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Miranda: A Jigsaw Puzzle World

When the *Voyager 2* spacecraft flew by the planet Uranus in January 1986, astronomers were treated to their first close-up glimpse of the satellites that orbit the seventh planet. In fact, the *Voyager* team discovered 10 new moons around Uranus during the spacecraft's brief visit, bringing the total number up to 15. But by far the most intriguing of those 15 satellites was a jigsaw-puzzle world called **Miranda**.

In a way, it was remarkable that we obtained any pictures of Miranda at all. Uranus is about 20 times farther from the Sun than the Earth is — which means sunlight is 400 times dimmer at Uranus than here.

How dark was it at Miranda? One of the *Voyager* scientists put it this way: Taking pictures in the Uranus system is like trying to do photography in a ballpark at night when the only light comes from a single candle. Clearly, the *Voyager* cameras would have to take *long-exposure* photographs — but there was a small additional problem.

The *Voyager* cameras were not sitting still — they were attached to a spacecraft that was moving rapidly through space —, and *Voyager*'s speed when it flew by Miranda was 43,000 miles per hour (about 12 miles each second). If the scientists left the camera shutter open for ten seconds, the spacecraft in that time had already sped 120 miles farther on.

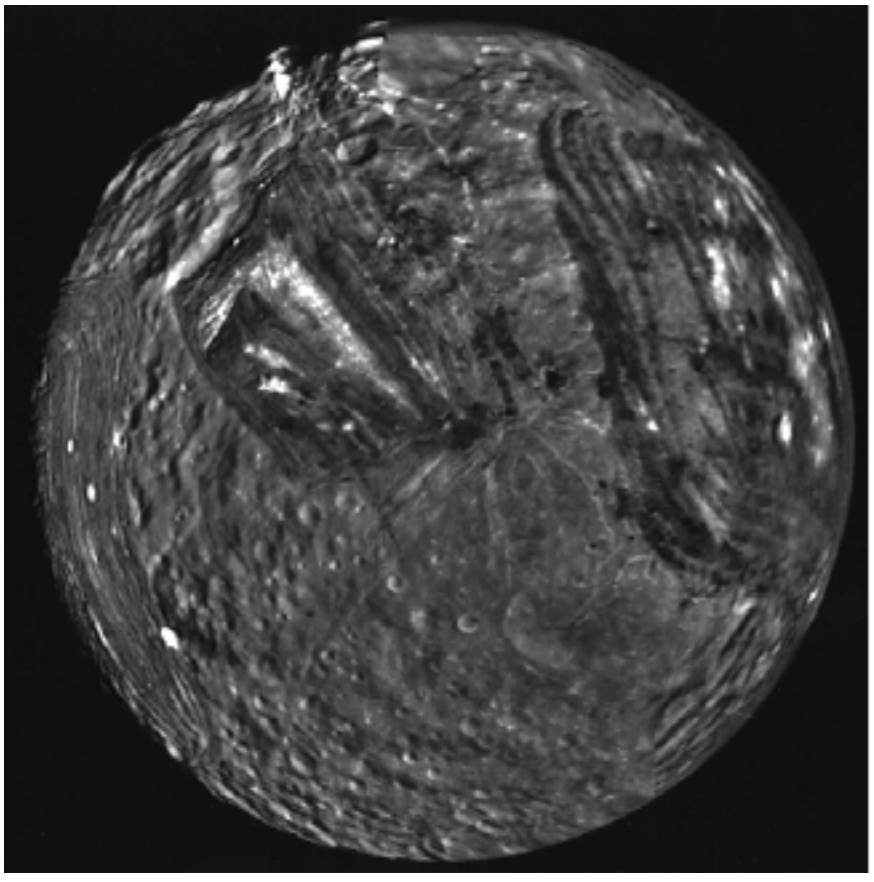
The only solution was to swing the spacecraft's camera steadily backward during the exposure, at just the right speed to make up for *Voyager*'s forward motion. To make matters even more complex, this backward swing had to be *pre-programmed* into the spacecraft's computers. This was because instructions sent by radio from Earth took about two and three-quarters hours to get to Uranus, much too late to do any good.

It is a tribute to the scientists and engineers who designed and built *Voyager* that we obtained a treasure-trove of clear, detailed pictures (and many other forms of scientific information) of Uranus, its thin rings, and its fascinating moons.

But there is no question that one of the most interesting of all the worlds we saw this time around was little Miranda. Only about 300 miles across and with only 1/1000 the mass of the Earth's moon, Miranda was the smallest of Uranus's moons that was known before the *Voyager* visit. (The new moons *Voyager* discovered all turned out to be smaller yet.) Miranda is so close to giant Uranus that it takes only about one and a half days to go around.

