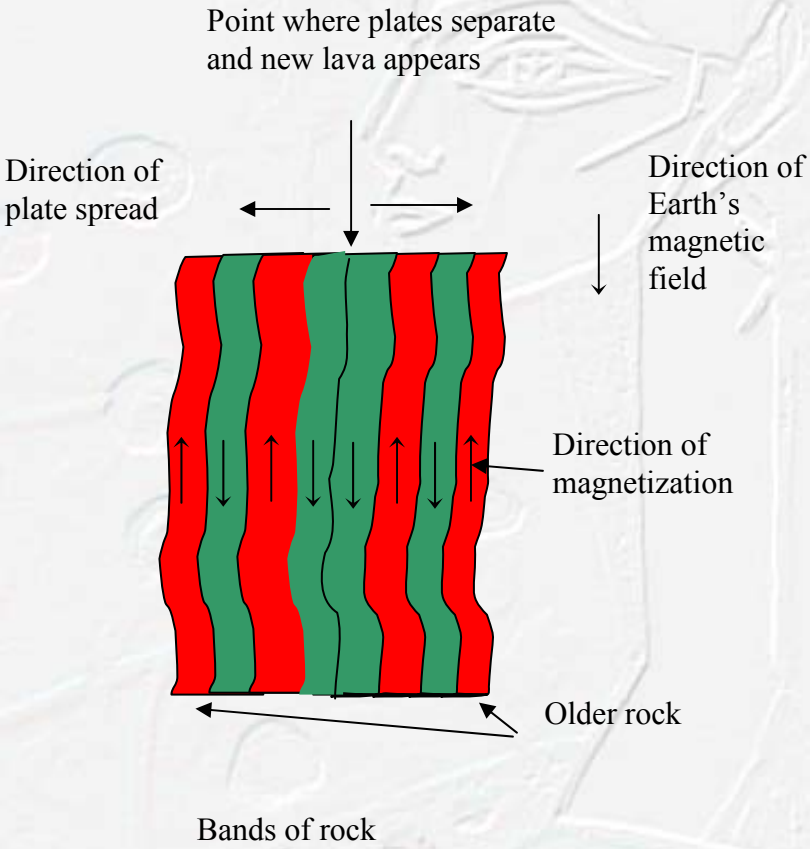

Figure 1: Diagram of mid-ocean rift

New molten lava appears where the plates separate. The lava contains material that can be magnetized. While molten, the magnetic material easily aligns in the direction of any applied magnetic field. As long as the magnetic field is present as the lava cools, the lava will retain its acquired magnetic alignment. Any material that has a net magnetic alignment is said to be "Magnetized". The term positive magnetization is used to describe rock magnetized in the same direction as the Earth's magnetic field. Negative magnetization is a term used to describe rock magnetized in a direction opposite to the Earth's Magnetic field.

Since the sea floor is spreading away from the rift, rock beds farther from the rift represent lava deposited farther back in the Earth's history. Samples taken from these rock beds show that the magnetization of the rock alternates approximately every 10,000 to 1 million years.

The only explanation for this alternating magnetic alignment in the geologic record is a theory proposed in 1963 by *Vine and Matthews* in which the poles of the Earth's reverse on a non-periodic basis.

Since the above theory requires changes to occur to the Earth's magnetic field, we shall explore the cause of the Earth magnetic field to see if such a change is possible or even probable.

The strength of the Earth's magnetic field is directly related to the speed at which the Earth rotates on its axis. The direction of the Earth's magnetic field is directly related to the direction of rotation. This magnetic field relationship to Earth's spin is true for both New Electromagnetism and classical theories about the source of the Earth's magnetic field.

The relationship between a heavenly body's direction of rotation and its magnetic field is demonstrated by examining the bodies in our solar system. The sun and every planet in our solar system (that have been measured) have consistent alignment between spin and magnetic field poles.

The relationship between the speed of a planets rotation and the intensity of its magnetic field is also demonstrated by the bodies in our solar system. The planet Venus, which has a magnetic field so small that it can not be measured, rotates so slow that its day is longer than its year. Another example is the planet Uranus which seems to have been knocked over on its side. Uranus has a polar shift of 97 degrees relative to the plane of its orbit. The magnetic field of Uranus is aligned with its spin.

A curious thing about the magnetic field of the Earth is that it does not align exactly with the rotational axis. This is not a large problem when you realize the large quantities of magnetic materials (iron, cobalt etc) are contained in the crust of the Earth. Everyone who has experimented with magnets knows that magnetic materials can focus and redirect magnetic fields in much the same way that lenses and mirrors can focus and redirect light. This focusing of a magnetic field by magnetic materials is the key to

explaining the anomaly in the geologic record. Before explaining the anomaly, we must finish our discussion of the Earth's magnetic field.

