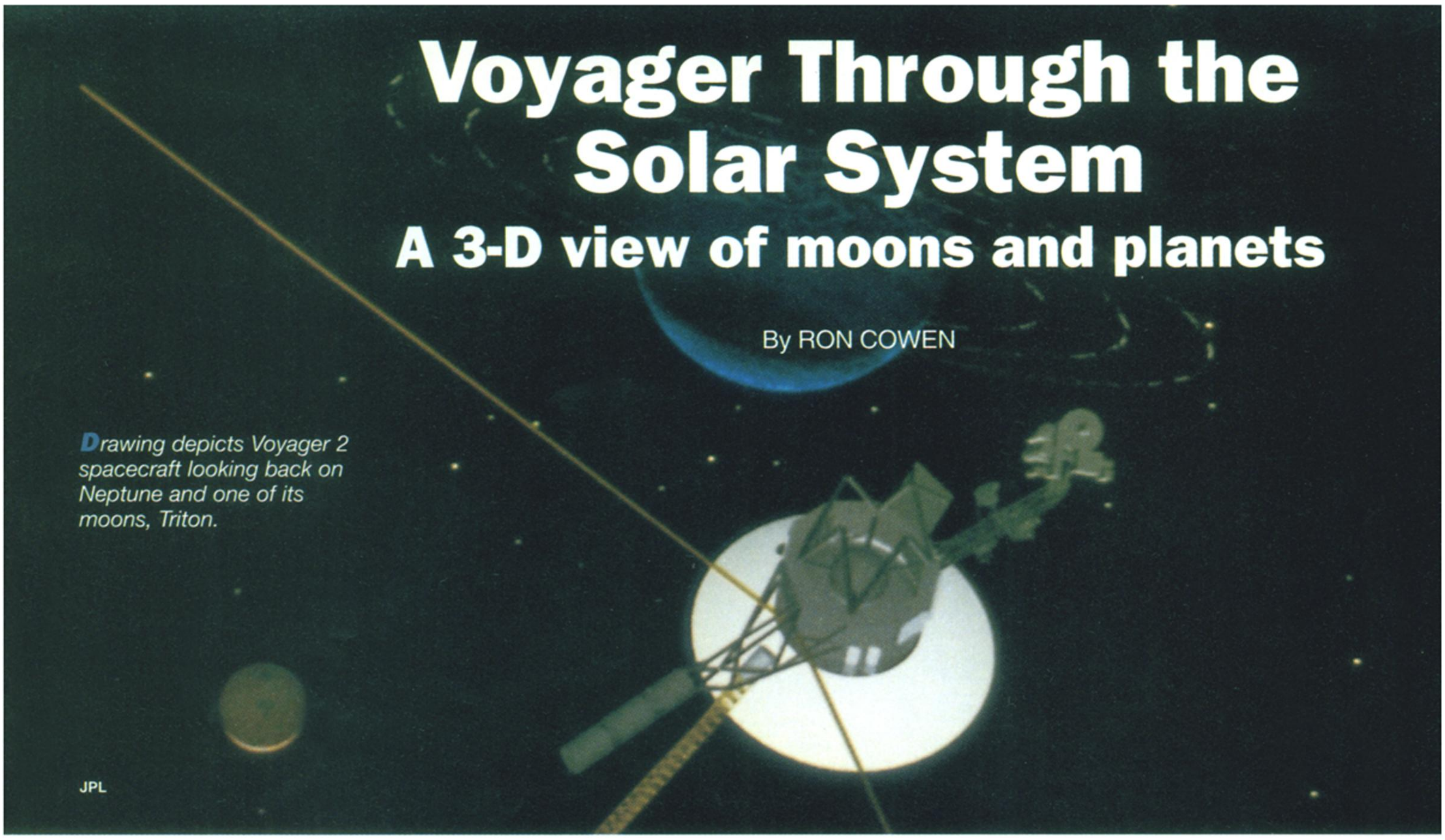
Voyager Through the Solar System

A 3-D view of moons and planets

By RON COWEN



Drawing depicts Voyager 2 spacecraft looking back on Neptune and one of its moons, Triton.

JPL

Paul Schenk had viewed photographs of Saturn's moon Rhea before, but never like this. Moments earlier, he had placed a pair of flat images under a special viewer that merged the two pictures before his eyes. Suddenly, the moon's rough terrain snapped into three-dimensional view: steep-walled craters shaped like cereal bowls; tall, clifflike ridges; and rolling hills wrinkled by sinuous fault lines.

Schenk and his colleagues had spent more than a year using special software to enhance these and other image pairs, culled from a library of photographs taken by the two Voyager spacecraft. Now he had but one word for the fruits of his labors:

"Wow!"

