Formation of the Moon and Its Influence on Earth’s Environment

Cui-Xiang Zhong

Department of Physics, Jiangxi Normal University, Nanchang 330022, China

Abstract: There are many hypotheses about the formation and evolution of the Moon, but all these hypotheses have their own questions that are hard to answer, therefore incredible. So by analyzing the evolution of the Earth, the author finds that after the formation of the Earth’s spherical structure, Earth’s polar vortices and active volcanoes can frequently eject large amounts of material into the upper air or even above the stratosphere, making the Earth’s atmosphere contain a lot of dust, volcanic ash, water vapor, aerosol and so on. As the Earth rotates, these materials gradually form “nebulae” around the Earth. The lunar prototype was formed near the stratosphere, it keeps colliding and accreting nebular material near its orbit and getting bigger and bigger, and gradually moves away from the Earth under the impact of planetesimals or during the contraction of the Earth, becoming today’s massive Moon. After the formation of the Moon, it can not only light up the night, but also call the wind and rain and regulate global climate change to create an environment suitable for living things.

Key words: Moon, formation, Earth, environment, global climate change.

1. Introduction

The moon is called Taiyin in ancient times, it is the only natural satellite orbiting the Earth. The study of the formation of the Moon can not only discover the formation law of natural satellites but also help to reveal the formation and evolution of general galaxies. Hence, many people have studied the Moon, and some even boarded the Moon by spacecraft, but the formation of the Moon is still controversial.

Several mechanisms have been proposed for the Moon’s formation 40 billion years ago. One is fission theory, i.e., some people suggest that the Moon was originally part of the Earth during the birth of the Solar System, when the young Earth was almost completely molten, but then the Moon detached from the Earth’s crust through centrifugal force, which would require too great an initial spin of the Earth. Another is capture theory, i.e., some people postulate that the Moon was formed somewhere in space, then moved through space until it came into contact with the Earth’s gravitational force and began its orbit around the Earth, but that would require an unfeasibly extended atmosphere of the Earth to dissipate the energy of the passing Moon. In addition, if this theory were true, the Moon would have crashed into the Earth or drifted far out of the Earth’s orbit. Still, another one is co-formation or condensation theory, which posits that the Moon and the Earth were condensed from a solar nebula at the same moment in the same place, and then the Moon began to orbit around the Earth. This theory answers the question why the Moon is in its fixed location near the Earth, but falls short when it comes to explaining the depletion of metallic iron in the Moon.

The prevailing hypothesis today is that the Earth-Moon system formed as a result of a giant impact: a Mars-sized body hitting the newly formed proto-Earth, blasting material into orbit around it, which accreted to form the Moon. However, meteorites show that other inner Solar System bodies such as Mars and Vesta have very different oxygen and tungsten isotopic compositions to the Earth, while the Earth and Moon have near-identical isotopic compositions.
compositions. Published in 2012, an analysis of titanium isotopes in Apollo lunar samples showed that the Moon has the same composition as the Earth, which conflicts with the impact event hypothesis for its formation. In addition, the large amount of energy released in the giant impact event and the subsequent reaccretion of material in Earth orbit would have melted the outer shell of the Earth, forming a magma ocean. The newly formed Moon would also have had its own magma ocean; estimates for its depth range from about 500 km to the entire radius of the Moon, but such is not the case, so the impact event hypothesis is still debated [5].

Now that the Moon is neither a pre-formed celestial body captured by the Earth nor a result of a giant impact, and the Moon and Earth have almost the same isotope composition, most of the materials forming the Moon come from the Earth. People should study the evolution of the Earth to find the origin of the Moon, then consider Moon’s inference on the environment of Earth.

2. A New Theory for the Formation and Evolution of the Moon

Since most of the materials forming the Moon come from the Earth, and the Earth’s rotation is not fast enough to throw the Moon joined tightly with the Earth into the lunar orbit, hence, the material composing the Moon must have been launched by a special force into some orbits around the Earth to form the Moon. To find out the origin of the Moon, it is necessary to find such a powerful force from the Earth. In fact, as long as we carefully analyze the evolution of the Earth and its sphere structure, we can find two such powerful forces, one is volcanic ejection force, another is polar vortex ejection force.

