The Genesis of the Earth's Moon

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Here we show how in the early Earth, a matter column, which extended from the Earth's surface down to near the upper boundary of the outer core, it was vaporized due to a suddenly increase of temperature greater than 8,367°C, and after ejected of the Earth by the enormous pressure at the bottom of the mantle (~136 GPa), forming posteriorly the Moon.

Key words: Moon origin, Earth, Solar UV Radiation, Gravitation, Gravitational Mass.

1. Introduction

For several years scientists have struggled to determine the origin of Earth's Moon. A common origin for the Moon and Earth is required by their identical isotopic composition. The Earth and Moon are isotopically indistinguishable from one another at the level of five parts per million [1].

Five theories have been proposed in order to explain the formation of the Moon:

1. *The Fission Theory:* The Moon was once part of the Earth and *somehow it has been separated from the Earth* early in the history of the Solar System [2, 3, 4, 5].
2. *The Capture Theory:* The Moon was formed somewhere else, and later captured by the Earth's gravitational field [6, 7, 8, 9].
3. *The Condensation Theory:* Moon and Earth have condensed together from the original nebula that formed the Solar System [10, 11, 12, 13].
4. *The Colliding Planetesimals Theory:* The interaction of earth-orbiting and Sun-orbiting planetesimals early in the history of the Solar System led to their breakup. The Moon condensed from this debris [14, 15, 16].
5. *The Giant Impact Theory:* A planetesimal with the size of Mars struck the Earth, ejecting large amounts of matter. A disk of orbiting material was formed, and posteriorly this matter was condensed, forming the Moon [17, 18, 19, 20].

Samples of lunar rocks brought to Earth by the Apollo project have revealed two important things:

a) The Moon lacks iron. While the Earth's core has a lot of iron [21].

b) The Moon and the Earth have exactly the same oxygen isotope composition [22].

The fact that the Moon and the Earth have exactly the same oxygen isotope composition has been a challenge for the giant impact theory, because the impactor's composition would have likely differed from that of Earth. In the impact theory, the Moon was formed from debris ejected into an Earth-orbiting disk by the collision of a large planetesimal with the early Earth. Prior impact simulations shows that much of the disk material originates from the colliding planet. Thus, is very difficult for the giant impact theory to explain the fact that the Earth and the Moon have essentially identical oxygen isotope compositions. This led recently scientists to wonder if there is another explanation for the origin of the moon besides the giant impact theory.

Here we show how in the early Earth, a matter column, which extended from the Earth's surface down to near the upper boundary of the outer core, it was vaporized due to a suddenly increase of temperature greater than 8,367°C, and after ejected of the Earth by the enormous pressure at the bottom of the mantle (~136GPa), forming posteriorly the Moon. As the ejected matter was basically mantle's matter, which is very poor in iron, the Moon has been formed with *low portion of iron*. This explain, why the Earth has a large portion of iron while the Moon almost none.

2. Theory

The physical property of mass has two distinct aspects: *gravitational mass* m_g and *inertial mass* m_i. The gravitational mass produces and responds to gravitational fields; it supplies the mass factor in Newton's famous inverse-square law of gravity $\left(F = GM_g m_g / r^2\right)$. The inertial mass is the mass factor in *Newton's 2nd Law of Motion* $\left(F = m_i a\right)$. These two masses are not equivalent but correlated by means of the following factor [23]:

$$\frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{\Delta p}{m_{i0} c}\right)^2} - 1\right]\right\} \qquad (1)$$

where m_{i0} is the *rest* inertial mass and Δp is the variation in the particle's *kinetic momentum*; c is the speed of light.

This equation shows that only for $\Delta p = 0$ the gravitational mass is equivalent to the inertial mass. When Δp is produced by the incidence of *electromagnetic radiation*, Eq. (1) can be rewritten as follows [23]:

$$\frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{n_r^2 D}{\rho\, c^3}\right)^2} - 1\right]\right\} \qquad (2)$$

where n_r is *the refraction index* of the particle; D is the power density of the electromagnetic radiation absorbed by the particle; and ρ, its density of inertial mass.