Since the spin of the Earth is one of the factors required to generate our planets magnetic field, then a reverse in the direction of the Earth's spin would reverse the direction of the magnetic field. Can the spin of the Earth ever change? The answer to this question is found in any introductory astrophysics text books which say that tidal forces will cause the rotational energy of a planetary body to eventually be converted to heat. This means that a planetary body in orbit around another will eventually come to a state where it does not rotate relative to the other. For dissimilar sized bodies, the smaller will succumb first. This is what has happened to our moon; have you ever wondered why the Earth always sees the same face of the moon? We never see the "dark side of the moon" because the Earth exerts a very strong tidal force which has depleted the rotational kinetic energy of the Moon.

This same phenomenon is at work on the planet Venus; however, because the solar tidal forces affecting Venus are much smaller than the tidal effect of the Earth on the Moon; Venus has not yet depleted all of its rotational kinetic energy. In a few billion years, one side of Venus will constantly face the sun and one side of the Earth will always face the Moon. One day, moon dwellers will ponder about the dark side of the Earth and the strength of the Earth's magnetic field will dwindle to $1/28^{th}$ of it current strength. At a much later time, solar tidal forces will drain the kinetic energy from the lunar orbit and the Moon and Earth will collide to become one planetary body.

If the spin of the Earth is slowly dissipated over the years, then the magnetic field of the Earth should only ever be decreasing. This would appear as decay in the magnetic alignment of the geologic record and not a periodic reversal. Furthermore, these changes occur over billions of years; this can not explain the short (thousands of year) periodicity of the geologic record.

The only other known method for drastically changing the spin of the Earth is though collision with another celestial body. This is not a likely explanation for the magnetic alignment anomaly since such a collision would cause a greater level of extinction than that which destroyed the dinosaurs. Paleontologists have determined that mass extinctions occur periodically about every 32 million years. The period between these mass

extinctions (even if all are caused by meteor impacts) can not explain the short periodicity shown in the geologic record.

Others argue that the magnetic field of the Earth could reverse if the concentrations of ions in the molten strata of the Earth switch in concentration. The classical theory holds that the ions in the molten strata of the Earth in conjunction with the spin of the Earth cause the magnetic field. Therefore a reversal in ion polarity would indeed reverse the Earth's magnetic field; however, from an electrical engineering standpoint this is ridiculous. If the dynamics of the molten strata of the Earth do cause sufficient charge separation to produce the magnetic field of the Earth, then there should be a measurable electric field emanating from below ground. We must remember that electrostatic forces generated from separated charges are about 10^{17} times more powerful than the magnetic field produced. The Earth would be a strange place if this were indeed the case. Simply combing your hair could be dangerous. To be sure, there is ionization and charge separation occurring in great quantities in the molten strata of the Earth; however, the distance and period of separation is only sufficient to facilitate the emission and transmission of thermal electromagnetic radiation (heat). The high mobility of charge in the molten media ensures that coulomb and magnetic forces annihilate very rapidly. There is just no way (that I'm aware of) to produce a sustained Coulomb field in order for the rotation of the Earth to generate a magnetic field from it.

There might very well be some unknown reason for the reversal of the Earth's magnetic field; however, this same mechanism should then affect other bodies in the solar system. Is it just chance that we live in a time when all bodies in the solar system coincidentally have magnetic field aligned in the same direction relative to their axis of rotation.

Since it is not likely that the magnetic field of the Earth has ever switched, then there must be a way to explain the reversals of the magnetic alignment (magnetic anomalies) shown in the geologic record. In fact there is a very simple explanation that can be demonstrated with a simple experiment.

