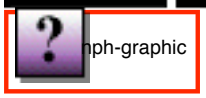

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Jupiter's Atmosphere Raises Questions on Planet Formation

Forum

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By JAMES GLANZ

probe that plummeted into Jupiter's atmosphere late in 1995, sampling its composition for the first time, found more than twice the concentration of elements like argon and nitrogen than expected, raising questions about standard theories of how the planets formed.

The findings, reported in Thursday's issue of Nature, suggest that at least some of the rocky bits of dust and ice that crashed together to form Jupiter -- cometlike bodies called planetesimals -- must have originated under cooler conditions than prevail in the region of the solar system where the planet orbits now. Otherwise the planetesimals would not have been cold enough to trap the volatile gases, those that escape easily from solids, which would have been dispersed among the other tenuous matter in interplanetary space.

The team of scientists reporting the observations is led by Dr. Tobias Owen of the University of Hawaii.

The observations, some researchers said, could mean that some planetesimals rained down on the forming planet from the outer reaches of the solar system, which are farther from the sun's warmth. Other planetary scientists suggested that the results implied that the whirling disk of dust, gas and rock in the young solar system, called the solar nebula, simply shaded the sun's light more than expected in standard theories.

There is even the bizarre possibility that Jupiter formed as much as 10 times farther from the sun than it is now, and somehow lumbered inward to its present position. Most scientists dismissed that as extremely unlikely, but said the results nevertheless posed a challenge for theories of planet formation. "The specific pattern they find is puzzling," said Dr. Jonathan I. Lunine, a professor of planetary science at the University of Arizona, "and it seems to require that the planetesimals that carried these materials into Jupiter came from very, very cold regions."

That conclusion could mean that the planetesimals came from near where the more distant planets Uranus and Neptune are now, or from still farther out, said Dr. Alan P. Boss, an astrophysicist at the Carnegie Institution of Washington. More likely, he said, is that the strong gravity of the forming planet pulled in objects from slightly outside its present orbit, and that the nebula was shaded more completely than earlier estimates had suggested.

"Now we have a new constraint saying, 'Well, it had to be cooler yet,' " Dr. Boss said.

He added that by trying to explain the results with a migrating Jupiter, "you get yourself into trouble very fast," since the solar disk was probably too tenuous that far away to spawn a giant planet like Jupiter.

The data for the measurements was collected in December 1995 when a probe set loose from the Galileo spacecraft, in orbit around Jupiter, plunged into the planet's atmosphere.

A device in the probe sorted the gases by mass and transmitted data that after extensive analysis yielded concentrations of carbon, sulfur, argon, xenon and krypton as compared to that of hydrogen, the most common element in the cosmos, said Dr. Sushil Atreya, a planetary scientist at the University of Michigan and another collaborator on the work. A different technique determined the nitrogen content, he said.

All of the concentrations were two or three times as high as those observed on the sun, Dr. Atreya said. Since the solar concentration should reflect the composition of the warm, inner portion of the solar nebula close to Jupiter's current position, he said, the overall results were unexpected.