2.1 The Evolution of the Earth and the Formation of Its Circle Sphere-Structure

Initially, during the formation of the Earth, as the Earth revolved around the Sun, it accreted dust and gas near its orbit, making Earth’s mass increase and Earth’s atmosphere become thicker, and gradually moved away from the Sun with the frequent collisions of prograde planetesimals or the accelerating rotation of the Sun due to the contraction of the Sun. With the continuous increase of the mass and volume of the Earth, the heat inside the Earth accumulated continuously. It is just the original thermal energy of the Earth accumulated to a certain extent that made the inner material of the Earth melted and differentiated, forming the different layers of the Earth: crust, mantle and core, as is shown in Fig. 1. The thickness of the mantle is about 2,865 km, which is the largest and most massive layer of the Earth’s interior. The mantle can also be divided into two layers: the upper mantle and the lower mantle. It is generally believed that there exists an as the nosphere in the uppermantle, which is mainly magma formed by the melting of rocks. The temperature of this layer is about 1,100-1,300 °C, so in this high temperature environment, most volatile components have been volatilized.

When the Earth is far enough away from the Sun, the Earth’s revolution around the Sun slows down, therefore the Earth is cooling down, and a thicker and thicker atmosphere forms around it. With the increase of water vapor in the atmosphere, clouds and rain often form over the Earth, and the rain falling to the ground cools the Earth’s surface. When the Earth’s surface condenses into a solid state, a thick atmosphere surrounds it, so the Earth’s atmosphere is also the product of the Earth’s formation and evolution, and the evolution of Earth’s atmosphere has undergone three distinct stages: Earth’s primordial atmosphere, Earth’s second atmosphere and Earth’s third atmosphere. With the increase of Earth’s mass, the atmosphere is gradually thickened. The whole atmosphere shows different characteristics with different height, so it is generally divided into five layers [6], as is shown in Fig. 2.

Troposphere—It is the first layer above the surface and contains about 80% of the total mass of the
Formation of the Moon and Its Influence on Earth’s Environment

Fig. 1  Earth’s structure.

atmosphere. Its average thickness is 12 km. Clouds exist only in this layer.

Stratosphere—Above the tropopause is the stratosphere. This layer extends from an average altitude of 11 to 50 km above the Earth’s surface. This stratosphere contains about 19.9% of the total mass found in the atmosphere, but very little weather occurs in the stratosphere.

Mesosphere—it stretches from 50 km to 85 km.

Thermosphere—it extends from about 85 km to more than 690 km. Under the action of solar ultraviolet rays and cosmic rays, the air of this layer is ionized, leaving the ions and free electrons floating, and a plasma region is formed at the bottom of the layer, which is called ionosphere. In addition, some of these positive and negative ions will diffuse down into the troposphere, gathered respectively at the top or bottom of clouds.

Exosphere—Exosphere is the upper limit of the atmosphere. It ranges from about 690 km up to 1,000 km. This layer is where atoms and molecules escape into space. The atmosphere becomes very thin in this layer. Gas particles in the exosphere either come down into the lower atmosphere due to Earth’s gravitational pull or escape into outer space.

With the increase of water vapor in the atmosphere, a hydrosphere consisting of liquid water and solid water forms gradually on the Earth’s surface.

