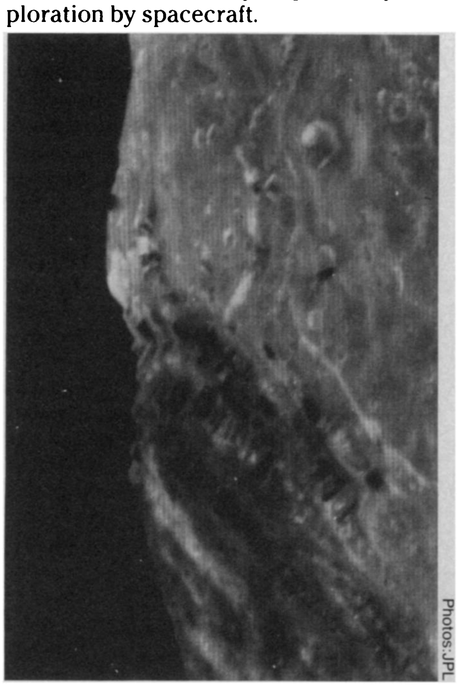
Mysteriously muddled Miranda

"Miranda is unlike any satellite we've ever seen before," says Bob Brown of Jet Propulsion Laboratory (JPL) in Pasadena, Calif.

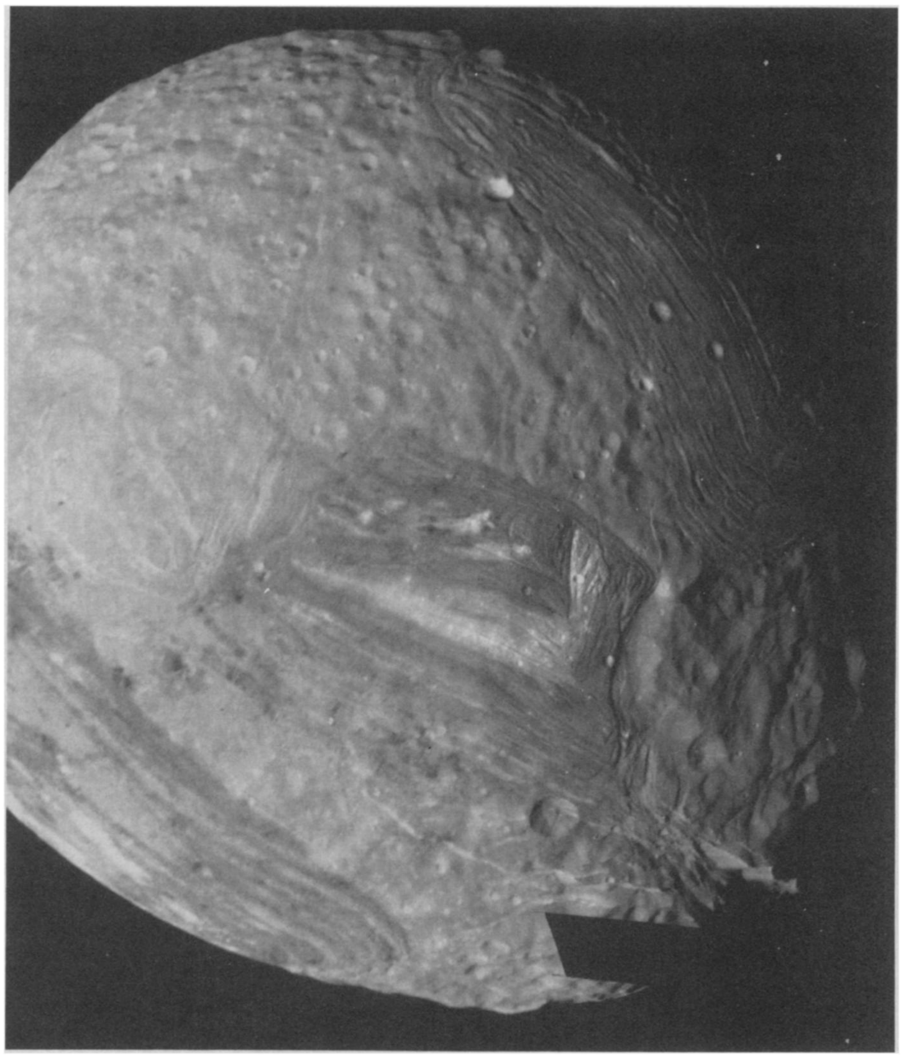
"If you can imagine taking all the bizarre forms in the solar system and putting them on one object," says Laurence Soderblom of the U.S. Geological Survey in Flagstaff, Ariz., indicating one of the Voyager 2 spacecraft's photos of the fifth-largest moon of Uranus, "you've got it in front of you."

"It's among the most enigmatic objects in the solar system," says Voyager imaging team leader Bradford Smith of the University of Arizona in Flagstaff, who rates it "a toss-up," even in comparison with Io, the Jovian satellite whose active volcanism has been one of the major discoveries in the history of planetary exploration by spacecraft.



