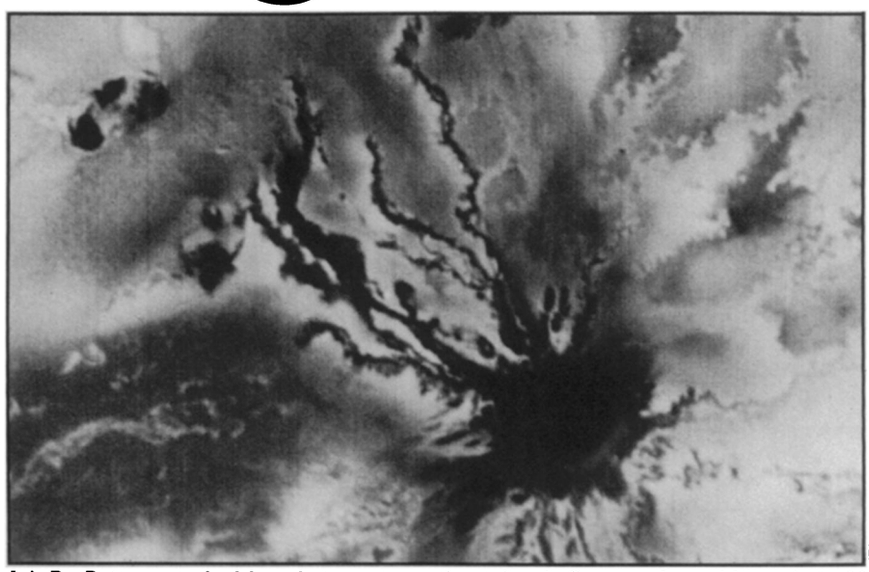
Io: Charting the Fire

Beginning a series of new maps of Jupiter's major moons

BY JONATHAN EBERHART



JPL

Io's Ra Patera, marked by what appear to be volcanic flows and a caldera about 30 kilometers across, is located — for now — at about 327°W by 8°S. Voyager 1 photo.

Jupiter's four major moons had been known for nearly four centuries as the Voyager 1 and 2 spacecraft approached the big planet last year. Two other probes, in fact — Pioneers 10 and 11 — had already passed that way. And yet, said the University of Arizona's Bradford Smith, head of Voyager's imaging team, "We know less about what to expect from the appearance of the Galilean satellites than about any other objects to which we've sent spacecraft."

"Unexpected" was certainly calling the shot. For this was no mere collection of rockballs. Callisto, farthest of the four from Jupiter, presented perhaps the oldest, most heavily cratered surface yet studied. Ganymede, bigger even than Mercury, showed what some scientists believe to be signs of a whole gamut of tectonic thrashings, twistings, turnings and slippings. Europa amazed onlookers by turning out to be, on its scale, smoother than a billiard ball, yet crisscrossed with myriad linear features that may be cracks left by global wrenchings but which somehow survived through the eons in the icy crust. And finally, stunning Io, bedecked in red and gold, silver, black and white, seething with sulfurous volcanic activity that is one of the major discoveries in the history of planetary exploration. A whole, previously unimagined family of exotic worlds, each radically different not only from its companions, but also from everything else in the planet-watcher's experience.

Now the spectacular photos have become maps, which fail completely to conventionalize the Galilean satellites' rampant strangeness, but which instead add the cartographer's veracity to the striking finds. Starting here, and in three subsequent (though not consecutive) issues, SCIENCE NEWS is presenting these maps, which will stand for at least half a dozen years (until the planned Galileo spacecraft gets to Jupiter) among the key documentation of some of the solar system's most exciting members.

The maps were produced by artists at the U.S. Geological Survey's Branch of Astrogeologic Studies in Flagstaff, Ariz., working with airbrushes directly from the Voyager photos. Consulting photos taken from different viewing and lighting angles, Patricia M. Bridges (who drew Io and Callisto) and J.L. Inge (Ganymede and Europa) sought to reproduce the actual surface appearances, minus the effects of shadow and distortion.