From Electrodynamics we know that

$$v = \frac{dz}{dt} = \frac{\omega}{\kappa_r} = \frac{c}{\sqrt{\frac{\varepsilon_r \mu_r}{2}\left(\sqrt{1 + (\sigma/\omega\varepsilon)^2} + 1\right)}} \qquad (3)$$

where k_r is the real part of the *propagation vector* $\vec{k}$ (also called *phase constant*); $k = \left|\vec{k}\right| = k_r + ik_i$; ε , μ and σ, are the electromagnetic characteristics of the medium in which the incident radiation is propagating ($\varepsilon = \varepsilon_r \varepsilon_0$; $\varepsilon_0 = 8.854 \times 10^{-12} F/m$; $\mu = \mu_r \mu_0$, where $\mu_0 = 4\pi \times 10^{-7} H/m$). Thus,

Equation (3), tells us that the *index of refraction* $n_r = c/v$, for $\sigma >> \omega\varepsilon$, is given by

$$n_r = \sqrt{\frac{\mu_r \sigma}{4\pi f \varepsilon_0}} \qquad (4)$$

Substitution of Eq. (4) into Eq. (3) yields

$$\chi = \frac{m_g}{m_{i0}} = \left\{1 - 2\left[\sqrt{1 + \left(\frac{\mu\sigma D}{4\pi\rho\, cf}\right)^2} - 1\right]\right\} \qquad (5)$$

It was shown that there is an additional effect - *Gravitational Shielding* effect - produced by a substance whose gravitational mass was reduced or made negative [23]. Also it was shown that, if the *weight* of a particle in a side of a lamina is $\vec{P} = m_g \vec{g}$ ($\vec{g}$ perpendicular to the lamina) then the weight of the same particle, in the other side of the lamina is $\vec{P}' = \chi m_g \vec{g}$, where $\chi = m_g / m_{i0}$ (m_g and m_{i0} are respectively, the gravitational mass and the inertial mass of the lamina). Only when $\chi = 1$, the weight is equal in both sides of the lamina. The lamina works as a Gravitational Shielding. This is the *Gravitational Shielding effect*. Since $P' = \chi P = \left(\chi m_g\right) g = m_g \left(\chi g\right)$, we can consider that $m'_g = \chi m_g$ or that $g' = \chi g$.

If we take two parallel gravitational shieldings, with χ_1 and χ_2 respectively, then the gravitational masses become: $m_{g1} = \chi_1 m_g$, $m_{g2} = \chi_2 m_{g1} = \chi_1 \chi_2 m_g$, and the gravity will be given by $g_1 = \chi_1 g$, $g_2 = \chi_2 g_1 = \chi_1 \chi_2 g$. In the case of multiples gravitational shieldings, with $\chi_1, \chi_2, ..., \chi_n$, we can write that, after the n^{th} gravitational shielding the gravitational mass, m_{gn}, and the gravity, g_n, will be given by

$$m_{gn} = \chi_1 \chi_2 \chi_3 ... \chi_n m_g\,, \quad g_n = \chi_1 \chi_2 \chi_3 ... \chi_n g \qquad (6)$$

This means that, n superposed gravitational shieldings with different $\chi_1, \chi_2, \chi_3, ..., \chi_n$ are equivalent to a single gravitational shielding with $\chi = \chi_1 \chi_2 \chi_3 \cdots \chi_n$.

The dependence of the shielding effect on the height, at which the samples are placed above a superconducting disk with radius $r_D = 0.1375m$, has been recently measured up to a height of about 3m [24]. This means that the gravitational shielding effect extends, beyond the disk, for approximately *20 times* the disk *radius*.

