Comets Were a Clerical Error

They were curious little inhabitants of the solar system, but now they are gone. A slip of a decimal point created a swarm of fluffy white comets and now the discovery of the error has sent them back to oblivion. The correction also undercuts any support for an even more exotic type of comet proposed by Louis Frank of the University of Iowa.

"There isn't much doubt about it," says Thomas Donahue of the University of Michigan, "I blew it." Donahue had gone to the ultraviolet observations returned by the Voyager spacecraft for proof that the house-sized, crud-encrusted balls of snow proposed by Frank, another prominent space physicist, did not exist (*Science*, 10 June, p. 1403). Given their supposedly huge numbers, he reasoned, no amount of surface crust could seal off the vaporization of the mini-comets' water and prevent the flooding of the solar system with water. The water must yield atomic hydrogen, and atomic hydrogen must emit ultraviolet radiation at a wavelength called Lyman-α. If the Voyagers did not detect any Lyman-α emission above that expected from atomic hydrogen wafted into the solar system by the interstellar medium, Donahue assumed, then Frank's mini-comets could not be there.

Much to his surprise, Donahue and his colleague at Michigan, Tamas Gombosi, and Bill R. Sandel of the University of Arizona could attribute only 477 of the observed 640 rayleighs of Lyman-α emission to hydrogen in the interstellar medium. The hydrogen emitting the remaining 163 rayleighs, they concluded, came from mini-comets no less exotic than Frank's—pure ice on the outside and rock on the inside, but 90% empty space. Even with their protective outer crusts, Frank's far more abundant mini-comets would release 10 million times more hydrogen than observed.

Frank's mini-comets were in trouble, yet again, but Donahue's were not well received either. In the course of amassing spacecraft ultraviolet observations, Donald Shemansky of the University of Arizona began to have his doubts about the claimed Lyman-α excess. He suggested that his student Doyle Hall compare Donahue's calculation, which was based on a published model of emission by interstellar hydrogen, with a computer program of the same model that recently became available. The computer model showed no evidence "of a measurable excess above what we see in the interstellar medium," says Shemansky. It produced an upper limit for the discrepancy, if any exists, of only 20 rayleighs, not 163. There seemed to be a problem with the Voyager data.

The next week Shemansky took their results to a workshop in Boulder called to consider how to follow up Donahue's results. Donahue returned from the workshop on a Friday and called Shemansky that Saturday morning to say he was wrong. "The explanation of what happened," says Donahue, "is that a student carrying out an integration erred in transcribing 3×10^{-2} from a table." In the calculation the figure became 3×10^{-3}. "I agree with Hall and Shemansky that no source is called for larger than 20 rayleighs. No Lyman-α data support either hypothesis." Donahue is presenting his revised perspective at a meeting in Helsinki this month.

This latest development leaves mini-comets on shaky footing indeed. No independent analysis has found anything but instrumental noise in the satellite images that Frank and his students claim record the remains of his mini-comets in Earth's upper atmosphere. The Voyager data eliminate the possibility of an abundance of such objects in interplanetary space, unless Frank can come up with an extraordinary means of sealing in the water. Donahue's version of mini-comets, when cloaked with a reasonably effective mantle, could still slip under the Voyager limit, he says. The next development will probably center around the claimed telescopic detection of Frank's mini-comets by Clayne Yeates of the Jet Propulsion Laboratory, another controversial piece of work that has yet to be confirmed by independent observers.

■ RICHARD A. KERR

New Ways to Chill Earth

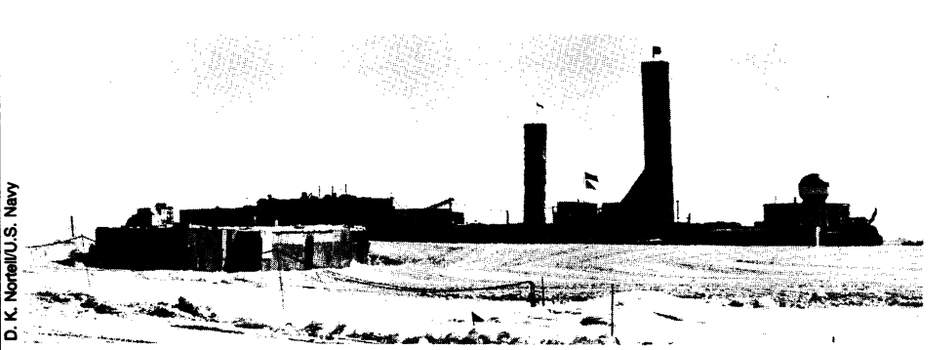
The mystery of the ice ages was a deep one indeed. Why should Earth oscillate between 100,000 years of deep freeze and a few thousand years of balmy relief? The mystery has not been solved completely, but another box within a box that conceals part of the answer has been opened. Within the past decade, paleoceanographers have identified rhythmic variations in the motions of Earth as the pacemaker of the ice ages. But the variations in the tilt and direction of Earth's axis of rotation and the shape of its orbit could not fully account for the magnitude of the chilling during an ice age.

Within the past few years, marine sediments and glacial ice have yielded evidence that carbon dioxide, through its greenhouse effect, acts as an essential amplifier of the climate effects of Earth's orbital variations. Now a host of other amplifiers are being suggested that could help explain the powerful link between Milankovitch orbital variations and the ice ages.

The latest evidence supporting the role of carbon dioxide comes from a 2200-meter core of ice extracted from the Antarctic ice sheet at the Soviet Vostok station. Claude Lorius of the Laboratory of Glaciology in St. Martin d'Hères, France, and his French and Soviet colleagues developed 160,000-year records of temperature from deuterium and of atmospheric carbon dioxide from the air trapped in the ice. Those records are long enough to include the entire ice age that ended 10,000 years ago as well as the end of the preceding ice age.

The Soviet-French collaborators concluded, on the basis of a simple calculation, that the difference between the 200 parts per million of carbon dioxide found during glacial periods and the 270 parts per million of interglacial periods could explain about 50% of the 10°C difference in temperature. Most of the rest of the temperature difference could be due to the changes in the amount of sunlight falling on different parts of the globe, as controlled by orbital variations.

But the Soviet-French team cautions that their simple model does not include several factors that could also be amplifying the



D. K. Nortell/U.S. Navy

Vostok Station. *Shrouds protect the ice-coring rigs on the Antarctic ice sheet in 1978.*