INTERCHANGING THE EARTH'S MAGNETIC POLES

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ABSTRACT

Some facts related to constant change of magnetic field of the Earth and magnetic poles position are presented. In the early 20th century geologists first noticed that some volcanic rocks were magnetized in a direction opposite to what was expected. Magnetic field has never been observed to reverse by humans with instrumentation, and the mechanism of field generation is not well understood. Because of that, it is difficult to say what the characteristics of the magnetic field might be leading up to such a reversal.

Keywords: magnetic field, magnetic poles, reversal

1 INTRODUCTION

Earth's magnetic field has changed the magnetic poles many times over the last billion years, according to the geologic records. But only in the past decade have scientists developed and evolved a computer model to demonstrate how these reversals occur. We can see reversals in the rocks, but they don't tell us how it happens.

2 EARTH'S MAGNETIC FIELD

Our planet's magnetic field is in a constant state of change. Scientists know this fact for a long time, but now days they are beginning to understand how it behaves and why.

Scientists have long known that the magnetic pole moves. James Ross located North Pole for the first time in 1831 after his arctic journey during which his ship got stuck in the ice for four years. In 1904, Roald Amundsen found the pole again and discovered that it had moved at least 50 km since the days of Ross.

North Pole kept going during last 100 years toward north at an average speed of 10 km per year, lately accelerating to 40 km per year (Fig. 1). By this speed it will exit North America and reach Siberia in a few decades. Because of such fast movement of pole position, scientists check its location once every few years.

It is important to realize that the position of the North Magnetic Pole given for a particular year is an average position. The Magnetic Pole wanders daily around this average position and, on days when the magnetic field is disturbed, may be displaced by 80 km or more. Although the North Magnetic Pole's motion on any given day is irregular, the average path forms a well-defined oval (Fig. 2).

The cause of the North Magnetic Pole's diurnal motion is quite different than that of its secular motion. The ultimate cause of these fluctuations is the Sun. The Sun constantly emits charged particles that, on encountering the Earth's magnetic field, cause electric currents to flow in the ionosphere and magnetosphere. These electric currents disturb the magnetic field, resulting in a temporary shift in the North Magnetic Pole's position. The size and direction of this shift varies with time, in step with the magnetic field fluctuations. Since such fluctuations occur constantly, the Magnetic Pole is seldom to be found at its "official" position, which is the position in the absence of magnetic field fluctuations.
**Figure 1:** North Pole position during the last 100 years  
Source: [1]

**Figure 2:** Daily North Pole movement  
Source: [1]
Movement of north magnetic pole in time may be presented by graph as it shown on Fig. 3. Increasing in movement speed is evident in the last 30 years.

![Graph showing velocity of North magnetic pole movement in last 100 years]

**Figure 3**: The velocity of North magnetic pole movement in last 100 years

Scientists believe Earth's magnetic field is generated deep inside our planet. There, the heat of the Earth's solid inner core churns a liquid outer core composed of iron and nickel. The churning acts like convection, which generates electric currents and, as a result, a magnetic field [2].

An imaginary line joining the magnetic poles would be inclined by approximately 11.3° from the planet's axis of rotation (Fig 4).

![Image of Earth's Magnetic Field]

**Figure 4**: Earth's Magnetic Field
Source: [3]

This magnetic field shields most of the habited parts of our planet from charged particles that emanate from space, mainly from the sun. The field deflects the speeding particles toward Earth's Poles.

The Earth's magnetic field changes in strength and position. The two poles are not at directly opposite positions on the globe. Currently, the magnetic south pole is farther from the
geographic south pole than the magnetic north pole is from the geographic north pole (Table 1).

<table>
<thead>
<tr>
<th>Table 1: Magnetic Pole Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Latitude, Longitude</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td>North Magnetic Pole, 2004 82.3 N, 113.4 W</td>
</tr>
<tr>
<td>South Magnetic Pole, 2004 63.5 S, 138.0 E</td>
</tr>
</tbody>
</table>

This means that center of mass of "magnetic body" is not correspond to center of mass of the planet Earth.

3 MAGNETIC FIELD REVERSAL

According to many geological investigations, there were in geological history a huge number of magnetic field reversals. Our planet's magnetic field reverses about once every 200,000 years on average. However, the time between reversals is highly variable. The last time Earth's magnetic field flipped was 780,000 years ago, according to the geologic record of Earth's polarity.

Most scientists believe our planet's magnetic field is sustained by what's known as the geodynamo. The term describes the theoretical phenomenon believed to generate and maintain Earth's magnetic field. However, there is no way to peer 4,000 miles (6,400 kilometers) into Earth's center to observe the process in action.

Glatzmaier and Roberts [4] developed their computer model of magnetic field reversal of the Earth. They used hardware Cray C90 computer and User-developed code software for simulation. Since then, they have continued to refine and evolve the model using ever more sophisticated and faster computers.