3. Gravitational Shieldings in the Van Allen belts

The *Van Allen belts* are torus of plasma around Earth, which are held in place by Earth's magnetic field (See Fig.1). The existence of the belts was confirmed by the Explorer 1 and Explorer 3 missions in early 1958, under Dr James Van Allen at the University of Iowa. The term *Van Allen belts* refers specifically to the radiation belts surrounding Earth; however, similar radiation belts have been discovered around other planets.

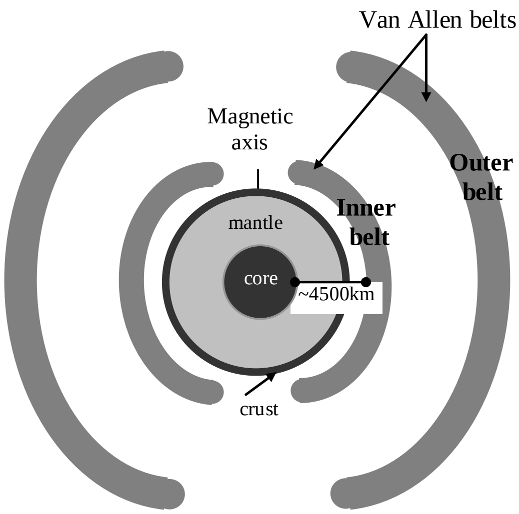

Fig.1 – Van Allen belts

The UV radiation emitted from the Sun interacts with the atoms of the upper atmosphere producing a large amount of ions. This put the value of the current parallel conductivities, σ_{0i} and σ_{0o}, in the Van Allen belts,* between the conductivities of the metallic conductors and the conductivities of the semiconductors [25]. However, if *a sufficiently strong stream of* UV radiation crosses the mentioned region, then the conductivity at the region can be increased up to a value of the order of the conductivities of the metallic conductors $\left(10^7 S/m\right)$.

Thus, assuming that this has occurred at about 4 billion years ago, in a region of the Van Allen belts, then two Gravitational Shieldings have been formed in this region, with conductivities of the order of $10^7 S/m$. The strong stream of UV radiation here mentioned, can have coming from the Sun, and also should not have been a single stream but a beam of streams.

On the other hand, considering that the quasi-vacuum of the interplanetary space might be thought of as beginning at an altitude of about 1000km above the Earth's surface [25], then we can assume that the densities ρ_i and ρ_o respectively, at the first gravitational shielding S_i (at the *inner* Van Allen belt) and at S_o (at the *outer* Van Allen belt) are $\rho_o \cong \rho_i \cong 0.8\times10^{-20} kg.m^{-3}$ (density of the *interplanetary medium* near the Earth [26]).

Thus, in these mentioned Gravitational Shieldings, according to Eq. (5), we have, respectively:

$$\chi_i = \left\{1 - 2\left[\sqrt{1+\left(4.1\times10^{11}\frac{D_i}{f}\right)^2} - 1\right]\right\} \tag{7}$$

and

$$\chi_o = \left\{1 - 2\left[\sqrt{1+\left(4.1\times10^{11}\frac{D_o}{f}\right)^2} - 1\right]\right\} \tag{8}$$

where

$$D_i \cong D_o \cong \frac{P_{rad}}{S_a} \tag{9}$$

P_{rad} is the UV radiation power; f is the

* Conductivity in presence of the Earth's magnetic field

frequency of the UV radiation; S_a is the area of the cross-section of the UV radiation flux.

Substitution of (9) into (7) and (8), leads to the following expression for $\chi_0\chi_i$:

$$\chi_o\chi_i = \left\{1 - 2\left[\sqrt{1 + \left(4.1\times10^{11}\frac{P_{rad}}{S_a f}\right)^2} - 1\right]\right\}^2 \qquad (10)$$

4. Effect of the gravitational shieldings S_i **and** S_o **on the Earth.**

If the *cross section of each stream* of the beam of solar UV radiation, which can have crossed a region of the Van Allen belts at about 4 billion years ago, had an *average length scale* of about 450km, then, based on the Podkletnov experiment previously mentioned, we can conclude that the effect of the gravitational shielding formed in the Van Allen belts extend down to near to the upper boundary of the Earth's outer core (about 4,500Km below Si) (See Fig.1), affecting therefore, a column of matter that extend since below of Si down to the upper border of the Earth's outer core.