2.2 Volcanic Eruption

During the formation of the hydrosphere, many parts of the Earth’s surface ruptured due to the long-term erosion of water, producing a series of cracks or caves connecting Earth’s mantle. When hot magma encounters a large amount of seepage water, a huge explosive pressure is produced, causing violent volcanic eruption. During some violent volcanic eruptions, some volcanic ash or rock debris could have achieved a velocity no less than the first cosmic velocity to enter some orbits around the Earth, forming layers of nebular around the Earth. In 1815, for example, Tambora volcano in Indonesia broke out the largest volcanic eruption ever recorded in the world. In that volcanic eruption, the pozzolanic column reached 45 km high and millions of tons of pozzolanic ash entered the stratosphere, which followed the atmospheric circulation to spread around the world, and stayed in the stratosphere for a long time, causing an average drop of 0.53 °C in global temperature and also the absence of summer on Earth in 1816, as is shown in Fig. 3.
Experts pointed out that volcanic eruption is the only surface activity that can send large amounts of dust into the stratosphere, and the volcanic ash will stay for a long time in the stratosphere, which lacks atmospheric activity, forming a dust layer that pervades the global atmosphere. So the prototype of the Moon probably formed in the stratosphere, in this way, it would not be blocked by mountain peaks or destroyed by storms, and with the rotation of the Earth, it could easily move around the Earth by the force of stratospheric airflow under the pull of gravity, growing up in a safety environment.

2.3 Jet of Polar Vortex

After the formation of the Earth’s atmosphere, the material exchange between the surface and the upper air is becoming more and more active. Through the troposphere, dust and gas on the ground can rise to the stratosphere along with the airflow, converging into the dust layer that pervades the global atmosphere.

It is well known that Earth has a dense atmosphere. Due to the effect of centrifugal force, the rotation of Earth around its axis has caused it to bulge around the Equator, making the Earth become an oblate spheroid with the radius of the two poles of the Earth less than the radius of the equator and other places, while the gravitational force is inversely proportional to the square of the distance. When the Earth rotates quickly, the rotation will produce strong centrifugal force, making the clouds over the equator and low latitudes tend to move away from their orbits to the South pole or the North Pole. Because the gravitational attraction of the polar position is greater than that of other locations, when clouds move above the polar regions, they are easily attracted by the gravitational pull of the polar regions, after inhaling cold air, they condense into thick clouds and sink gradually. Many polar-plunging clouds form a strong circulation around the pole as the Earth rotates, that is polar vortex, as is shown in Fig. 4. The Earth has two group of vortices, located at the South pole and the North pole respectively, which can span troposphere and stratosphere. This kind of vortex structures exists throughout the four seasons, reaching maximum strength in winter. When the Arctic is in summer and its vortex structure becomes weaker than in winter, the Antarctic is in winter and its vortex becomes stronger than in summer, and vice versa. So these two vortex structures have complementary advantages.
Since the clouds involved in a polar vortex are constantly in flux and revolve downward rapidly in a spiral manner, a series of parallel thick spiral cloud paths can be formed, which facilitate the downward flow of heavier negatively charged cloud droplets, thus forming a series of good circuits with excellent electrical conductivity, as is shown in Fig. 5. Since the clouds involved in the polar vortex are numerous and revolve rapidly, it is easy to have violent frictions and collisions among clouds, constantly generating violent thunderstorms, releasing huge amounts of electricity, which can reach billions to hundreds of billions of watts, making the ambient air temperature rise rapidly to 10,000-20,000 °C, therefore resulting in violent explosions, finally causing strong jets of the polar vortex [7]. Since the depth of the polar vortex can span the Earth’s atmosphere, dust and volcanic ash from the ground can enter the stratosphere even the high layer of atmosphere with the jet of the polar vortex, providing an endless supply of material resources for the Moon.

In recent years, Russian scientist Igor Barukin has used Solar and Heliospheric Observatory to detect Earth’s atmosphere. After more than 20 years of observation, he found that the atmosphere has expanded to 630,000 km above the surface [8]. This means that the Earth has a significant gravitational pull on atmospheric molecules in this range, so the polar vortices formed by the Earth’s rotation and gravitation can also reach this height. Hence, during the intense ejection of polar vortices, some dust and volcanic ash from the ground can be injected into the air 600,000 km high, providing material resources for the Moon high in the sky.

2.4 Formation and Orbit Variation of the Moon

According to the general principle known as “dust particles collide and accrete to form planetsimals, then planetsimals collide and accrete to form satellites or planets”, it is easy to know the formation of the Moon.

