Comet Impact Poses Intriguing Riddles

Comet Shoemaker-Levy 9 is gone, its fragments exploded last week in Jupiter's atmosphere. But they leave behind more than a trail of dusty debris and giant smudges marring the solar system's largest planet. Astronomers must now contend with the task of wresting meaning from the barrage of data from this cosmic collision.

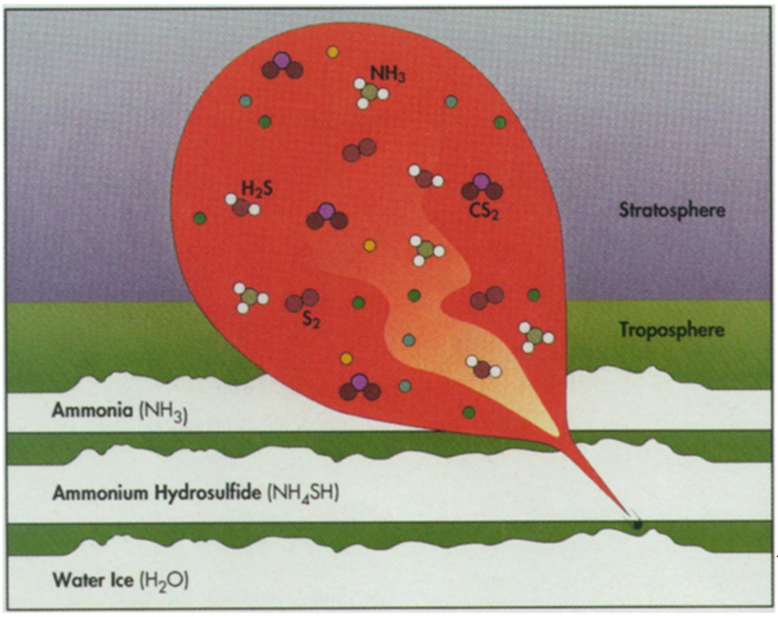
As it turned out, the 6-day-long event contained enough surprises to delight — and perplex — just about everyone. Some astronomers even doubt that Shoemaker-Levy 9 was a comet.

"It's astonishing to me that these faint little fragments we've tracked for 14 months have produced these big scars on Jupiter," says Paul Chodas of NASA's Jet Propulsion Laboratory in Pasadena, Calif.

Scientists had expected to find at least traces of water and an abundance of compounds rich in oxygen and carbon in Jupiter's upper atmosphere. They reasoned that the explosion of a dusty ice ball — the usual model for a comet — should readily release such material.

Moreover, if the comet chunks plowed deeply enough, they might also excavate water from a layer of water clouds thought to reside lower in the Jovian atmosphere. But telescopes found no direct evidence of water or a definitive enhancement of oxygen- or carbon-bearing compounds. Astronomers have now retracted a preliminary report that spectra taken with the U.K. Infrared Telescope after one of the first impacts reveal methylene and the hydroxyl ion in the Jovian atmosphere (SN: 7/23/94, p.55).

Instead, ultraviolet spectra from the Hubble Space Telescope reveal strong emissions from ammonia, sulfur, and hydrogen sulfide. Observers had seen ammonia before, but no one had ever detected the other two gases on Jupiter.



STSI/NASA

Diagram shows the three cloud layers believed to make up Jupiter's upper atmosphere and how far down the biggest fragments may have penetrated. Molecules emerging from the impact — ammonia (NH_3), hydrogen sulfide (H_2S), carbon disulfide (CS_2), and sulfur (S_2) — are among those found by Hubble.

Surprisingly, the compounds thought to be abundant in comets were missing. This led some researchers to propose that Shoemaker-Levy 9 might actually be a rocky body — either an asteroid or a burned-out comet completely stripped of its ices — rather than an active comet. Such distinctions are far from academic: The different bodies would profoundly affect the types of chemical reactions triggered by the impacts.

Scientists may solve these and other riddles as they address several key questions: How big were the Shoemaker-Levy 9 fragments? How deep did they penetrate into Jupiter? What were their chemical compositions?

Several lines of evidence suggest that the exploding fragments, despite the towering plumes and dark clouds they created, didn't burrow deeply into the Jovian atmosphere. In particular, the chemical fingerprints — spectra taken by the Hubble Space Telescope and other instruments — show no signature of material exhumed from regions well below Jupiter's visible cloud tops.