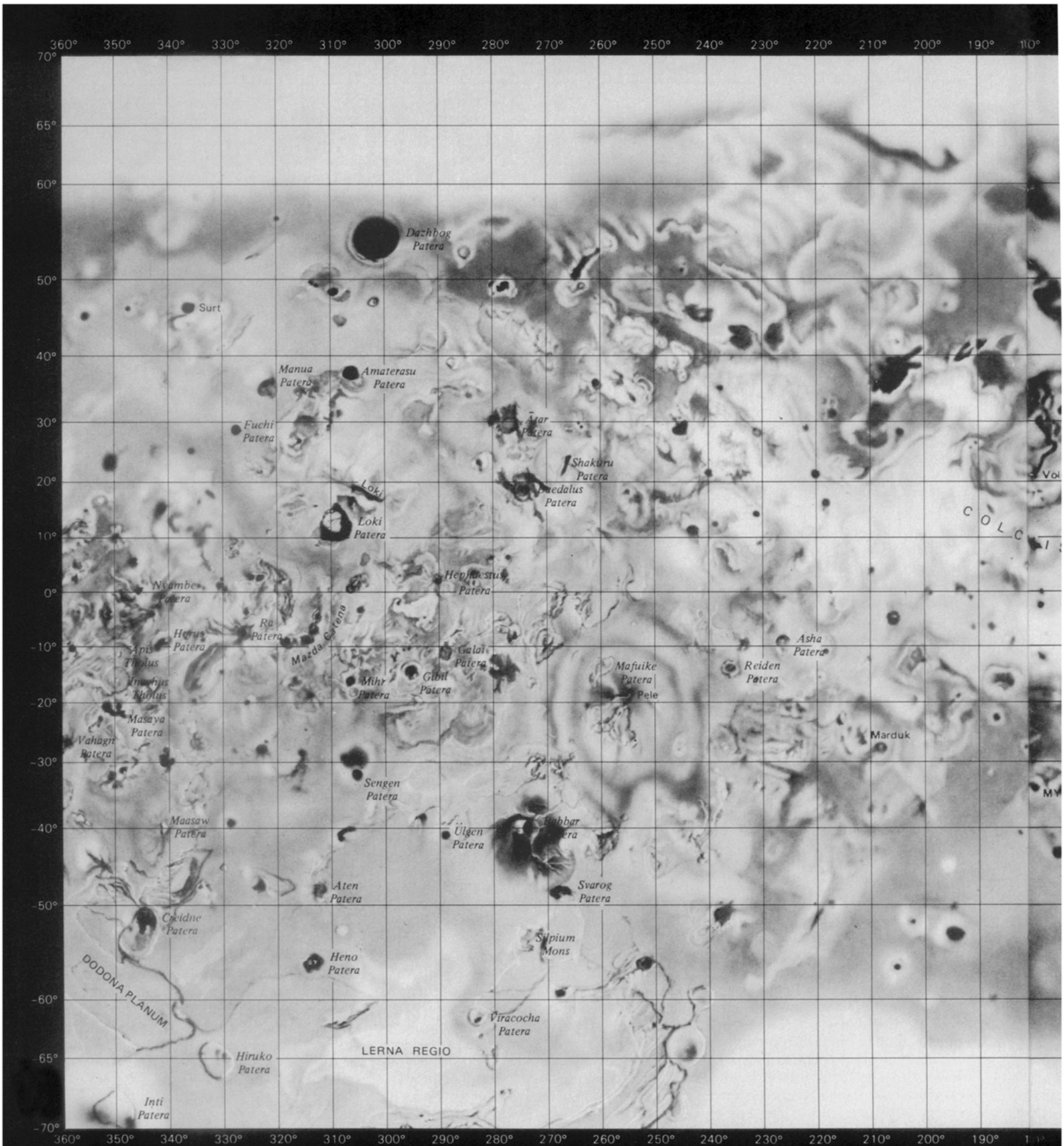
A key element in such mapping is the longitude-latitude grid, or "control net," which has been produced by a team headed by Merton E. Davies of the Rand Corp. in Santa Monica, Calif. It is an exacting, back-and-forth process of fine-tuning and correction, beginning before the photos are taken when the coordinates to be covered by each image are predicted on the basis of the planned aiming angles of the spacecraft's computer-guided cameras, combined with the anticipated effects of each satellite's gravity on the flight trajectory. Afterwards, tracking data gathered during the flight are used to pin down the precise path, while measurements from the photos themselves help refine the exact angles at which the cameras were pointing. Besides identifying the locations of surface features, the process of establishing the control net often also results in improved knowledge of the target object's size and shape.