The simulation shows that in the time of reversal, unusual exist three pairs of north-south poles (Fig. 5).

![Figure 5: Computer model of Earth magnetic lines (Source: [4])]
Because the magnetic field has never been observed in time of reverse by humans with instrumentation, and the mechanism of field generation is not well understood, it is difficult to say what the characteristics of the magnetic field might be leading up to such a reversal. Some speculate that a greatly diminished magnetic field during a reversal period will expose the surface of the earth to a substantial and potentially damaging increase in cosmic radiation. However, *Homo erectus* and their ancestors certainly survived many previous reversals. There is no evidence that a magnetic field reversal has ever caused any biological extinction. A possible explanation is that the solar wind may induce a sufficient magnetic field in the Earth's ionosphere to shield the surface from energetic particles, even in the absence of the Earth's normal magnetic field.

Earth's magnetic field is changing in other ways, too: globally, the magnetic field has weakened 10% since the 19th century. Does it mean that Earth's magnetic field collapsing, to vanishing in the future?

The answer is: probably not. From the data recording on Geomagnetic observatories in Central Europe in the last 50 years, components of geomagnetic field show trend of increasing for about 15 nT (nanoTesla) per year.

The yearly trend of total vector of geomagnetic field is presented in Table 2. According to International formula, this trend is depended on latitude and longitude too.

### Table 2: The yearly trend of geomagnetic field intensity in nanoTesla (nT)

<table>
<thead>
<tr>
<th>Latitude (degrees)</th>
<th>0</th>
<th>30</th>
<th>60</th>
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<tbody>
<tr>
<td>0</td>
<td>7.9</td>
<td>-22.7</td>
<td>9.5</td>
<td>7.2</td>
</tr>
<tr>
<td>10</td>
<td>8.5</td>
<td>-4.5</td>
<td>4.0</td>
<td>4.1</td>
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<td>20</td>
<td>9.8</td>
<td>6.8</td>
<td>1.7</td>
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<tr>
<td>30</td>
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<tr>
<td>70</td>
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<td>0.5</td>
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</tr>
<tr>
<td>80</td>
<td>0.2</td>
<td>-2.1</td>
<td>-7.6</td>
<td>-13.8</td>
</tr>
<tr>
<td>90</td>
<td>-9.5</td>
<td>-10.2</td>
<td>-10.2</td>
<td>-10.6</td>
</tr>
</tbody>
</table>

According to Glatzmaier, the ongoing 10% decline doesn't mean that a reversal is imminent. The field is increasing or decreasing all the time. It is well known from studies of the paleomagnetic record. Earth's present-day magnetic field is, in fact, much stronger than normal. The dipole moment, a measure of the intensity of the magnetic field, is now $8 \times 10^{22}$ amps $\cdot$ m$^2$. That's twice the million-year average of $4 \times 10^{22}$ amps $\cdot$ m$^2$.

To understand what's happening, says Glatzmaier, we have to take a trip ... to the center of the Earth where the magnetic field is produced.

At the heart of our planet lies a solid iron ball, about as hot as the surface of the sun. Researchers call it "the inner core." It's really a world within a world. The inner core is 70% as wide as the moon. It spins at its own rate, as much as 0.2° of longitude per year faster than the Earth above it, and it has its own ocean: a very deep layer of liquid iron known as "the outer core."

Using the equations of magnetohydrodynamics, a branch of physics dealing with conducting fluids and magnetic fields, Glatzmaier and colleague Paul Roberts have created a
supercomputer model of Earth's interior. Their software heats the inner core, stirs the metallic ocean above it, then calculates the resulting magnetic field. They run their code for hundreds of thousands of simulated years and watch what happens.

What they see mimics the real Earth: The magnetic field waxes and wanes, poles drift and, occasionally, flip. Change is normal, they've learned. And no wonder. The source of the field, the outer core, is itself seething, swirling, turbulent. "It's chaotic down there," notes Glatzmaier. The changes we detect on our planet's surface are a sign of that inner chaos.

They've also learned what happens during a magnetic flip. Reversals take a few thousand years to complete, and during that time - contrary to popular belief - the magnetic field does not vanish, it just gets more complicated. Magnetic lines of force near Earth's surface become twisted and tangled, and magnetic poles pop up in unaccustomed places. A south magnetic pole might emerge over Africa, for instance, or a north pole over Tahiti. But it's still a planetary magnetic field, and it still protects us from space radiation and solar storms.

4 CONCLUSION

The earth's magnetic field is still, after so many years of researching, unknown event that exist on our planet. After geological evidence on many magnetic reversal events in million years of Earth's history, scientists tried to explain what caused such enormous change of magnetic polarity and what happens on the earth surface during the event occurs. Some explanation appeared, but no one of them is quite satisfied. The far future will tell us the answer.

REFERENCES