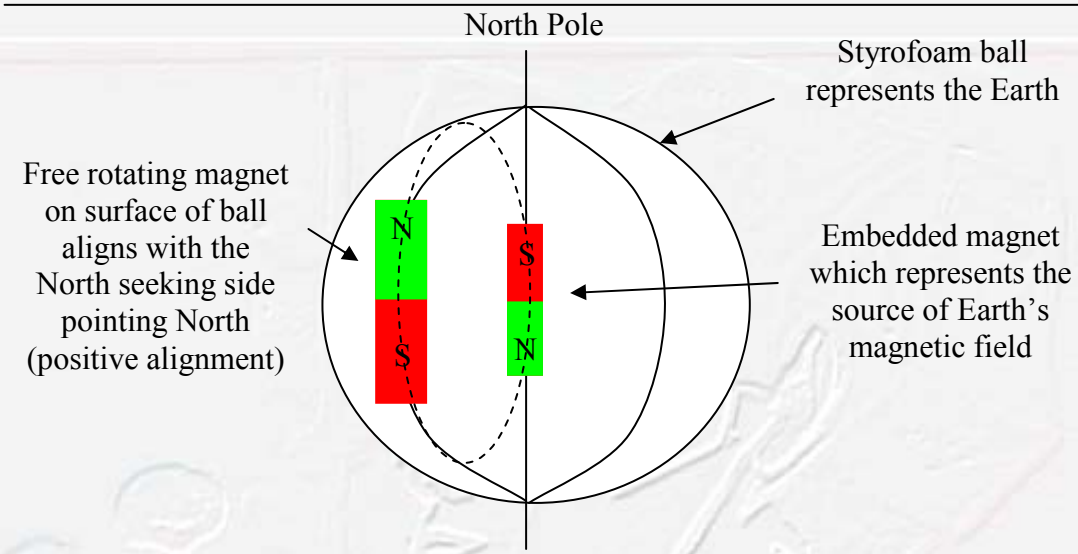

Figure 2 The simple experiment setup

The experiment is constructed by embedding a bar magnet inside a Styrofoam ball. The ball represents the Earth and the bar magnet provides a magnetic field which represents the Earth's Magnetic field. Remember, the embedded magnet must have its South seeking pole oriented toward the North Pole of the simulated Earth.

Next place another bar magnet tangent to the equator of the ball and allow it to freely rotate as shown in Figure 2. This free-rotating magnet represents molten lava containing magnetic materials capable of aligning to an applied magnetic field. Since the only magnetic field present is from the simulated Earth, the free rotating magnetic will align with its North seeking end pointing toward the North. Once the free rotating magnet has stabilized, tape it in place to prevent it from moving. Taping the magnet represents lava that has hardened.

New molten lava is then introduced next to the hardened lava by placing another free rotating magnet next to the immobilized magnet as shown in Figure 3

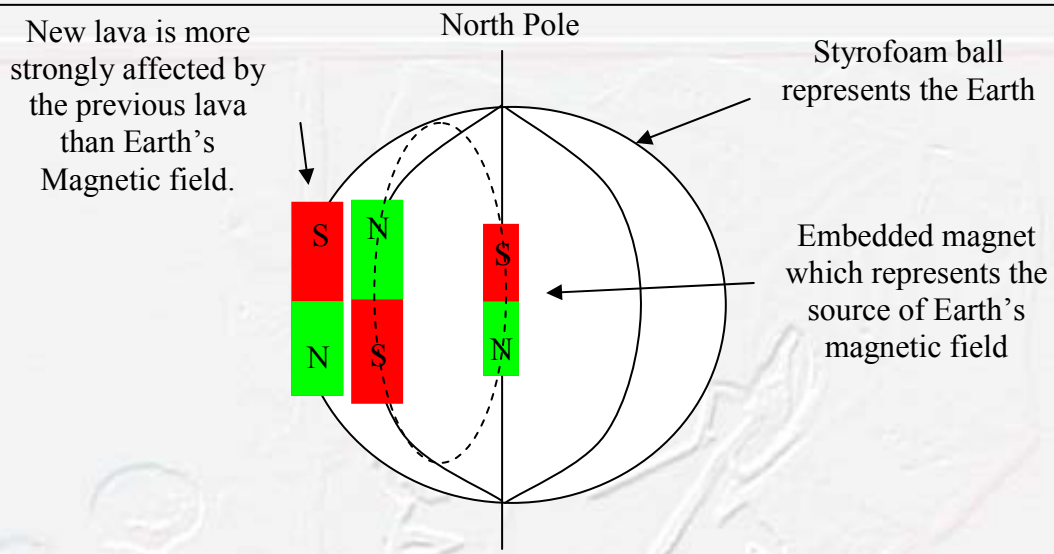

Figure 3

Because of the inverse square nature of magnetic fields, the alignment of the magnetic molecules in the new lava is more heavily governed by the previous bed of lava than the magnetic field of the Earth. Since opposite ends of magnets attract, the new lava becomes negatively magnetized.

The above experiment shows the general behavior of what is happening. This theory can only work if it is possible that the rock beds acquire a magnetic field strength (field lines per unit area) greater than the field strength of the Earth present at the point where the rock formed (we use the term "ambient field" for simplicity from now on). A logical question: how can rock acquire more magnetization than present in the ambient field?