"You could actually visualize the moon right in front of you, crater upon crater," says Schenk, a planetary scientist at the Lunar and Planetary Institute (LPI) in Houston. "Everything stood out in sharp relief, so crisp and so clear. It was the first time that Rhea had been seen that way.

"It was like flying over Rhea."

For Schenk, the images of Rhea, which he generated a year ago, proved a turning point. Most of the Voyager stereo pairs were taken by chance, when a camera on one of the craft happened to record the same terrain twice, at different viewing angles. The Rhea photographs convinced the planetary scientist that although many of the image pairs were recorded by happenstance, typically covering only a small fraction of a planet or moon at low resolution, some could yield spectacular three-dimensional images.

The stereo images, published for the first time in this article, can both educate and inspire, notes Schenk. Such images mimic the differing perspectives of our eyes. Each eye views a nearby object as if that object were at a slightly different location. Merging the two views creates a three-dimensional perspective.

Stereo views can reveal whether a change in brightness and color indicates a change in elevation or a true variation in the mineral composition of a surface. Image pairs can reveal the steepness of a volcanic mountain or the depth of an impact crater.

And for planetary bodies that appear flat because they were imaged when the sun shone directly overhead, stereo coverage can return the third dimension stolen by the absence of shadows in a single picture. At the poles of a planet, stereo imaging can distinguish actual hills and valleys from uneven frost deposits that may mask such topography.

"Stereo imaging can literally transform our perception of planetary bodies," Schenk says.

As a geology student, Schenk had become familiar early on with the power of stereo images — pictures of the same terrain taken from different perspectives.

If stereo worked so well for terrestrial features, why not for the rest of the solar system?

With the notable exceptions of Apollo's topographic maps of the moon and Magellan's recent stereo views of Venus, efforts to create stereo images of the solar system have been few and far between. Researchers in the 1970s generated image pairs of Mercury, thanks to photographs taken by Mariner 10 in 1974. In 1989, researchers used pairs of Voyager images to discover geysers on Neptune's moon Triton (SN: 10/14/89, p.247).

But, says Schenk, researchers didn't think that Voyager had taken stereo images of less familiar parts of the solar system, places like Rhea, Jupiter's moon Ganymede, and Uranus' moon Titania. As a result, no one had systematically combed through files of photos from old missions to find image pairs of the outer planets and their moons. Schenk figured it was time someone did.

He knew just where to look. As a freshman in college, Schenk had marveled at the 1977 launches of Voyager 1 and Voyager 2. Two years later, he spent the summer as an intern at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, Calif., which managed the two Voyager missions. While at JPL, he got a chance to see breathtaking images of Jupiter, Saturn, and their moons transmitted by the Voyager craft in real time.

"I was like a kid in a candy store," Schenk recalls.

In graduate school, he wrote a master's thesis in geology that included an

These pairs of stereo images, generated from photographs taken by the Voyager spacecraft, can be viewed with a pocket stereo viewer available from a local map store or school supply distributor. They can also be viewed by placing an index card vertically on the boundary between the two images and allowing your eyes to cross until the images merge. All stereo pairs have a vertical exaggeration; these range from 1.4 to 7.0.

analysis of images of Europa, one of Jupiter's larger moons, taken by Voyager 2. He discovered that the Voyager 2 craft had imaged part of the moon in stereo.

"I realized there was a change in viewing angle between the two main imaging sets [of Europa]. The [Voyager 2 camera] took one mosaic, waited awhile, and then took another one." Combining the two sets of images, Schenk did indeed produce a stereo pair. But because Voyager never ventured close to Europa, the detail provided by the stereo images proved limited.

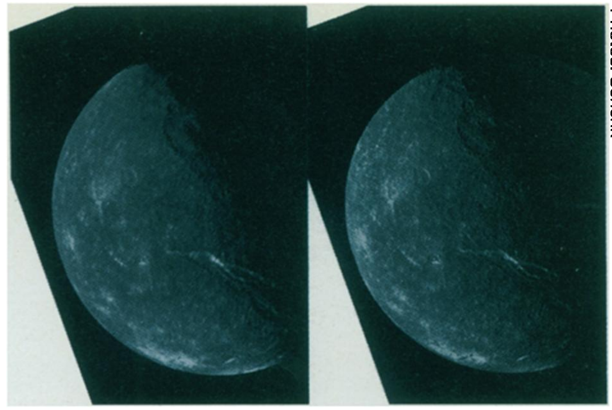
Joining LPI in 1992, Schenk finally had access to the kind of computing power needed to enhance, remap, and properly align Voyager images that might lend themselves to stereo views.

At first, he concentrated on Voyager images that related to his own specialty — impact basins, including those on the icy Jovian moons of Ganymede and Callisto. But he soon expanded his work.