What makes Miranda so interesting to astronomers is that it seems to be several worlds in one. The region everyone notices first on Miranda is what looks like a bright check mark or number "7'' on a darker wrinkled background. Two other such mysterious blocks of ground are also seen elsewhere on Miranda. We know these places must be younger than the rest of the satellite because we see very few craters on them.

Craters are formed on an airless world like Miranda when small chunks of material coming from space hit the moon and blast a hole on impact. The longer a particular piece of ground has remained unchanged, the longer it has served as a target for craters. In fact, most of Miranda's surface is made of old rolling terrain, with many craters dotting the landscape. For some reason we don't understand, the regions like the checkmark must have formed or changed later in Miranda's history.



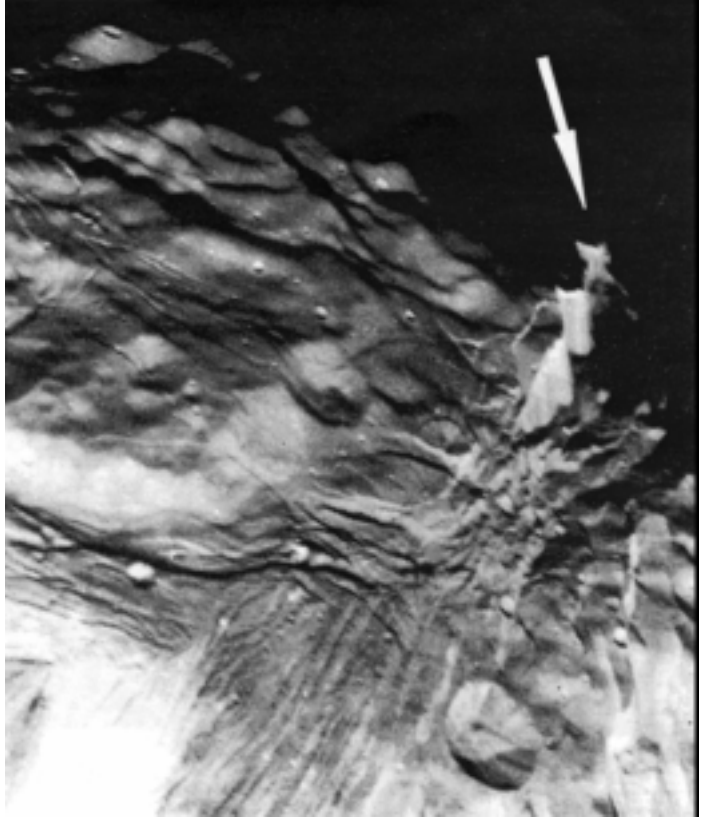
Miranda (NASA photograph).

Miranda also has vast cracks in the surface where the land seems to have shifted, exposing giant cliffs that would put many a mountain cliff on Earth to shame. The most impressive of these cliffs towers some 6 to 9 miles above its valley floor. (Compare this to the Grand Canyon in Arizona, which is only about a mile deep.) Furthermore, gravity is so weak on this little world that if you were to drop a rock from Miranda's tallest cliff, it would take a full five minutes to reach the bottom.

Miranda also has several other kinds of surface features and reminded the scientists who first looked at the *Voyager* photos of a giant cosmic geology museum. How did this little moon get such a complicated, mixed-up surface? It's far from certain yet, but at least one group of planetary scientists has come up with a very interesting suggestion. What if, long ago, Miranda had been hit by a large chunk of material, such as an asteroid or a small moon? If the incoming chunk were large enough and moving fast, its impact could have broken Miranda into pieces. When the pieces came back together again, there would be no reason for the landscapes to line up or for parts that were inside to remain on the inside. It may even be that the chunk that caused the impact remained close to the scene of the accident and was included in the new Miranda. This would explain why Miranda's surface today is such a crazy-quilt of different kinds of material, with different ages and geology.

Interestingly enough, *Voyager 2* only saw half of Miranda — the hemisphere illuminated by the Sun. Like Uranus, Miranda was tilted so its South Pole was pointed directly toward the Sun as *Voyager* passed. Thus our brief glimpse was only of its Southern Hemisphere. We can only wonder what sights await us on the other half of the satellite.

At the very least, Miranda teaches us that we cannot take anything for granted when we look at a planet or satellite for the first time. It is precisely because nature always seems to have a few surprises in store for us that astronomers have been urging NASA not to eviscerate the planetary exploration program that has given us so much exciting information on the worlds with which we share our solar system.



A cliff nearly 10 miles high on Miranda (NASA photograph).