Magnetic flux lines, like electricity, seek the path of least resistance. A property of magnetic materials which represents the ease at which flux lines can pass through is call permeability. A material with a high permeability can "focus" or "concentrate" magnetic fields better than a material with a low permeability. Water, sand, mud and air have a very low relative permeability of about 1. Because the lava contains minerals such as iron, cobalt and others, it has a higher permeability. Iron is 4000 times more permeable than air or water, Cobalt is 60 times and Nickel is 40. Even if a sample of lava only contains 1 part per 400 of iron, it can be as much 10 times more permeable than air or water (depending upon how the iron reacts with the other materials). This sample of lava could concentrate the magnetic field of the Earth 10 times better than the surrounding media such as the sea water. Also, since the mid-ocean-rifts are thousands of miles

long, these long bands of molten magnetic material provide the magnetic equivalent of a short circuit to the Earth's magnetic field. Consequently, a piece of this material chiseled from a long deposit of hardened magnetic material is likely to have stronger field strength than the ambient field. The following diagram explains how permeable materials concentrate the magnetic field of the Earth.

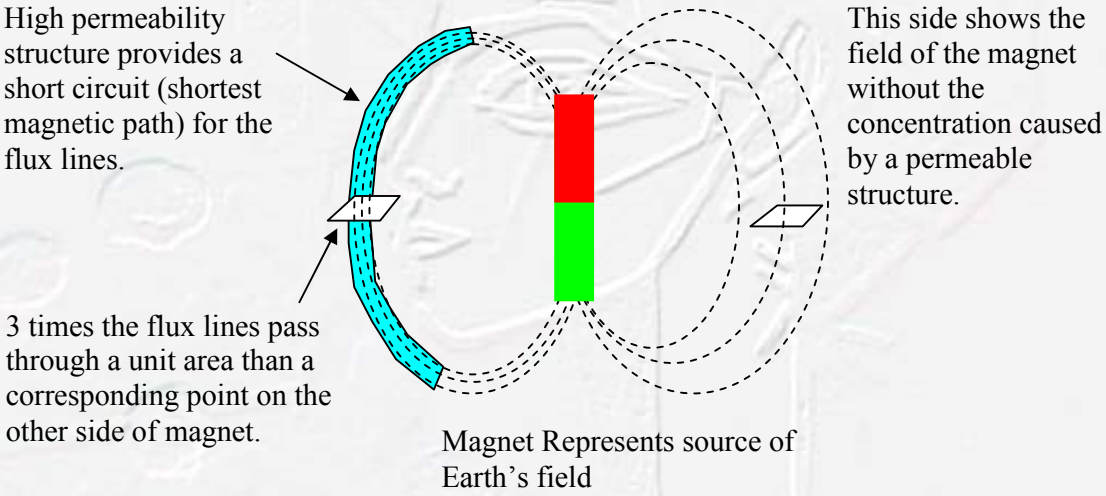

Figure 4

When tectonic forces fracture the long veins of magnetized materials into "little magnets" (Figure 5), the concentrated magnetic fields of these little magnets are "released". Since magnetic field lines seek the easiest path, the easiest path is through the permeable molten lava emanating from the rift. Since the field lines flow from S-to-N inside a magnet and from N-to-S outside then the magnetic field on the outside of the "little-magnets" is reverse to the field of the Earth. Remember that the Earth's magnetic field flows from the South-pole to the North-pole.

Since the magnetic field of these "little-magnets" is stronger than the ambient magnetic field (magnetic field of the Earth present where the rocks form), then the new lava acquires a magnetic field that is greater than, and opposite to the ambient field.

