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On the Origin of Water on Earth and Mars - A New Hypothesis

Hans Merkl[1]

[1] Am Kirchsteig, Germany

Correspondence: Hans Merkl, Am Kirchsteig 4, D-92637 Weiden, Germany. E-mail: flacherhans@gmx.de

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Abstract

The question regarding the origin of water on Earth is still to be answered scientifically and accurately. It is certain that water in liquid or gaseous form could not have existed on the young, red-hot Earth. It is therefore generally assumed that comets brought water to Earth. However, the isotope ratio (H/D) of water on comets is more than double that of water on Earth, which means that only part of Earth´s water could have come from comets.

Intensive laboratory experiments at the Tokyo Institute of Technology in Japan shows that, the stable bipolar magnetic field that we have today, that protects the Earth from the solar wind – a plasma flow of protons and electrons – was actually formed just less than one billion years ago. Interestingly, recent laboratory tests at the University of Maryland, USA, have shown that during the Earth´s early period, when its core of iron and nickel was still molten, the young Earth must have had a multipolar magnetic field. However, this multipolar magnetic field could not have provided any protection from the solar wind. In fact, it would have acted as a huge collector of the solar wind and the same would have applied to our neighboring planet Mars. The result from these two research experiments have now led to a completely new hypothesis regarding the origin of water on both Earth and Mars.

During the early period of the two planets, the solar wind would have been able to penetrate along the vertical magnetic field lines into the dense, Venus-like carbon dioxide atmospheres of Earth and Mars. Because of the lack of an ozone layer, the atmosphere would have been exposed to the powerful ultraviolet rays and strong solar wind of the young Sun, which would have split the carbon dioxide molecules in the atmosphere into their component parts of oxygen and carbon. The oxygen released would therefore have been able to combine with the hydrogen nuclei of the solar wind to form water molecules which then fell down as rain.

Keywords: Earth magnetic field, solar wind, Mars

1. Introduction

1.1 Existing Theories on the Origin of Water

Most geologists believe that the formation of the oceans and the atmosphere can be attributed to activities that occurred within the Earth itself. They argue that water was originally locked inside certain minerals as for example ringwoodite (FeOH). In other words, it existed as “hidden water” (Pearson et al.) in the form of its component parts, oxygen and hydrogen. But it is not clear how much water resides within the solid Earth, and where it is to be found. Approximately 500 million years after the Earth’s formation, when its surface had cooled sufficiently for a crust of rock to form, volcanoes then transported gases such as water vapour, carbon dioxide, nitrogen, and sulphurous compounds to the surface in conjunction with the lava, which led to the formation of the atmosphere surrounding the Earth in its original state. The water vapour then condensed and the ensuing rain created the oceans.

This is one possibility; however, astronomers do not agree with this theory at all. They argue that water could not have existed at that time, either in liquid or in gaseous form, because of the high temperatures within the region in which the Earth was formed. Therefore, they believe that water first arrived on Earth through bombardment by asteroids, meteorites, and comets that came from the cooler peripheral fringes of our planetary system. Comets, also known as dirty snowballs, certainly are worthy of consideration; however, there are two problems. The first is that the isotope ratio (Deuterium/H_20) of water on most comets and especially of comets from the Oort cloud (D/H = 0.031%) is more than double that of water on Earth (D/H = 0.015%). Comet 67P Tschurjumov-Gerasimenko, measured 2014 by Rosetta even had a D/H of 0.053%. The second problem is that the actual percentage water content of comets is still not known; some scientists believe it could be 80–90%. In 2005, the comet Tempel 1 was struck by a 372 kg projectile fired from a space probe. The impact created a crater with an estimated diameter of 450 m and depth of 50 m. The material ejected comprised fine dust without sizeable quantities of water vapour. For this reason, it is suggested that the assumed value of the water content of a comet's composition of 80–90% is much too high. It may possibly be as low as 10%, in which case, bombardment by a very high number of comets would have been necessary to account for the quantity of water in our oceans

1.2 Another Point of View about the Origin of Water

Which of these two theories is then correct? Why, when they presumably experienced the same history as Earth, namely volcanism and bombardment by stray celestial bodies does Venus have only traces of water in its atmosphere (20 ppm) and Mars just frozen remains on its polar caps.

How do the three inner planets—Venus, Earth, and Mars—differ from one another, apart from with regard to the volume of water? All three planets are composed of similar material. Their atmospheres at the beginning of time were similar to that found on Venus today, which is composed of 96% carbon dioxide with a volume that generates an atmospheric pressure on the planet's surface of 90 bar, as opposed to the pressure of just 1 bar on Earth. Despite Venus being closer to the sun, the higher percentage of carbon dioxide and the greater atmospheric pressure are the major reasons for the low-level atmosphere's high temperature of 450 °C. That Mars once had water and perhaps even a sea has now been proven by the Mars probes that have landed there. However, now most of its surface is as dry as dust and Mars only has a thin atmosphere consisting largely of carbon dioxide.