Photos: JPL

Miles-deep grooves (above) are silhouetted as notches against the sky over Miranda's Uranus-facing hemisphere, just off the left edge of photomosaic at right.



Miranda is a little moon, barely 300 miles across. Not too many years ago, scientists would have expected such a small object to have had a fairly dull geologic history, born with too few heat-producing radionuclides to have generated much in the way of internal tectonic thrashings, let alone actual volcanism. Such views were wrenched out of shape in 1980 and '81 by Voyager 1 and 2, whose close-ups of the moons of Saturn — some no bigger than Miranda — revealed not only vast grooves and fractures but also huge, smooth areas on otherwise crater-ridden surfaces. It was as though the ice-clad terrain, hard as rock at Saturn's distance from the sun (and overlying interiors that density calculations indicated to be largely ice themselves, with even less likelihood of buried radionuclides), had been somehow softened, erasing the evidence of past scarrings.

Other hypotheses were offered, such as tidal heating (cited by many as the key factor driving Io's volcanoes) due to gravitational tug-of-wars that may have stressed a given satellite between Saturn itself and one or another of its nearby moons. The effect could be enhanced, it was proposed, if the affected objects included ices such as methane and ammonia, which could be softened with less heat. Planetary scientists were having to learn whole new disciplines.

But Miranda is stranger still. Voyager 2's precious treasure-trove of pictures of Miranda numbers barely a dozen frames (many of which have been combined into the preliminary photomosaic above), but they are more than enough to provide clear evidence of Miranda's exciting — and mystifying — past.

From nearly 900,000 miles away, the day before the spacecraft's closest approach and with most details still all but unrecognizable, one photo revealed a large dark feature bearing a brighter V-shape that was promptly dubbed "the chevron." A closer look provided no easy answers when the dark patch turned out to be nearly rectangular. (Whatever happened to "Nature abhors a straight line?") "Mosaicking" the images together further showed two sides of the rectangle to be aligned with a pair of seeming fracture zones that extend all the way to the horizon, nearly 150 miles away, at approximately a right angle.

Also conspicuous on the face of Miranda are at least two other huge patches (Voyager 2's close-ups cover only about half the surface), similar to the one containing the chevron but more rounded at the corners. And all three are bordered by families of grooves or lineaments, nested one outside the other like the lanes of a gigantic racetrack.

Voyager's past images of the satellites of Jupiter and Saturn provided no precedent for such a phenomenon, even among the multiple groove-families on the Jovian moon Ganymede. Atypically stuck for a bit of descriptive jargon, the imaging-team scientists have adopted the tentative term "circus maximus," after the great chariot-race course of ancient Rome.

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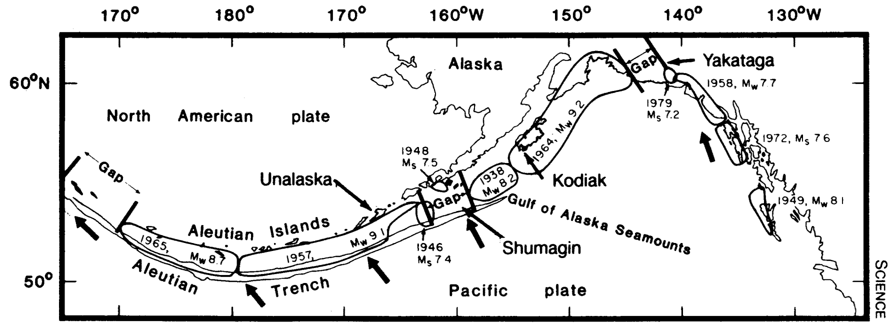
way in which the two plates slide past one another has changed fundamentally. Instead of sticking and then slipping as they had done before the last great earthquakes, the two blocks are now sliding continuously and stably, in a process called aseismic subduction. Because reliable strain measurements have been made for only a relatively short period of time, it's not possible to tell if the subduction along the gap is now permanently aseismic or if it is episodic, with long periods of aseismic subduction being punctuated by strain- and earthquake-generating stick-slip cycles.

Alternatively, says Savage, "our models of how strain accumulates may be wrong." It's possible that just before a large quake, the strain rate falls below a detectable level, he notes.

Last fall the state seismologist of Alaska, in conjunction with Klaus Jacob and other researchers at Lamont-Doherty Geological Observatory in Palisades, N.Y., issued an earthquake alert for the Shumagin gap because the occurrence rate of small earthquakes during the months May through October 1985 had increased from 30 to 80 percent above the average rate measured in previous years. Moreover, a sequence of magnitude 5 to 6.4 earthquakes had rattled the islands in October, and because the seismic pattern of this sequence was not typical, seismologists were concerned that these were precursory signals of a great earthquake. Now seismologists have to reconcile those seismic signals with Savage's strain results.



Strain is building up along the Yakataga segment of the Aleutian island chain in a manner consistent with what scientists expect when plates collide and generate earthquakes. But at the Shumagin gap, for which an earthquake alert was issued last fall, scientists are puzzled by the lack of strain accumulation.