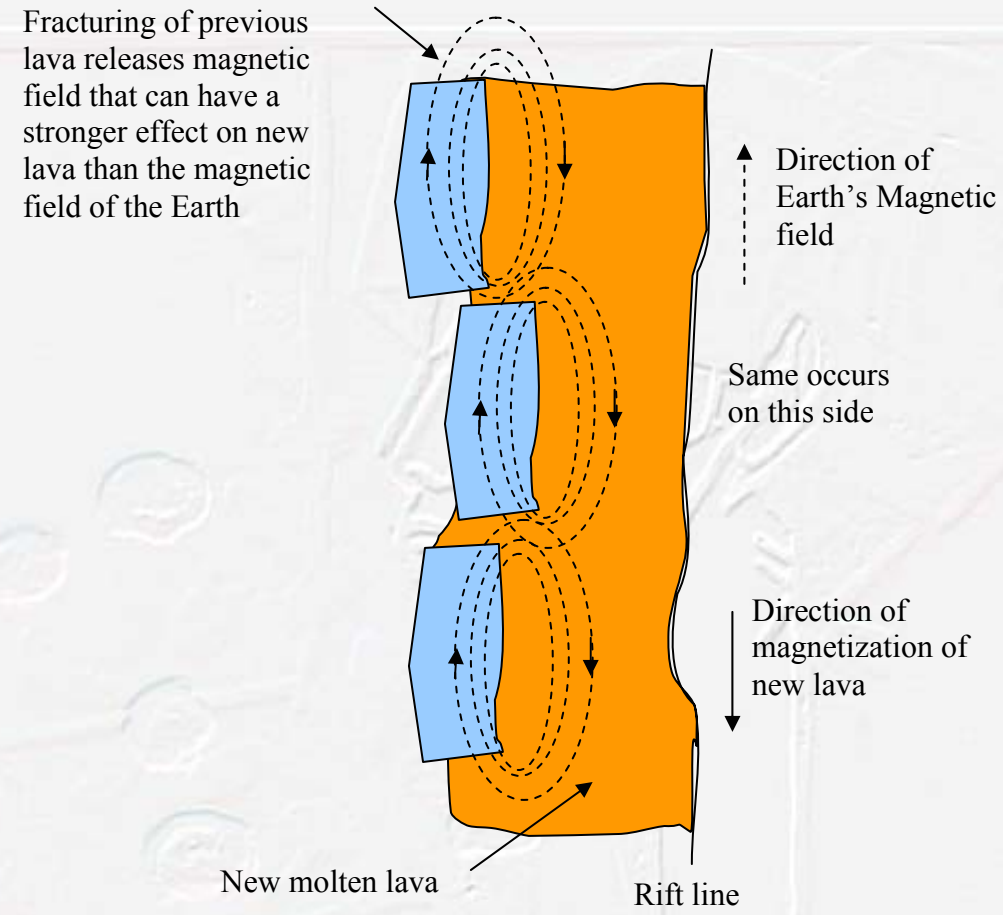

Figure 5 Tectonic fracturing

Figure 6 This is what magnets do; the alternating pattern represents a lower energy state than when all are in same direction

Let us make some general observations about this theory to see what aspects can be ascertained.

1) Since magnetic field strength is an inverse square relationship, the distance from new lava to where the fracturing occurs will affect the strength of the effect on the new lava. The longer the distance the weaker the effect.
2) Long segments of fractured lava have a farther ranging but weaker effect.
3) Short segments of fractured lava have a shorter ranging but stronger effect.
4) Pulverized lava has no appreciable affect.
5) Since the Earth's magnetic field is always a component of the magnetic alignment, the reverse aligned lava will generally have a weaker strength than the forward aligned material. For example, suppose that the first lava is magnetized to 10 times the strength of the Earth's field. When this first band fractures it affect the new lava with a field -10 times that of the Earth. Since the Earth will add a +1 component, the new lava will have a net magnetization of -9. Of course this is a simplistic example.

The above observations lead us to conclude that there should be more positively aligned lava than negatively aligned lava. This is indeed the case.

This explanation provides the simplest explanation to the mystery of the reversing magnetic alignment of the geologic record.

The simplest way to prove this theory is to prove that new lava is forming with magnetic alignment reverse to that of the Earth's magnetic field. This will occur where lava is cooling in a negatively aligned magnetic field. If there exists a spot on the Earth where a compass can align negative to the field of the Earth (due to rock deposits or other effects), then any lava that is allowed to cool where that compass is will acquire a magnetic alignment reverse to the Earth's magnetic field. This reverse alignment is acquired without reversing the poles of the Earth.

Conversely, if the reversal of the Earth's magnetic field was the correct explanation for the geologic record, then it must be the dominant magnetic field effect present when lava cools. This means that you could not have cooled lava with acquired field strength greater than the ambient field

strength. Otherwise, if the magnetic poles of the Earth did reverse, then the stronger field intensity in the rocks would create points on the Earth where a compass would align in the negative direction to the Earth's field and the pole reversal theory is moot.

The simple fact that a compass can show a negative reading in spite of the Earth's field is proof that the lava can acquire field strength greater than the ambient field. Furthermore, the field strength acquired by older rock formations is the predominant component affecting the magnetic alignment of new lava.

As a final note, the field reversal can occur if the original rock bed does not fracture; however, the effect may not be as dramatic.

The theory proposed in this paper is a more logical explanation of the magnetic anomalies found in the ocean floor than the theory put forward by *Vine and Matthews*.

The following sources used in this paper

http://gemoc.anu.edu.au/courses/geol3005/jean/GEOL3005/PlateTectonics/Magnetic.html