Since the mass that corresponds to the Earth's mantle in the mentioned column of matter, is much larger than the mass that corresponds to crust and the mass of air column, we can express the mass of the column by means of the following expression $m_{col} \cong \bar{\rho}_m V_m$, where $\bar{\rho}_m$ is the average density of the mantle; V_m is the volume of the column through the mantle.

The gravitational potential energy related to m_{col}, with respect to the Sun's center, without the effects produced by the gravitational shieldings S_o and S_i is

$$E_{p0} = m_{col} r_{se}\left(g - g_{sun}\right) \qquad (11)$$

where, $r_{se} = 1.49\times10^{11}m$ (distance from the Sun to Earth, 1 AU), $g = 9.8m/s^2$ and $g_{sun} = -GM_{sun}/r_{se}^2 = 5.92\times10^{-3}m/s^2$, is the gravity due to the Sun at the Earth.

The gravitational potential energy related to m_{col}, with respect to the Sun's center, considering the effects produced by the gravitational shieldings S_o and S_i, is

$$E_p = m_{col} r_{se}\left(g - \chi_o\chi_i g_{sun}\right) \qquad (12)$$

Thus, the *decrease* in the gravitational potential energy is

$$\Delta E_p = E_p - E_{p0} = \left(1 - \chi_o\chi_i\right) m_{col} r_{se} g_{sun} \qquad (13)$$

Substitution of (10) into (13) gives

$$\Delta E_p = \left\{1 - \left\{1 - 2\left[\sqrt{1 + \left(4.1\times10^{11}\frac{P_{rad}}{S_a f}\right)^2} - 1\right]\right\}^2\right\} m_{col} r_{se} g_{sun} \qquad (14)$$

This decrease in the gravitational potential energy of the matter column, ΔE_p, produces a decrease Δp in the local pressure p (*Bernoulli principle*). Then the pressure equilibrium between the Earth's mantle and the Earth's core, in the region corresponding to the mentioned column, is broken. This is equivalent to an increase of pressure Δp in the bottom of the column (Fig.2).

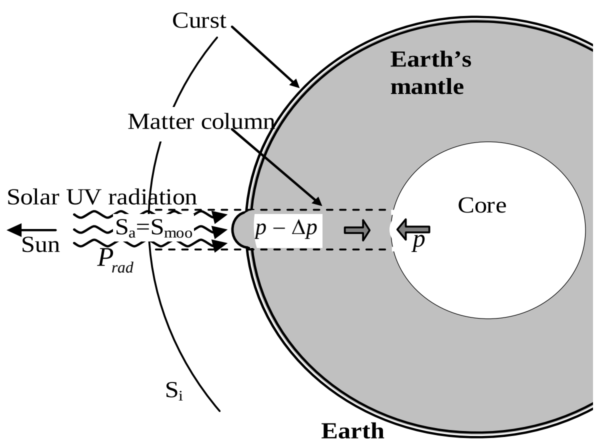

Fig. 2 - The decrease in the gravitational potential energy of the matter column, ΔE_p, produces a *decrease* Δp in the local pressure p (Principle of Bernoulli). Then the pressure equilibrium between the Earth's mantle and the Earth's core, in the region corresponding to the matter column, is broken. This is equivalent to an increase of pressure Δp in the bottom of the mentioned column.

