

## **New origin, evolution theory of Earth put forth**

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- At the dawn of Earth's history, our planet probably had no Moon.
- Early in Earth's evolution, between five and 10 "mini-moons" may have formed around our planet.
- There is little doubt that Earth "captured" our present Moon.
- Some or all of the mini-moons eventually were swept up by the larger Moon, forming some of the "mascons," or mass concentrations, detected beneath the lunar surface during Apollo explorations.

These are among features of a new general theory about the origin and evolution of the Earth-Moon system announced today by two scientists at the University of California in San Diego. They are Dr. Hannes Alfvén, professor of physics, who won the Nobel Prize in physics in 1970, and Dr. Gustaf Arrhenius, professor of oceanography at Scripps Institution of Oceanography.

Alfvén and Arrhenius are consultants to the National Aeronautics and Space Administration on space research, and Arrhenius is one of the scientists selected by NASA to analyze lunar samples. The research on which their theory is based was funded by NASA grants.

The scientists announced their conclusions after comparative studies of planet-satellite systems throughout the solar system.

They reported they had discovered a "normal" pattern followed in the evolution of planets and their satellites, and said the presence of such a large body as Earth's Moon did not fall within the "normal" pattern.

Examples of a normal system are seen in the planets Jupiter, Saturn and Uranus, they said.

"Each of these has five or more secondary bodies, or satellites," Alfvén explained. "Mars, with only two satellites, may be less typical. Mercury and Venus have no satellites, probably because of their extremely slow rotation and their lack of magnetic fields. No one knows, at present, whether or not Pluto has satellites."

Two planets - Earth and Neptune - are exceptions to the "normal" rule.

"The reason, in both cases, seems straightforward," the scientists noted. "Earth and Neptune might well have produced normal satellite systems early in their development, but these have been destroyed by a large satellite which was, in both cases, captured by the planet. In the case of Neptune the satellite is Triton, the 'moon' of Neptune. In the case of Earth, the large satellite was our own Moon."

In the normal system, the mass of each satellite is but a tiny fraction of the mass of its primary body, the UCSD scientists observed. For example, in the case of Jupiter, the mass of the biggest satellite is 10,000 times smaller than that of the planet itself, and several Jupiter satellites are much smaller.

"On this basis," said Alfvén, "we should expect a normal satellite of Earth to be something like 100 times smaller than our present Moon. For this reason, we believe it highly unlikely that the Moon could have accreted, or come together, near the Earth."

Alfvén and Arrhenius argued that it would be inconsistent to advance one theory for the evolution of satellite systems elsewhere in the solar system while supporting a different theory for the Earth-Moon system.

"We feel that to regard Earth as a special case is not justified," they said.

If Earth and its satellites had evolved in a normal pattern, our planet once could have had between five and 10 satellites, according to the UCSD scientists. They said Earth also may have had a ring, like Saturn's ring, comprised of boulder-sized particles of matter.

The possibility that Earth once had satellites in orbit around it has long been the subject of speculation. But the UCSD scientists are the first to predict their number, size and orbits as the result of systematic investigation.

"There are many theories of the origin of the Moon, but very few that are consistent with the observed dynamic state of the solar system," they noted. "By plotting and studying the other planets and their satellites, we see a sequence which, by extrapolation, may be applied to the Earth."

Earth today would still have these satellites if our planet had not captured its present Moon, they argued.

"The only likely possibility is that the Moon swept out the space occupied by these original satellites, either colliding with them or forcing them from their normal orbits. In the latter case, the satellites would either have collided with Earth, or been ejected into remote space.

"The large circular or slightly elliptical basins on the Moon would seem to be features which could mark the resting places of these original Earth satellites. Nine such basins, each one exceeding 300 miles in diameter, occur on the Moon. Five or six of these contain mascons, which might well be the embedded, spread-out remains of these smaller bodies. There are also immense impact areas on our own globe which might have been caused by collisions with these satellites. This possibility can be explored scientifically."

Alfvén and Arrhenius argue that the planets, satellites, comets and asteroids in our solar system were formed by the accreting, or coming together, of solid particles of matter. These particles, condensed out of primeval plasma, accumulated in space at the dawn of time and formed "Jet streams."

According to their theory, these jet-stream particles collided and eventually bonded together to form the primary body in a planet-satellite system. Studies of extinct radioactivities in meteorites and lunar samples indicate that the process may have taken from 10 to 100 million years. Most of the particles accreted in the planet, but some eventually formed the satellites.

"When the solar system itself was formed, most of the mass of particles came together to form the Sun," Alfvén said. "The remnants formed jet streams, and these eventually condensed to form the Sun's nine planets, including Earth. Remnants of jet streams still exist in the form of the asteroid belt between Jupiter and Mars."

The same process was repeated, on a miniature scale, to form the satellites around the planets, the UCSD scientists argue.

Had an observer been present on Earth in those early epochs when the satellites still circled our planet, he could have seen them clearly, day or night, as miniature moons, according to Alfvén and Arrhenius. An observer standing on the surface of the planet Uranus today would see a similar sight, as that planet's five satellites circle Uranus continuously.

In size, Earth's ancient satellites would have measured something like 50 to 100 miles in diameter. The Moon, by comparison, has a diameter of 2,160 miles. The mini-moons would have circled much closer to Earth, the scientists said, the closest some 12,000 miles away and the farthest some 40,000 miles. The Moon's present distance from Earth is about 238,000 miles.

In shape, said Alfvén, Earth's satellites probably would have been irregular, like Phobos and Deimos, the jagged moons of Mars.

"Small celestial bodies are not necessarily spherical," Arrhenius explained. "In such bodies, roundness is a function of size: the bigger the body, the more round. Smaller, lighter bodies do not exert sufficient gravitational force to bring about this roundness."

Would these satellites have been able to evolve and support life forms?

"We think not," said Arrhenius. "They would have been too small to hold onto an atmosphere."

Could a crater like the one at Canyon Diablo, Arizona have been formed by the impact of an early Earth satellite?

"No," he said. "The Arizona crater is much too small. There is a possibility that one or more of the satellites hit Earth, but we cannot come to any conclusions on this before making certain rather complicated calculations. This is a matter which, however, can be clarified by computers."

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