If aseismic slip is indeed occurring in the Shumagin gap, says Jacob, "then the activity we saw in October [could mean] that while most of it slips aseismically, there are patches that rupture seismically." Jacob, however, thinks permanent aseismic subduction, while possible, is the least likely explanation for the lack of strain. The alternative, and the most tantalizing of the ideas, he says, is that the patches are only the beginning of a larger rupture to come, and that, as Savage notes, the absence of strain is itself a precursor of a great quake.

"So right now we are in somewhat of a dilemma," says Jacob. "From a research point of view it's an extremely crucial time." Ironically, in spite of the Shumagin gap's heavy instrumentation and puzzling behavior, Jacob worries that it may not be the best place for catching the precursory signals of a great quake. In the course of reanalyzing the seismic hazards in Alaska and parts of Canada, Jacob and his co-workers recently identified a 1,000-kilometer segment — stretching from Kodiak Island to Unalaska Island and including the 350-km-long Shumagin gap — that has a high probability of rupture. It is possible that a great earthquake and its precursory signs could start somewhere near Kodiak and outside of the Shumagin gap, which would be only minimally involved in the quake. "If that is the case," says Jacob, "we may miss our chance to do really good earthquake prediction." — *S. Weisburd*

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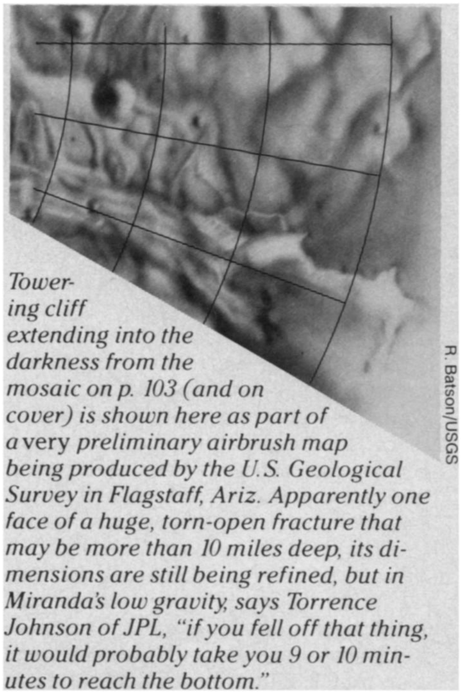
Having had barely three weeks to study the images, the researchers have agreed on no common explanation for the strange patterns. At a team meeting at JPL on Feb. 5, says Smith, the discussion of Miranda "just went around and around and around." According to assistant team-leader Soderblom, "We're back in the 19th century — all we're doing is classifying things."

One of the most curious aspects of the "circi maximi," notes Smith, is that the terrain outside them seems so unaffected by their presence. Compared with the stark contrast between the circi and their intervening ordinariness, in fact, he says, even a spectacular like the chevron "is not so bothersome."

Some of the team members have observed that the three circi seem to suggest the same phenomenon with different degrees of evolution. The one containing the chevron could be the least refined, while the one in the lower left corner of the photomosaic may show the most worn appearance, though no one is going so far out on a limb as to assert one circi to be older than the other. Even the less-disturbed-looking "inter-circus plains," however, are anything but dull, bearing intricate patterns of intersecting faults and fissures that one team-approved photo caption describes as "bewildering."

"Isn't it wonderful?" says Soderblom of Miranda's complexities. Says Smith, "It looks like a satellite designed by a committee." — *J. Eberhart*



Towering cliff extending into the darkness from the mosaic on p. 103 (and on cover) is shown here as part of a very preliminary airbrush map being produced by the U.S. Geological Survey in Flagstaff, Ariz. Apparently one face of a huge, torn-open fracture that may be more than 10 miles deep, its dimensions are still being refined, but in Miranda's low gravity, says Torrence Johnson of JPL, "if you fell off that thing, it would probably take you 9 or 10 minutes to reach the bottom."

R. Batson/USGS

Bridge to freedom

There is something dramatic about crossing a bridge. This is especially true of the Glienicke Bridge between Potsdam and the Wannsee section of West Berlin, which has become the traditional place for prisoner exchanges between the Eastern and Western powers. On Feb. 11 mathematician Anatoly B. Shcharansky crossed the Glienicke Bridge, ending nine years of incarceration in the Soviet Union.

Shcharansky's treatment had symbolized the plight of the Soviet "refuseniks," people who had been refused permission to emigrate and then harassed in various ways for insisting on their desire to do so. Many of them have professional qualifications the Soviets deem sensitive to their national security. Shcharansky was sentenced in the Soviet Union on a charge of being a CIA agent, an accusation that the U.S. government denies. He insisted on his innocence in a telephone call to President Reagan the evening of his release: "As you know, I never was an American spy." After his release, Shcharansky met his wife, Avital, who had spent the last nine years fighting for his freedom, and the two went on to Tel Aviv. □