The decrease, ΔE_p, in the gravitational potential energy *increases* the *kinetic energy* of the local at the same ratio, in such way that the mass m_{col} of the column acquires a kinetic energy $E_k = \Delta E_p$. If this energy is not enough to pluck the mass m_{col} from the Earth, and launch it into space, then E_k is converted into heat, raising the local temperature by ΔT, the value of which can be obtained from the following expression:

$$\left\langle \frac{E_k}{N} \right\rangle \cong k\Delta T \qquad (15)$$

where N is the number of atoms in the volume V of the substance considered $(V = V_m)$; $k = 1.38\times10^{-23}\,J/K$ is the *Boltzmann constant*. Thus, we can write that

$$\Delta T \cong \frac{E_k}{Nk} = \frac{(1-\chi_o\chi_i)m_{col}r_{se}g_{sun}}{(nV_m)k} \qquad (16)$$

Since $m_{col} \cong \bar{\rho}_m V_m$, we get

$$\Delta T \cong \frac{(1-\chi_o\chi_i)\,\bar{\rho}_m r_{se} g_{sun}}{nk} \qquad (17)$$

where n is the number of atoms/m^3 in the substance considered ($n \cong 8\times10^{28}\,atoms.m^{-3}$ for Earth's mantle, since Earth's mantle contains 46.6% of Oxygen, 27.7% of Silicon, 5% of iron, 2.1% Magnesium, 3.6 Calcium [27]). The Earth's mantle is a layer between the crust and the upper border of the outer core. Earth's mantle is a silicate rocky shell about 2,900 km thick. The pressure at the bottom of the mantle is ~136 GPa [28]. The average density of the Earth's mantle is about 4,500kg/m^3 [29].

Thus, from (17), we obtain the increase of temperature in the matter column (portion of the mantle), i.e.,

$$\Delta T \cong 3.6\times10^6(1-\chi_o\chi_i) \qquad (18)$$

By substitution of Eq. (10) into Eq. (18), we obtain

$$\Delta T \cong$$
$$\cong 3.6\times10^6\left\{1-\left\{1-2\left[\sqrt{1+\left(4.1\times10^{11}\frac{P_{rad}}{S_a f}\right)^2}-1\right]\right\}^2\right\} \qquad (19)$$

Considering that the average frequency of the UV radiation is about $10^{16}\,Hz$, then Eq. (19) can be rewritten as follows

$$\Delta T \cong$$
$$\cong 3.6\times10^6\left\{1-\left\{1-2\left[\sqrt{1+\left(4.1\times10^{-5}D_{rad}\right)^2}-1\right]\right\}^2\right\} \qquad (20)$$

where D_{rad} is the power density of the UV radiation.

Note that for $D_{rad} > 845.28\,W/m^2$ *the increase temperature in the column of matter* previously mentioned, according to Eq. (20), is $\Delta T > 8{,}640\,K = 8{,}367°C$.

Around four billion years ago, the temperature of Earth's mantle was around *T* = 1,700°C [30]. Thus, with the increase of $\Delta T > 8{,}367°C$, *the matter column*, which extended basically from the Earth's surface down to near the upper boundary of the outer core, it was suddenly vaporized (*rock vapor*), and after ejected of the Earth by the enormous pressure at the bottom of the mantle, which is of the order of 136 GPa [28].

Therefore, if the beam of solar UV radiation (distribution of the streams inside the beam) has affected a total area, which was approximately equal to, or greater than the area of the cross-section of the moon, then the amount of ejected matter has been sufficient to form the Moon.

As the ejected matter was basically mantle's matter, which is very poor in iron, the Moon has been formed with *low portion of iron*. This explain, why the Earth has a large portion of iron while the Moon almost none.

Also explains why the density of the Moon is the same as that of the rocks of Earth's mantle. In addition, condensing in space, the high-speed cloud of rock vapor would incorporate *refractory elements*, while would be poor in *volatile elements* (gases that become liquids at very low temperatures such as water vapor) because they would be slow to condense. This shows therefore, why Moon rocks have a composition which is similar to that of our own planet, but are *slightly enriched in refractory elements* (metals with a very high melting point), and are relatively lacking in *volatile* elements.