One physical fact immediately stands out: neither Venus nor Mars has a magnetic field. Therefore, is the existence of Earth's magnetic field one of the reasons for the abundance of water on our planet?

2. Recent Research Results on the Magnetic Field

2.1 The Stable Magnetic Field

Hirose (2010) at the Tokyo Institute of Technology, has performed a number of experiments on this subject and has made a completely new scientific discovery about the Earth's magnetic field. Laboratory experiments based on high temperature and high pressure have led to the discovery that the mantle material 660 km underground is composed of magnesium silicate ($MgSiO_3$), a material with a compact crystalline structure from the so-called perovskite crystal family. Back in the 1960s, however, a seismic anomaly was discovered at a depth of 2,600–2,900 km, on the border of the molten ferrous core.

Through his experiments in the high-pressure laboratory, Hirose has proved that the perovskite underwent a phase transition and it was converted to post-perovskite. However, this post-perovskite layer at the depth of 2,600–2,900 km has greater conductivity, raising the heat flow from the Earth's core by 20%. Historically, this accelerated cooling process had far-reaching consequences both for the Earth's surface (volcanism, plate tectonics) and more especially for its molten core, where a solid metal core was able to form in the centre. This division into a solid inner and a molten external metal core could only have occurred during the more recent period of Earth's history of less than one billion years ago; otherwise, the solid core would be much larger than it is today. From this, Professor Hirose deduced that the Earth's stable, bar-shaped, bipolar, and protective magnetic field was able to form as a consequence. Interestingly, this finding coincides with other scientific research in the fields of geology and biology. We now know that 540 million years ago, life on Earth evolved abruptly. It is known as the "Cambrian Explosion" of life, but it was only possible because the new bipolar magnetic field protected our planet from the deadly cosmic radiation.

2.2 The Early Multipolar Magnetic Field

However, we also know through laboratory experiments performed by Lathrop (2010) at the University of Maryland, USA, that in the case of a completely molten metal core, as the young Earth once had, the magnetic field would be multipolar.

Professor Lathrop's model of the Earth comprised a 3-m-diameter metal sphere filled with liquid sodium, which weighed 13 tonnes. The temperature of the sodium during the experiment was just slightly over 100 °C. Molten iron would have been too hot. As soon as the sphere was made to rotate, a multipolar magnetic field formed together with internal heat convection. The magnetic field lines from the surface of the sphere emanated vertically in all directions, traced arcs, and then returned vertically to the surface of the sphere. Such behaviour of magnetic fields is familiar to us from observations of the surface of the Sun.

Because of this multipolar form of the magnetic field, the young Earth was not shielded from the solar wind during its first billion years of existence. The vertical magnetic field lines would have offered no protection and the protons and electrons of the solar wind would have been able to penetrate into the Earth's carbon dioxide atmosphere directly along the vertical magnetic field lines. Thus, the magnetic field acted as a huge collector of solar wind plasma. As the Earth took at least 10 hours to complete one rotation on its axis at the beginning of its existence, the magnetic field must have been very strong. In addition, astronomers (Lammer et al., 2008) have discovered that nearby young stars—cosmically speaking—that are similar to our sun, have a solar wind that is almost 1000 times stronger than that currently emitted by the Sun.

This extremely strong solar wind would have been positively sucked up by the vertical magnetic field lines. The probably strong ultraviolet rays from the young Sun, which would not have been slowed down because of the lack of an ozone layer, would have split the carbon dioxide molecules in the dense, Venus-like atmosphere of the early Earth. The released oxygen atoms and the hydrogen ions of the solar wind would therefore have been able to form water.

2.3 Calculation

How long might it have taken the early multipolar magnetic field to produce our oceans?

Average readings of the solar wind between 2001 - 2004:

$$\text{Velocity} = 450 \text{ km/s} \qquad [v]$$

$$\text{Particle density} = 6.5 \text{ protons/cm}^3 \qquad [d]$$

Values according to Eric Wischnewski´s encyclopedia (2006): Velocity = 400 – 800 km/s

Particle density = 5 - 40 p/cm^3

If it is assumed that the extent of the Earth's early multipolar magnetic field was roughly the same as the protective, bipolar magnetic field we have now, namely 60,000 km [r], and that the solar wind was 1000 times more powerful than that currently emitted by the Sun, it is possible to calculate:

$$v \times d \times A[r^2 \times \pi] = 4.5 \times 10^7 \text{ cm/s} \times 6.5 \text{ prot./cm}^3 \times [(6 \times 10^9\text{cm})^2 \times \pi]$$

$$\approx 3 \text{ prot.} \times 10^8/\text{cm}^2\text{s} \times 36 \times 10^{18} \text{ cm}^2 \times 3.14 = 339 \times 10^{26} \text{ prot./s}$$

Because it is necessary to have two protons (hydrogen ions) to obtain one water molecule, we get in 1 s = 169.5×10^{26} water molecules.