Due to the continuous ejection of polar vortices and the frequent ejection of volcanoes, the Earth’s atmosphere contains large amounts of injected matter, including dust, volcanic ash, water vapor, aerosols and other interstellar matter. As the Earth rotates from west to east, these materials gradually form “nebulae” around the Earth, and there were more prograde planetsimals than retrograde planetsimals in the same orbit around the Earth. Hence, the prograde planetsimals could merge more prograde particles or planetsimals and bump less into retrograde particles or planetsimals, therefore easily grow up to be a Moon. That is why the Moon is a prograde satellite.

Since the Moon was formed near the stratosphere, so the Moon, like a snowball, could unceasingly merge the ejecta to become larger and larger, and farther and farther away from the Earth. This can be proved as follows [9]:

When the Moon moved around the Earth normally, the centrifugal force was produced by the Moon’s rotation around the Earth and the Earth’s gravitation pull on the Moon had the same size but opposite directions, as is shown in Fig. 6.

Let $M$ be the mass of the Earth, $m_1$ be the mass of the Moon, $r_m$ be the radius of the Moon, $r$ be the centroid distance between the Earth and the Moon, $v$ be the tangential velocity of the Moon around the Earth, then:

$$\frac{Gm_1M}{r^2} = \frac{m_1v^2}{r} \quad \Rightarrow \quad v = \sqrt{\frac{GM}{r}}$$

![Fig. 6 The orbits of the Moon and planetsimals.](image-url)
Formation of the Moon and Its Influence on Earth’s Environment

Near the orbit of the Moon, there were also many smaller prograde planetsimals moving around the Earth’s centre in circular orbits of radius 

\[ r_x \ (r - r_m < r_x < r) \]

with velocity \( v_x \). Since

\[ v_x = \sqrt{\frac{GM}{r_x}} > \frac{GM}{r} \]

which implies \( v_x \geq v \), these smaller planetsimals would finally catch the Moon. When a smaller planetsimal approached the Moon, the Moon’s gravitation force would accelerate the motion of the planetsimal, making the planetsimal’s velocity become much larger than \( v \). Let \( m_2 \) be the mass of the planetsimal, \( v_y \) be its velocity when it impacted the Moon, then the centrifugal force of the Moon merged with the planetsimal was:

\[ m_1 \cdot \frac{v_x^2}{r} + m_2 \cdot \frac{v_y^2}{r} > (m_1 + m_2) \cdot \frac{v^2}{r} = G(m_1 + m_2) \cdot \frac{M}{r^2} \]

That is, the centrifugal force produced by the Moon’s rotation around the Earth was larger than the Earth’s gravitation pull on the Moon, therefore the moon’s center of gravity has a trend moving away from the Earth.

Especially, if a planetsimal or asteroid was large enough, it would impact the Moon fiercely, making the Moon’s velocity increase to a larger value \( v_2 \), then:

\[ (m_1 + m_2) \cdot \frac{v_2^2}{r} > (m_1 + m_2) \cdot \frac{v^2}{r} = G(m_1 + m_2) \cdot \frac{M}{r^2} \]

therefore the Moon’s center of gravity moved a reasonable distance from the Earth.

(2) During the normal revolution of the Earth around the Sun, the atmospheric pressure on the trailing hemisphere of the Earth is higher than the other hemisphere, effectively increasing its revolution speed, thus making the Earth gradually move away from the parent-star along a spiralline. In addition, with the parent star’s shrinking from time to time and thus the speeding up of its rotation, the revolution speed of the Earth will also increase correspondingly and thus the Earth will move away from its parent star gradually. As the Earth gradually moves away from their parent star, the gravitational attractions of the parent star to the Earth also gradually become smaller, consequently the Earth’s self-rotation will gradually accelerate. The observation result of American National Institute of Standard Technology in 1999 also shows that the Earth’s rotation is speeding up, which makes the Moon’s revolution faster, eventually causing the Moon to move away from their planet.

(3) With the growth of the mass of a planet, the temperature of planetary core strata gradually rises under increasing pressure, making the core stratamelt into magma. When a large quantity of magma encounters external infiltrated water, it will be cooled and solidified, contracting the planet’s volume yet conserving the angular momentum of the planet, so a decrease in the rotational inertial results in an increase in the rotation speed of the planet, and consequently also an increase in the revolution speed of the Moon, making the Moon move away from the planet. For example, 2011 Tohoku earthquake has shifted Earth’s figure axis by about 25 cm and accelerated Earth’s spin [10].