Ultimately, Schenk says, he would like to build a library of stereo images of the outer solar system. His goal: to make scientists and the public alike as familiar with faraway planetary bodies as they are with the riveting three-dimensional images of Venus recently produced by the Magellan spacecraft.

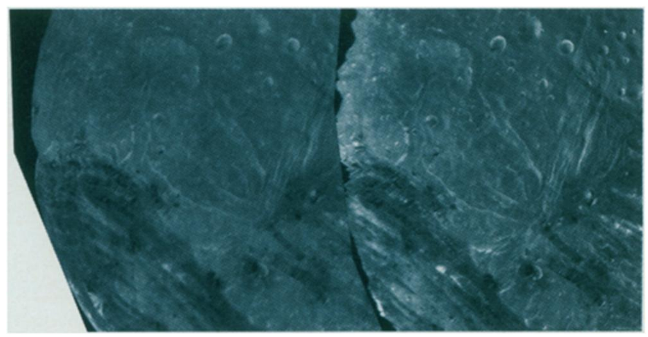
Analyzing Voyager images over the past 2 years, he and his colleagues, Daniel G. Wilson and Robert D. Morris of the LPI and Jeffrey M. Moore of NASA's Ames Research Center in Mountain View, Calif., have now created stereo views of a variety of bodies in the outer solar system. In addition to Ganymede and Callisto, these include Jupiter's volcanically active moon, Io; Saturn's moon Rhea; three of Uranus' moons, Titania, Ariel, and Miranda; and Neptune's Triton.

Voyager 1 spent about a day photographing Io on its 1979 flyby. Using images from that photo session, Schenk and his colleagues have now mapped about 60 percent of this Jovian moon in stereo. About one-third of these stereo images resolve features of the moon as small as 1 kilometer in length; the remaining two-thirds resolve features about twice that size. Schenk says he has already discovered five previously unknown mountains on Io.

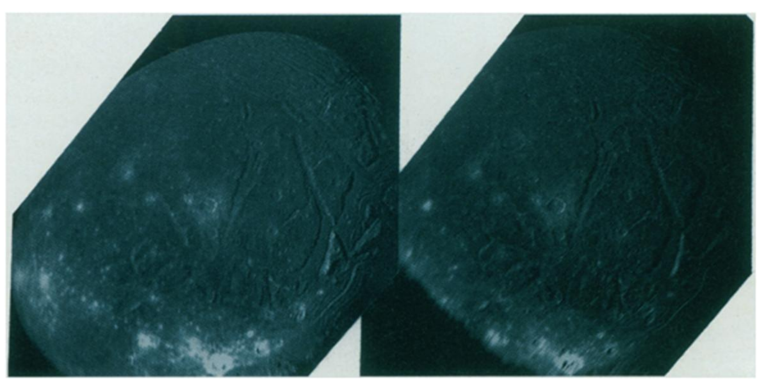


Photos: Schenk

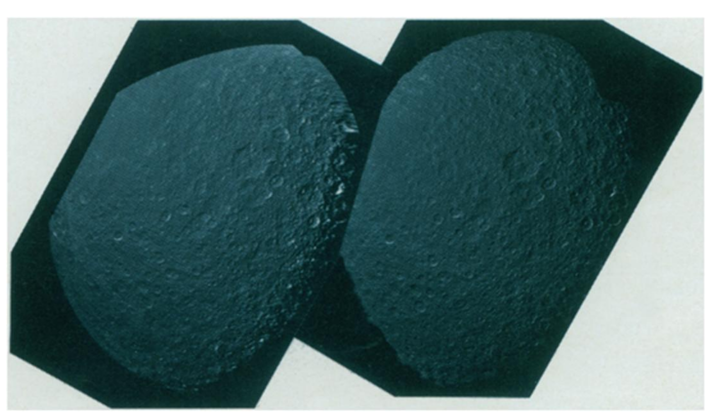
This pair of images shows craters, extensional trenches, and compressional ridges of Titania, a moon of Uranus.



This stereo view of Miranda, another moon of Uranus, shows the border between a bright, cratered plain and intriguing circular features known as Arden (left) and Inverness. These circular features, called coronae, were created by a combination of volcanic eruptions and fracturing. Complex topography is seen within Arden.



Three-dimensional image of Uranus' moon Ariel reveals deep canyons partly flooded by ancient lava flows.



Saturn's Rhea is probably the most heavily cratered moon in the outer solar system, yet the stereo view also shows several long ridges.

Stereo views of a volcano on Io called Ra Patera, some 500 km in diameter, show that its tallest parts have a surprisingly low elevation — only about 3 km. (Other mountainous areas on this moon run as tall as 10 km.) According to Schenk, the shallowness of the slopes suggests that the lava that built Ra Patera and its surroundings, which extend for about 250 km around the volcano, must have been rather runny. A thicker lava couldn't have traveled as far over this relatively flat region.