Researchers believe that the upper reaches of the Jovian atmosphere consist of three distinct cloud layers. The highest are the visible clouds of ammonia. Beneath them, according to models, lies a layer of ammonium hydrosulfide. The final layer is thought to be water.

The abundance of sulfur and ammonia and the lack of water may indicate that the fragments of Shoemaker-Levy 9 reached no farther than the ammonium hydrosulfide layer, notes Keith S. Noll of the Space Telescope Science Institute (STSI) in Baltimore.

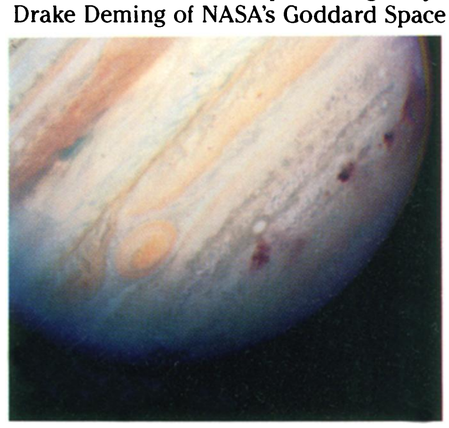
An entirely different phenomenon — observed within the dark cloud created by fragment G, the largest of the 20-odd chunks — also supports the idea of a shallow strike into Jupiter.

When Andrew P. Ingersoll of the California Institute of Technology in Pasadena studied Hubble images of this cloud, which resembles a black eye, he found evidence of a sound wave. Hubble pictures of the G impact site, taken during a 20-minute period beginning about 90 minutes after the explosion, show a sharply defined dark circle moving outward at a speed of about 800 meters per second.

Several researchers had predicted that the impacts might cause Jupiter to ring like a bell, producing sound waves deep within the planet that would then refract up to the visible surface. "But that's not the effect this comet is producing," says Drake Deming of NASA's Goddard Space

G. Orton/JPL/NASA Infrared Telescope Facility

Infrared image taken shortly after the R impact (brightest spot) also shows dimmer spots from previous collisions. Northern spot is Jupiter's moon Io.



Hubble Space Telescope Comet Team/NASA

Hubble image of Jupiter taken last week shows eight bruises, some of which overlap.

Flight Center in Greenbelt, Md. Instead, he and Ingersoll believe, the sound waves come from Jupiter's tropopause, a region just below the stratosphere and above the ammonia clouds.

Because the temperature rises both above and below the tropopause, sound waves remain trapped in this region, expanding horizontally rather than bending upward from a lower depth, Deming adds. The generation of such waves "is consistent" with the notion that the fragments exploded at or just below the visible cloud tops, he says.

Disappointed that the sound wave didn't originate from a deeper, more intriguing part of Jupiter, Deming notes that features of the wave may still offer important clues about the nature of the Jovian troposphere.

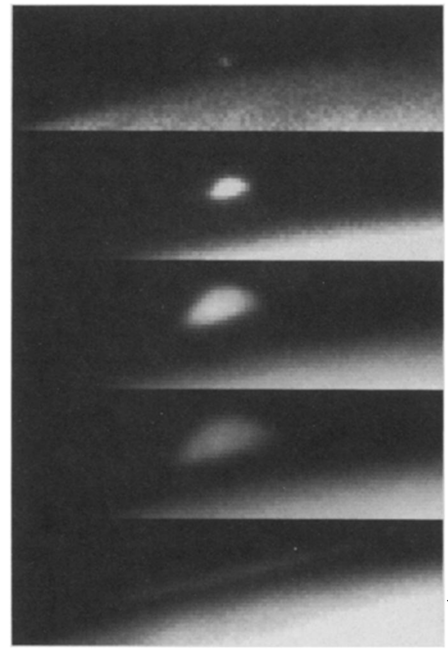
Ingersoll also found evidence of another type of wave nearer the center of the G impact site. He has tentatively identified this fainter, slower-moving dark circle as a gravity wave, whose expanding ripples cause material in Jupiter's upper atmosphere to bob up and down. Ingersoll believes that the slower speed of the gravity wave indicates that it comes from the water-cloud layer, which lies deeper in the atmosphere. At the same time, the faintness of the wave indicates that the G fragment triggered the ripple when it exploded higher in the planet's atmosphere, he says.