For the same reason, batch after batch of Earth’s ejecta or planetsimals were moved away from the Earth and sent to the Moon, making the Moon become a giant satellite in four billion years.

3. The Influence of the Moon on the Earth’s Environment

It is well known that the Moon can attract ocean tides, but few people know that the Moon has also a gravitational effect on the polar vortices. In fact, Polar vortices are persistent, large-scale cyclones that originate in the Earth’s polar regions, and are generally located in the middle and upper troposphere and can extend to the stratosphere. Usually they move around the North (or South) Pole, and can not easily go out of the polar basin, as is shown in Figs. 7 and 8. Polar vortex usually strengthens in winter and decreases in summer.
When the polar vortex is not destructed by the outside world, it can control the cold air of the polar circle well, as is shown in Fig. 9a. But when the polar vortex breaks apart due to external destruction, cold air can be brought to the middle and low latitudes [11, 12], as is shown in Fig. 9b.

Just as the Moon can cause ocean tides, the Moon has also a gravitational effect on the polar vortices. When the Moon approaches a polar vortex, the Moon can tilt or break the polar vortex, pour out some cold-air stream and inner cyclogenesises [11]. With the rotation of the Earth and the revolution of the Moon, the cold-air stream from the polar vortex pours down around the planet, as is shown in Fig. 9b. Some of these cold-air stream and cyclogenesises fall in the polar basin, while some of these cold-air stream and cyclogenesises, accompanied by the stratospheric flow, pour in the direction of the Moon’s gravity. Hence, these cold-air stream and cyclogenesises can flow with a speed greater than 50 m/s, which can reach the latitude of the Moon in a few days. Where the cold-air stream goes, the wind blows widely, floating clouds turn into rain, temperature drops sharply, even causing seasonal changes. Specially, some drifting cyclogenesises can absorb the warm and moist airflow evaporated from deep valleys to intensify into a strong atmospheric vortex, which then falls into a nearby forest to become a fire tornado, setting off a big wildfire to destroy a large area of forest or grassland while some cyclogenesises, when encountering the high temperature airflow from the ocean surface, immediately intensify into typhoons or hurricanes [12].

From the first day to the sixth day of the lunar calendar, when the Moon moves north from New Moon to the first quarter, as is shown in Fig. 10, it can attract and even break Arctic vortices, and pour out some cold-air stream and inner cyclogenesises.

From the 7th day to the 8th day of the lunar calendar, when the Moon is over the North Pole, as is shown in Fig. 10, it can pull the Arctic vortices up, making them absorb a lot of cold air and recover their strength, as is shown in Fig. 9a. At this time, the pouring of polar vortex ‘s cold air is weakened, and the wind and rain in middle and low latitude vanish temporarily.

From the 9th to the 14th day of the lunar calendar, when the Moon moves southward from the First Quarter to Full Moon, as is shown in Fig. 10, it can also attract and even break Arctic vortices, and pour out some cold air and inner cyclogenesises, as is shown in Fig. 9b.

Every time around the 15th day of the lunar calendar, when the Moon reaches the equatorial plane of the Earth, it is far from both poles, it has less attraction to polar vortices, and the polar vortices pour out less cold air, therefore at the middle and low latitude, the wind is calm, the clouds are light, the sky is clear and the Moon is full, as is shown in Fig. 10.
From the 17th to the 22nd day of the lunar calendar, when the Moon moves southward from Full Moon to Third Quarter, as is shown in Fig. 10, as the distance between the Moon and the Antarctic vortex gets closer and closer, the Moon’s attraction to the Antarctic vortex is also increasing, more and more cold-air streams are poured out of the Antarctic vortex, and the cyclogenesis poured out get bigger and bigger.