The mass of one water molecule = 3.0129×10^{-26} kg

Therefore, in 1 s, it is theoretically possible that:

169.5×10^{26} mo./s × 3.0129×10^{-26} kg/mo. = 510.7 kg/s of water could have been produced in the atmosphere of the early red-hot Earth in one second!

Therefore, in one year: 510.7 kg/s × 365 × 24 × 3600 s = 1.61054×10^{10} kg of water.

In one million years: 1.6×10^{10} kg × 10^6 = 1.6×10^{16} kg of water.

In 100 million years: $1.6 \times 10^{16} \times 10^2 = 1.6 \times \cdot 10^{18}$ kg of water.

If the solar wind were 1000 times stronger, we would obtain a mass of 1.6×10^{21} kg of water in 100 million years.

Therefore, the quantity of water (1.4×10^{21} kg) found in our oceans today, could have been created in just 100 million years.

3. Discussion

We know a similar reaction from space, where H + O = OH and then H + OH reacts to form H_2O (Rehder, 2011). This reaction also could have taken place in the primordial atmosphere of the Earth due to the high CO_2 concentration. The water molecules which have been generated in this way would have been heavy enough to be prevented from drifting off into space by the gravitational pull of the Earth. They would have fallen to the ground as rain, causing the red-hot surface of the young Earth to cool very quickly.

Studies of single zircons ($ZrSnO4$) from Jack Hills, Western Australia with an age of 4.4 billion years show that, at that early time the continental crust of the Earth surface already was cool enough for liquid water (Valley, 2010). It likely was cooled down in this early stage by great amounts of rain.

In the case of Venus, which has no magnetic field because of its slow rotation, this process of collection of the solar wind plasma would have been missing. This would then explain why Venus does only have traces of water (20 ppm) in its atmosphere and why it still has its original, dense atmosphere, rich in carbon dioxide. In the Earth's case, almost all the carbon dioxide in the atmosphere was transformed into water. This conversion of the carbon dioxide by the solar wind saved us from being exposed to the powerful greenhouse effect that exists on Venus. In addition, our oceans were formed very soon afterwards, providing water essential to life.

Of course, a similar process also occurred on Mars, which soon cooled down because of its small size. We even know now that it lost its magnetic field four billion years ago. According to NASA, the largest meteorite crater in our planetary system, which has a diameter of 2,000 km, is to be found on Mars. This gigantic impact occurred four billion years ago. The meteorite punctured the crust on Mars, resulting in the crater filling with magma. The rock around the crater is magnetized although the magma within the basin of the crater shows no traces of magnetization. This means that Mars no longer had a magnetic field at the time of the impact; thus, its molten ferrous core had already solidified. As such, one of the prerequisites for a magnetic field (convection in the core + rotation) had ceased to exist. Over billions of years, it lost almost all its water and most of its atmosphere because of its low gravity and lack of a protective, bar-shaped magnetic field. Furthermore, it did not receive replenishment via the solar wind plasma at the poles to compensate for the loss of water into space.

4. Conclusion

Our sun - that huge gaseous ball of hydrogen at the centre of our planetary system - ejects its ionised and therefore bare hydrogen nuclei at high velocity into its solar environment. Therefore, the suggestion that soon after the formation of the inner planets, the solar wind acted as a water supplier, aided by the multipolar magnetic fields on Earth and Mars, is not a utopian idea. Analyses of samples brought back from the Moon as part of the Apollo program point to the accuracy of this theory. Stephant and Robert (2014) show that most water in lunar soil is generated by solar wind, and not a result of comet or meteorite impacts.

Other researchers believe that water could also have been formed along the same principle, at least on planets close to the sun. However, the splitting of carbon dioxide molecules in the dense atmosphere of a planet by the solar wind, trapped by a distended multipolar magnetic field, must be a more effective mechanism for producing vast quantities of water. – The Solar wind is theoretically deuterium free. But in reality it has a D/H-ratio of 2×10^{-5}. The Isotope ratio (D/H) of the water in the ocean is 15×10^{-5}. This raises the question where the high D/H-value comes from? – The simplest explanation is that a mixture between the comets´ water ($D/H \geq 50 \times 10^{-5}$), the hidden water and the water produced from solar wind has taken place.

Astronomers should search for evidence of this hypothesis in extrasolar planetary systems, because the same physical laws apply throughout the entire universe.

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