The other major component of the maps is their nomenclature, selected by members of a working group of the International Astronomical Union, whose subsequent approval renders the names official. In some cases, the name game has been a highly contentious process, in which distinguished researchers from many countries find themselves bickering over whose esteemed national hero or other favorite shall be honored with the designation of a ten-kilometer crater. In the case of the Galilean satellites, the task was rendered somewhat easier by the decision to select names from mythology and legend. The IAU nomenclature working group's "outer planets task group," chaired by Tobias Owen of the State University of New York at Stony Brook, began making lists of possible names in 1977, before anyone had the faintest idea about the features to which they would be applied. A month after the Voyager 2 flyby last July, at an IAU meeting in Montreal, the names were hurriedly applied so that they could receive the organization's approval. Otherwise approval would probably have been delayed until 1982, when the IAU will hold the next of its triannual gatherings.

The maps were drawn at a scale of 1 to 25 million, and a 1-to-5-million set should be ready in about a year. A few more names remain to be applied, and the control net, which at present varies in uncertainty from about 1° for Io to 3° for Ganymede, may get tightened to about 1° for all four satellites.

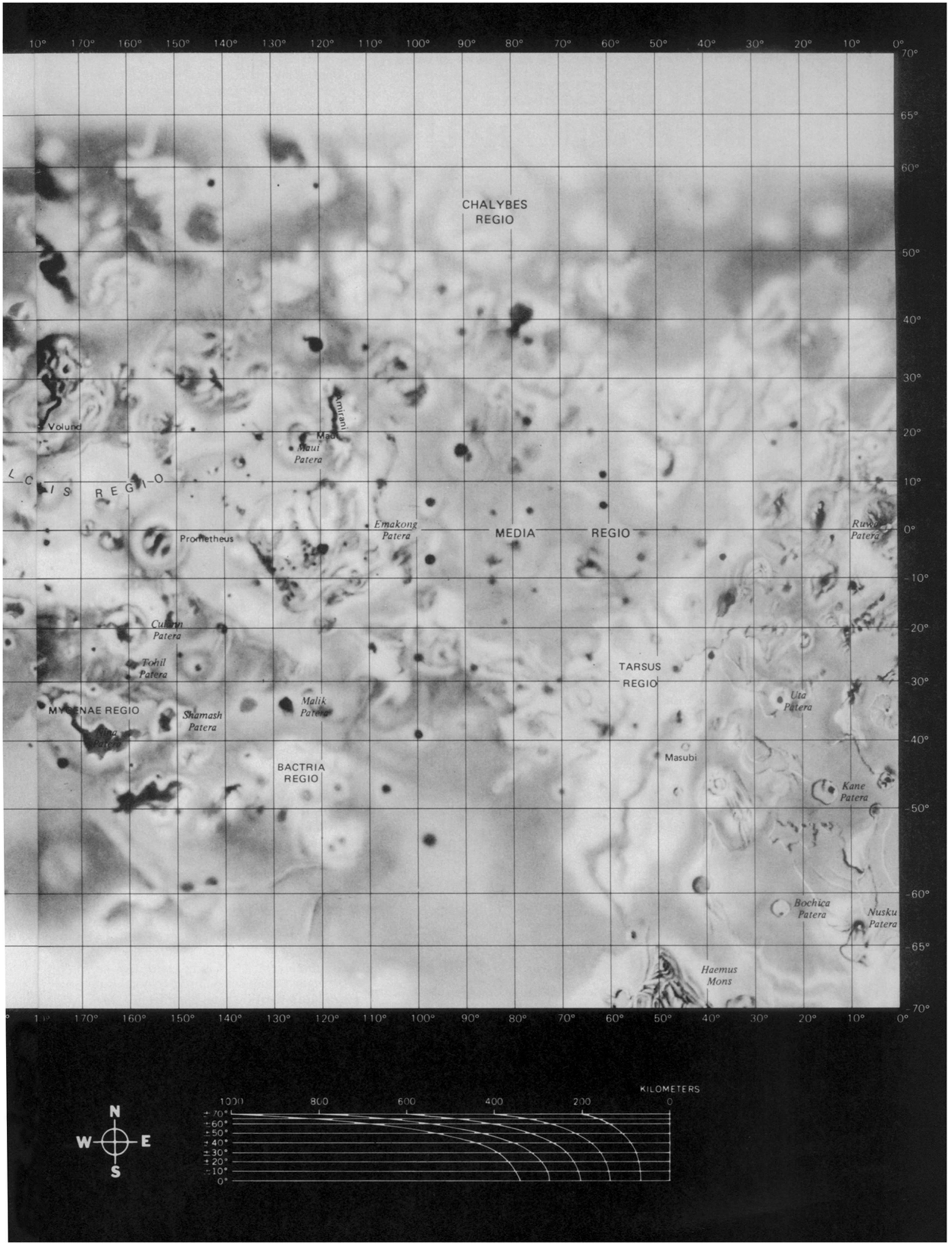
Io is the closest of the Galilean satellites to Jupiter (though not the closest satellite), and far and away the most dramatic. Nine active "eruptive centers" (a term that avoids specifying whether a given feature is a peak, a shield volcano or a vaporous fissure) were identified in the photos clearly enough to warrant names, and here the naming was a natural: the IAU task group simply extracted from its lists the names of deities associated with fire. The cast, in alphabetical order, includes Amirani, from Soviet Georgia; Loki, the prankster of Norse myth; Marduk, the Sumero-Akkadian fire god; Masubi, from Japan;