From the 22nd to the 23rd day of the lunar calendar, when the Moon is over the South Pole, as is shown in
Fig. 10, it can pull the Antarctic vortex up, making it absorb a lot of cold air and recover its strength. At this time, the pouring of Antarctic vortex’s cold air is weakened, and the wind and rain in middle and low latitude vanish temporarily.

From the 24th day to the 30th day of the lunar calendar, when the Moon moves northward from the Third Quarter to New, as is shown in Fig. 10, it can also attract and even break Antarctic vortex, and pour out some cold-air stream and inner cyclogenesis, making the temperature in the middle and low latitudes of the southern hemisphere and the northern hemisphere drop or even enter extreme cold weather. The poured cyclogenesis may be intensified into a strong tropical cyclone.

4. Conclusions

The Moon is neither a pre-formed celestial body captured by the Earth nor a result of a giant impact, and the Moon and Earth have almost the same isotope composition, so most of the materials forming the Moon come from the Earth. By analyzing the evolution of the earth, it is easy to find that after the formation of the Earth’s spherical structure, Earth’s polar vortices and active volcanoes can continuously spew large amounts of material into the upper air even stratosphere, making the Earth’s atmosphere contain large amounts of injected matter, including dust, volcanic ash, water vapor, aerosols and other interstellar matter. As the Earth rotates, these materials gradually form “nebulae” around the Earth. The lunar prototype was formed near the stratosphere, it keeps colliding and accreting nebular material near its orbit and getting bigger and bigger, and gradually moves away from the Earth under the impact of planetesimals or during the contraction of the Earth, becoming today’s massive Moon. After the formation of the Moon, it can not only light up the night, but also call the wind and rain and regulate global climate change to create an environment suiting for the living things.

Since the above theory shows that the Moon is actually generated by the Earth, it can be called “generation theory”. This theory is established by reasoning, it can be well verified by modern artificial satellite launch experiments. It has many advantages over the existing explanations. It can answer many questions that the existing hypothesis could not explain.

References

[1] Jolliff, B. L., Wieczorek, M. A., Shearer, C. K., et al. 2006. New Views of the Moon. Washington: Mineralogical Society of America.
[2] Darwin, G. 1879. “On the Procession of a Viscous Spheroid and on the Remote History of Earth.” Philos. Trans R. Soc. London 170: 447-538.
[3] Schmidt, O. Y. 1959. A theory of the Origin of the Earth. Lawrence and Wishart.
[4] Canup, R., and Asphaug, E. 2001. “Origin of the Moon in a Giant Impact near the End of the Earth’s Formation.” Nature 412 (6848): 708-12.
[5] University of Chicago. “Titanium Paternity Test Says Earth is the Moon’s Only Parent.” http://www.astrobio.net/pressrelease/4673/titanium-paternity-test-says-earth-is-the-moons-only-parent.
[6] Zhong, C. X. 2016. “Revealing the Cause of Global Climate Change from the Formation and Evolution of Atmosphere.” International Journal of Geophysics and Geochemistry 3 (1): 1-5.
[7] Zhong, C. X. 2018. “The Origin of Geomagnetic Fields and the Cause of Its Reversal.” International Journal of Geophysics and Geochemistry 5 (2): 53-7.
[8] Baliukin, I., Bertaux, J.-L., Quemerais, E., Izmodenov, V., and Schmidt, W. 2019. “SWAN/SOHO Lyman-Alpha Mapping: The Hydrogen Geocorona Extends Well beyond the Moon” J. Geophys. Res. Space Physics 124 (2): 861-85. https://doi.org/10.1029/2018JA026136.
[9] Zhong, C. X. 2014. “Origin and Evolution of the Moon.” In Proceedings IAU Symposium, No. 298, 257.
[10] Chang, K. 2011. “Quake Moves Japan Closer to U.S. and Alters Earth’s Spin.” The New York Times.
[11] Reed, R. J. 1979. “Cyclogenesis in PolarAir Streams.” Mon. Wea. Rev. 107: 38-52.
[12] Emanuel, K. 2005. “Increasing Destructiveness of Tropical Cyclones over the Past 30 Years.” Nature 436 (7051): 686-8.