The finding may shed new light on the chemical composition of Ra Patera's lava as well — whether it consists primarily of basalts or contains a high concentration of sulfur compounds.

In 1979, both Voyager 1 and Voyager 2 photographed Ganymede. From these pictures, Schenk and his team have constructed stereo pairs that cover about 8 percent of this moon's surface. The images show in sharp relief the depth of craters; grooves; flat, circular features known as palimpsests; and the large basin Gilgamesh. The stereo pictures reveal that a highly fluid material once puddled between the basin's ridges, filling in and smoothing over the older terrain.

Although the Voyager 1 images of Callisto have poor resolution, stereo pairs reveal new details about a huge complex called Valhalla. Scientists already knew that the roughly circular structure, which contains a large set of concentric rings and ridges, has a diameter of 3,500 km. The stereo coverage shows that throughout a small section at the center of Valhalla — a region measuring about 400 km across — a once viscous material blankets its ridges and mountains.

Schenk speculates that when a large body slammed into Callisto sometime in the distant past, it blasted loose and melted material from the floor of Valhalla. The molten material then splashed onto the ridges and mountains before solidifying.

Titania, photographed by Voyager 2 in 1986, has significantly fewer craters than other moons of Uranus. Scientists had previously suggested that this moon underwent some kind of upheaval — a geologic face-lift that wiped its surface clean of other craters. The stereo images may shed light on the nature of the upheaval.

The pictures reveal a buckled landscape known to occur when a planetary body compresses or shrinks. Schenk suggests that Titania has shriveled like a dried-up apple, causing its surface to crinkle and buckle. This would explain both the rolling topography and the low density of craters.

Schenk says he'll have plenty to do, even after he exhausts the supply of stereo pairs provided by Voyager.

For instance, in reexamining stereo images of Mercury taken by Mariner 10, Schenk plans to compare the pictures with stereo pictures of Earth's moon recorded earlier this year by the Clementine spacecraft. Schenk will attempt to determine if the bright streaks of material seen radiating out from craters on both the moon and Mercury were created by similar processes.

In addition, Timothy J. Parker of the University of Southern California in Los Angeles has independently begun generating three-dimensional perspectives of Mars. He bases his work on images taken by the two Viking spacecraft, which photographed the Red Planet from orbit for 5 years, beginning in 1976. Parker hopes to find new evidence of ancient lake beds on Mars.

Future planetary missions, Schenk notes, could easily and cheaply incorporate stereo photo sessions. But even single sets of new images have a hidden value, he says. By carefully matching fresh images of a planetary body with those taken during older missions, scientists can literally add a new dimension to our understanding of the solar system. □

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work with students has greatly expanded the scientific horizons of thousands.

Many people remember Robert Ballard as the man who discovered the sunken remains of the *Titanic* and the German battleship *Bismarck* and who surveyed the final resting place of the torpedoed liner *Lusitania*.

Others recall his scientific feats, including participating in the first manned exploration of the Mid-Atlantic Ridge, part of the submerged mountain chain that winds through Earth's oceans like the seams of a baseball, and the discovery of the Galápagos Rift hot water vents and the unusual sea creatures living around them. Pictures from these expeditions rank among the most dramatic works of undersea photography.

Remarkable as these achievements are, Science Service and Science News honor Ballard for his equally remarkable efforts to capture the imaginations of children, particularly through his Jason Project.

Each year, he organizes a deep-sea expedition — utilizing the remote-controlled research submarine *Jason* — and periodically telecasts live reports to some 400,000 schoolchildren age 10 to 15 in the United States, Canada, England, and Bermuda. Ballard narrates the expedition's activities, and participating scientists provide commentary. The result is real scientists doing real science brought to life.

Jason voyages have included visits to hydrothermal vents in the Mediterranean Sea and to the perfectly preserved remains of two War of 1812 warships resting on the floor of Lake Ontario. Next year, *Jason* will venture to the ocean floor off Hawaii to investigate an active undersea volcano.

Of Glenn Seaborg, Chemical & Engineering News once said that his name "immediately brings to mind nuclear chemistry." He won the Nobel Prize for Chemistry in 1951 for his pioneering studies of transuranium elements.

A past chairman of the former Atomic Energy Commission and a leader long active in efforts to improve science education, Glenn Seaborg has provided Science Service his knowledgeable guidance for more than 25 years as a member of our Board of Trustees. He well deserves the Explorers Club award for both his scholarly and his educational accomplishments.

I hope you will join me in saluting Robert Ballard, Glenn Seaborg, and the other scientists who work so hard to open the eyes of the world's youth to science. And if you wish to nominate someone for our 1995 award, please write to me. You, too, can help promote a better understanding of science among our children, our future leaders.

— *Alfred Scott McLaren*