Continued on page 254



Io

Map of Io, innermost of Jupiter's four Galilean satellites, reveals numerous volcanic features but few if any impact craters. Prepared from Voyager 1 and 2 photos by the U.S. Geological Survey's Branch of Astrogeologic Studies, map was drawn at 1:25,000,000 scale, reproduced here at 1:29,000,000. South pole appears at same scale on cover; north pole is unmapped for lack of photo coverage. Io's diameter, refined in the process of establishing the map's latitude-longitude grid, is 1,816 ± 5 kilometers.


CHALYBES REGIO
Volund
Amirani
Mad
Maui Patera
LOKI REGIO
Prometheus
Emakong Patera
MEDIA REGIO
Ruwa Patera
Culann Patera
Tohil Patera
TARSUS REGIO
Uta Patera
MYCENAE REGIO
Shamash Patera
Malik Patera
Masubi
BACTRIA REGIO
Kane Patera
Bochica Patera
Nusku Patera
Haemus Mons
10° 170° 160° 150° 140° 130° 120° 110° 100° 90° 80° 70° 60° 50° 40° 30° 20° 10° 0°
70° 65° 60° 50° 40° 30° 20° 10° 0° -10° -20° -30° -40° -50° -60° -65° -70°
N
W
E
S
KILOMETERS
1000 800 600 400 200 0
±70° ±60° ±50° ±40° ±30° ±20° ±10° 0°

. . . Io

Maui, a Hawaiian demigod who sought fire from the fire-fingered demigoddess Mafuike; Pele, the Hawaiian goddess of the volcano; Prometheus of Greece; Surt, from Iceland; and Volund, the Germanic supreme god of blacksmiths. Non-eruptive, or former, volcanic features called *"paterae"* were also named for deities of fire and the sun, adding a host of figures such as the Japanese sun-goddess Amaterasu, who restored light to the world when she emerged from a cave within which she had barricaded herself. Names were taken from Persian, Mongolian, Egyptian, Celtic, Iriquois, Inca, Nicaraguan, Zambezi, Quechua, Pawnee, Babylonian, Hopi and other traditions. Each broad region, or *regio,* was named from the myth of Io, as was each feature defined as a *mons,* or mountain.

The maps do not show the complete surface of Io (or any others of the group), due to the incomplete photo coverage. In the careful renderings by Bridges and Inge, the resolution or sharpness declines with the resolution of the photos, in part because attempts to extrapolate could result in errors when dealing with such alien terrain. In fact, Ray Batson, head of the USGS planetary cartography unit, prefers to use non-geologists as his artists, to prevent unwarranted assumptions that might have grown out of experience with terrestrial landforms.

Io's volcanic environment also poses a unique problem for the mapmakers: It undoes their work. Some researchers have calculated that, with all its outpourings, the satellite may be resurfacing itself as rapidly as a millimeter per year. That may not seem like much, but the newly ejected material does not spread out in an even, one-millimeter layer all over Io. As a result, the active regions can undergo radical changes in short periods of time. In the mere four months between the Voyager 1 and 2 flybys, for example, one of the largest eruptive centers on Io, known as Prometheus, was transformed from a roughly heart-shaped feature into a circular one. And Prometheus is more than 200 kilometers across.

One effect of this ever-changing face is to make it difficult to pin down a given surface feature for purposes of defining a prime meridian of longitude. On Europa, Ganymede and Callisto, says Davies, one can simply pick a handy crater. For Io, however, Davies's group had to go by the satellite's rotation rate, identifying a surface location that was pointing directly at Jupiter at a certain time and leaving that spot's position to be defined by the precise number of times Io has since turned on its axis. Currently visible surface features on the evolving object are simply too untrustworthy, Davies says, "because I'm not sure, even if we go back to Io in the Galileo period, which would be 1986, how much of it we'll recognize."

Next: Europa. □