Astronomy

From Cambridge, Mass., at the annual meeting of the American Astronomical Society's Division for Planetary Sciences

Modeling the moon's origin

Some 4.5 billion years ago, an object the size of a small planet whacked into the youthful Earth, hurling into space chunks of the terrestrial mantle as well as pieces of the object itself. From these bits of hot, ejected material, a solid body coalesced.

This violent scenario best accounts for the birth of the moon, researchers since the mid-1970s have generally agreed. The moon's low density, similar to that of Earth's mantle, and evidence that lunar rocks had once been subject to the high temperatures expected in a collision attest to the validity of such a model. Using new computer simulations, scientists are now attempting to elucidate the details of the moon's formation.

Researchers had previously estimated that the body that rammed into Earth had about the same mass as Mars. A computer analysis by Robin M. Canup of the University of Colorado at Boulder and her colleagues indicates, however, that the culprit was two and one-half to three times more massive than Mars. That could pose a problem: Some researchers have suggested that the total mass of large impactors near the infant Earth was less than three times Mars' mass. In that case, all the impactors in Earth's vicinity must have somehow gathered into a single body.

Canup and her team also report another vexing finding. They calculate that the angular momentum imparted by the colliding body was twice that possessed by the Earth-moon system today. That's puzzling because the Earth-moon duo cannot have lost a significant amount of angular momentum over the past few billion years.

Computer simulations of the moon's formation are far from perfect, so despite these apparent discrepancies, a terrestrial collision remains the most promising theory, notes Stuart J. Weidenschilling of the Planetary Science Institute in Tucson. Alastair G.W. Cameron of Harvard University, a collaborator with Canup's team and one of the original proponents of a collisional origin for the moon, suggests a way around the problems. He speculates that the rocky body that struck Earth did so before our planet had finished assembling.

If Earth at that early time had only 60 to 70 percent of its present mass, the impactor could also have been smaller, closer to twice the mass of Mars, Cameron says. The collision of a smaller impactor with a smaller Earth would have imparted only about as much angular momentum as the Earth-moon system currently possesses. Cameron details some of his work in the March ICARUS. —*R.C.*

Earth, water, and comets

Although comets contain an abundance of water-ice, they could not have been the main source of water for Earth's oceans. That's the conclusion of a group of French, Swiss, and U.S. researchers who measured the ratio of heavy hydrogen, or deuterium, to ordinary hydrogen in water in Comet Hale-Bopp.

Using the James Clerk Maxwell submillimeter radio telescope atop Hawaii's Mauna Kea, they found that Hale-Bopp's deuterium-to-hydrogen ratio—0.0003—was about the same as the ratios measured by other researchers in the well-known comets Halley and Hyakutake. All three have twice the deuterium-hydrogen ratio of seawater, note Roland Meier, Tobias C. Owen, and David C. Jewitt of the University of Hawaii in Honolulu and their colleagues.

This across-the-board mismatch suggests that these comets, which are several kilometers in diameter, and other comets of their size did not fill terrestrial oceans, says Owen.

"I agree with them perfectly," says Louis A. Frank of the University of Iowa in Iowa City. He adds that the measurements in no way discount his controversial assertion that much smaller, water-bearing bodies, which he classifies as house-size comets, pelt Earth's upper atmosphere by the thousands each day and could have delivered the bulk of the planet's water supply (SN: 5/31/97, p. 332).

Frank notes that no one has yet measured the deuterium-hydrogen ratio in these small bodies, whose presence he most recently deduced in images taken by NASA's Polar satellite. If their ratios don't match the value measured in the oceans, Frank says, he would readily agree that these small bodies did not supply Earth's seas. He told SCIENCE NEWS that he now has evidence that the bodies differ in some respects from typical, kilometer-size comets. In a report scheduled for September publication in GEOPHYSICAL RESEARCH LETTERS, Frank argues that the house-size bodies contain much less dust and have less sodium than typical comets.

If comets didn't provide most of our planet's water, what did? Carbonaceous meteorites might have carried water to Earth, Owen says. Water trapped in Earth rocks is another possibility.

The team also measured the deuterium-hydrogen ratio in hydrogen cyanide in Hale-Bopp and found a higher value in this molecule than in water. The difference between the two ratios in the comet resembles that found in the interstellar medium, the source of material from which our solar system formed. The similarity suggests that comets are truly pristine bodies that preserve much of the original chemical makeup of interstellar space, he asserts.

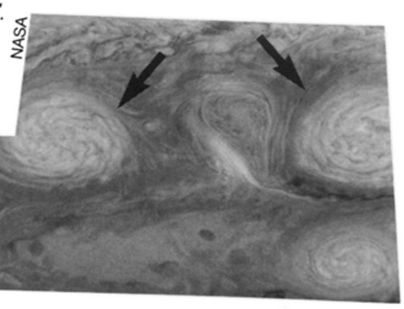
Owen theorizes that water from the interstellar medium warmed only slightly when it entered the outer, frigid reaches of the solar nebula—the disk of gas, dust, and ice that swaddled the infant sun. He suggests that the period between the entry of interstellar water into the outer solar system and the time when it recondensed and became incorporated into comets was too short for the water to have been chemically altered. —*R.C.*

Tracking Jovian storms

Making their debut on Jupiter in the 1930s, three white, oval-shaped storms followed each other around the planet like a three-car train but typically got no closer to each other than about 70,000 kilometers. Now, as Hubble Space Telescope observations between 1994 and 1996 show, the storms are separated by only about 20,000 km.

Amy A. Simon of New Mexico State University in Las Cruces says that as the biggest oval grew still bigger, it encountered strong winds blowing in the opposite direction and slowed down. This allowed the other two ovals to catch up and lessen the distance between them. There's no danger of a pileup, she adds, because each oval vortex is separated by material that rotates in the opposite direction and keeps the storms apart.

Recent images taken by the Galileo spacecraft have enabled the researchers to measure the relative altitude of clouds within the storms. —*R.C.*



This infrared image, taken last February by Galileo, shows two of the three oval-shaped storms (arrows) that formed more than 60 years ago in a region south of Jupiter's largest storm system, the Great Red Spot. The oval at the left has a diameter of 9,000 kilometers, nearly three-fourths that of Earth.