Both sound waves and gravity waves produce tiny changes in temperature as they travel through the atmosphere. So why didn't infrared telescopes, which can directly detect such changes, find the waves? Ingersoll proposes that the ripples were so close together that even the highest-resolution infrared instruments couldn't distinguish a hotter-than-average ripple from an adjacent, colder one.

He ascribes their detection in visible light to both Hubble's ability to image small features "and luck." The luck, Ingersoll notes, came because the material surrounding the G impact acted as a visual tracer for the waves, condensings a dark solid around colder ripples and remaining as a relatively transparent gas around adjacent, warmer ones.

Debate continues about whether each fragment consisted of a single solid body or a loosely bound agglomeration of much smaller pieces. The latter model, known as the rubble pile, seemed to fall into disfavor as astronomers witnessed the Jovian fireworks. But Erik Asphaug of NASA's Ames Research Center in Mountain View, Calif., who helped develop the model, responded to critics in a widely circulated electronic-mail message entitled "Rubble Piles Are Not Wimps."

Kevin Zahnle of NASA Ames claims that the model matches the observations and that even the G fragment may have measured no more than 1 kilometer across, one-third the size estimated by Hubble scientists. Images of the actual impacts, taken by the Galileo spacecraft and expected to be radioed in 2 weeks, may help settle part of the controversy. – *R. Cowen*



STSI/NASA

On July 18, Hubble captured this sequence showing the emergence of a plume and its flattening as it sinks back into the Jovian atmosphere.

Does a virus cause some kids' asthma?

For some children with asthma, no amount of medication seems to relieve their wheezing. New research now suggests that certain children with hard-to-treat asthma may suffer from a smoldering viral infection of the lungs.

Asthma specialists have always known that some children develop the disorder after suffering an acute bronchial infection with a bug called adenovirus. Scientific dogma holds that the body's immune system clears this virus, but an infection can leave the lungs vulnerable to a chronic condition in which pollutants in the air and other allergens trigger breathlessness.

Vasilija Maček of the University Medical Center in Ljubljana, Slovenia, and her colleagues wondered if such children continue to wheeze because they never really got rid of a lung infection. To test that hypothesis, they recruited 34 children who had recovered from such an acute infection and had then been diagnosed with asthma. All 34 had failed to breathe more easily with conventional treatments, such as steroid drugs and bronchodilator medication.

The team began its study by inserting a slender tube into each recruit's trachea and collecting fluid samples from their lungs. The researchers discovered a protein made by the adenovirus in samples from 31 of the 34 children. When the researchers tested 20 children who did not suffer from asthma, they found no sign of this viral protein. Such evidence is suggestive but does not prove that the virus is actively replicating in the lungs, comments Hugh O'Brodovich, a lung specialist at the Hospital for Sick Children in Toronto.

Next, the team took lung-fluid samples from 6 of the 31 children and successfully grew cultures of adenovirus from them. "I think it's a very provocative finding," O'Brodovich says. That evidence indicates that the virus is actively replicating in the lungs of these children, he adds.

The Slovenian investigators describe their findings in the July American Journal of Respiratory and Critical Care Medicine, a journal published by the American Lung Association. The results suggest that some kids fail to quash an adenovirus infection, continuing instead with a low-grade infection that leads to chronic breathing problems. Still, these findings have yet to be confirmed, O'Brodovich says, noting that this is the first study to implicate adenovirus directly in the development of asthma.

The new research hints that antiviral therapy might benefit certain kids with intractable asthma, adds Maček. She hopes her findings will spur drug developers and clinical researchers to take a hard look at the impact of antivirals on such cases.

Does a viral infection underlie other cases of asthma, including some in the adult population? Maček suspects so, but she says further study must answer that question.

There's evidence that adenovirus also plays a part in a different respiratory ailment. James C. Hogg of St. Paul's Hospital in Vancouver, British Columbia, and his coworkers have found previously that some smokers who develop chronic obstructive lung disease show evidence of adenovirus infection.

Hogg, who wrote an editorial to accompany the Solvenian report, also points out that the new results raise a red flag for the emerging field of gene therapy. Genetic researchers have employed a crippled adenovirus to carry a therapeutic gene into the pulmonary cells of cystic fibrosis patients. Maček and her team point out that some people may have a latent adenovirus infection. Hogg worries that the crippled virus may combine with the virus already in the lungs and start to spread.

– *K.A. Fackelmann*