Title: **Origin and Evolution of Solar System**

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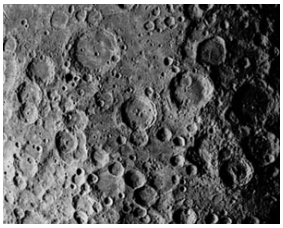
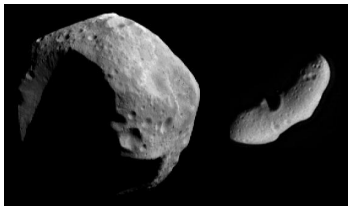
1. **The solar system**: There are 8 planets and several types of small bodies in our solar system: they are satellites, asteroids, comets and Kuiper belt objects. The planets are classified into two groups according to their physical properties, that is, the terrestrial planets mainly made of rocks and metals and the Jovian planets mainly made of hydrogen gas.
2. **Origin of the solar system**: The solar system bodies are formed in the solar nebula about 4.6 billion years ago. At the beginning of the solar system, the proto-sun was surrounded by a gas disk composed of hydrogen gas and dust. The sub-micron dusts were coagulated each other in the gas disk to form aggregates with larger size, then these aggregates were gravitationally or mechanically accreted to form planetesimals with the size of km.
3. **Impact events in the solar system**: The planetesimals collided each other to grow in their sizes. The impact velocity among them was several hundreds m/s to several km/s, so that the planetesimals were sometimes catastrophically disrupted into small fragments and they were left as asteroids and other small bodies in the solar system. But, the most of planetesimals accreted to form planets such as the Earth and the Mars etc. Especially, in the outer solar system, water ice was the main component of the planetesimals and the total amount of water ice was several times larger than that of rock composing the terrestrial planets. Thus, giant icy planets were formed in the outer solar system, and these planets attracted a large quantity of hydrogen gas by their self-gravity to form a thick gas envelope, then the Jovian planets called as a gas-giant were born.

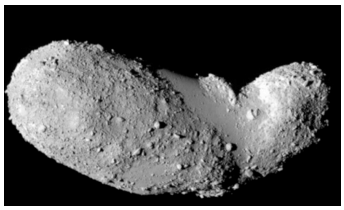
4. **Impact crater**: The evidence of the planetary accretion process by planetesimals in the proto-solar system was recorded as craters on the solid bodies without atmosphere such as the Mercury and the Moon etc. We can observe a lot of craters on these bodies with various sizes and morphologies. The impact craters were formed by high velocity impacts of small bodies on the surface, and they



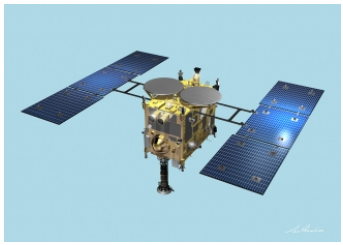
have a circular shape and sometimes have a mountain at the center called as a central peak when their size is larger than 10km on the Moon.

5. **Crater chronology**: The impact crater can be used to estimate the surface age of the solar system bodies. We can recognize that the number density of the crater on the planetary surface changes depending on the surface geology. The crater number density is small on the new surface, for example, covered by lava flow, but it is large on the old surface because the flux of the small bodies colliding on the planetary surface have been almost constant or decreased slightly since the origin of these bodies. Thus, the impact craters accumulate with time to show a large number density on the old surface.





6. **Asteroids and Meteorites**: In the case of the Moon, their impact craters have been formed by collisions of asteroids. Asteroids are small bodies orbiting between the Mars and the Jupiter, and more than 100 thousands of bodies are now astronomically discovered. From time to time, their orbits are disturbed by the Jupiter and other large planets, so that they would move toward the orbit for the Earth and the Moon. Meteorites are one of these bodies or their fragments that we can obtain on the Earth. The Hayabusa spacecraft, which is for the Japanese asteroid exploration mission, returned small amount of sample from the asteroid Itokawa, and elucidates that the Itokawa's samples have almost the same composition as that of some type of meteorites recovered on the Earth.



7. **Japanese asteroid exploration mission Hayabusa-2** : In 2014, JAXA will launch a new spacecraft named the Hayabusa-2 for the asteroid sample return mission: the purpose of this new mission is to explore the asteroid 1999JU3, which is seemed to be very pristine asteroid keeping a lot of volatile materials. We expect that the returned samples will include organic materials and hydrous minerals that may help us to clarify the relationship between these volatile materials and the compounds related to the origin of life on the Earth.

Key words: asteroid, solar nebula, planetesimals, impact crater, meteorites, asteroid Itokawa