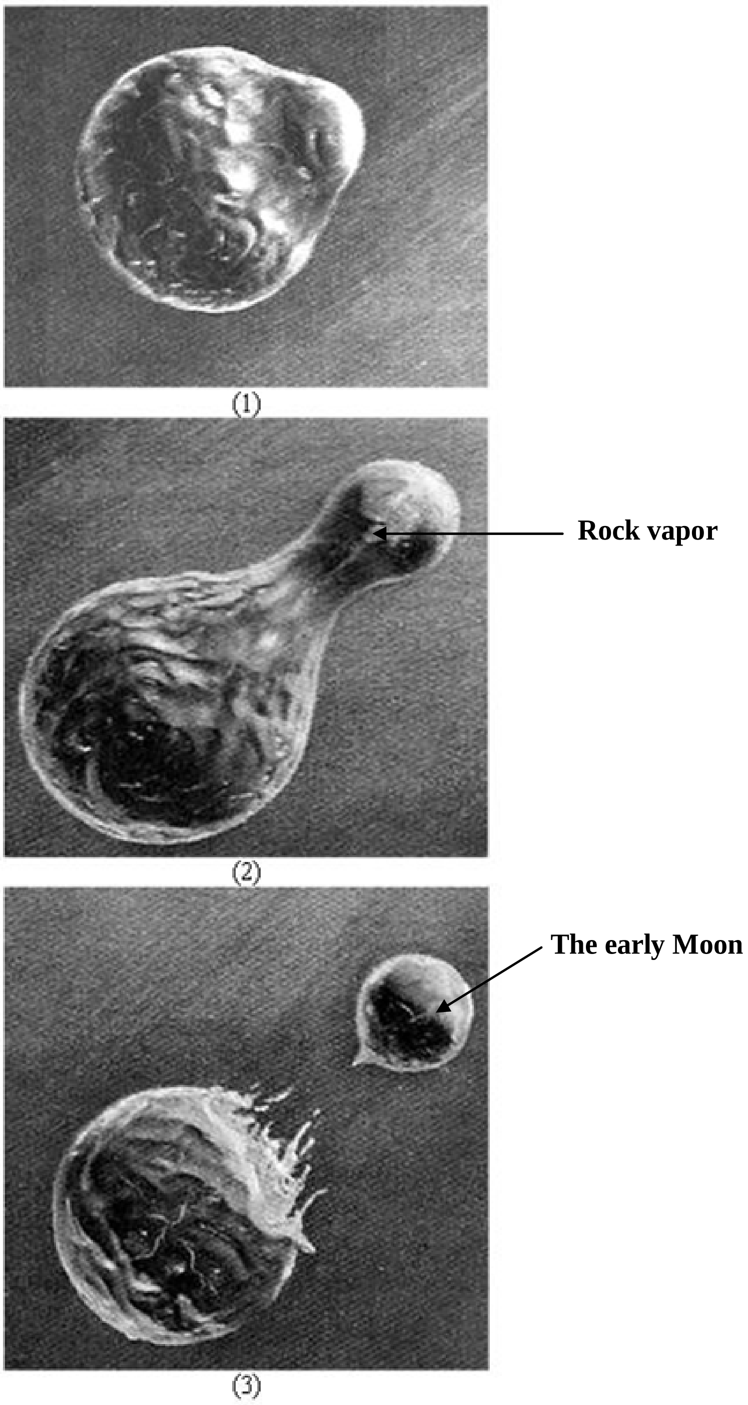

Fig. 1 – The *Genesis of the Moon*. With the increase of $\Delta T > 8{,}367°C$, *the matter column*, which extended from the Earth's surface down to near the upper boundary of the outer core, it was suddenly vaporized (*rock vapor*), and after ejected of the Earth by the enormous pressure at the bottom of the mantle, which is of the order of 136 GPa, forming posteriorly the Moon. The figures (1), (2), and (3) illustrate the phenomenon.

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