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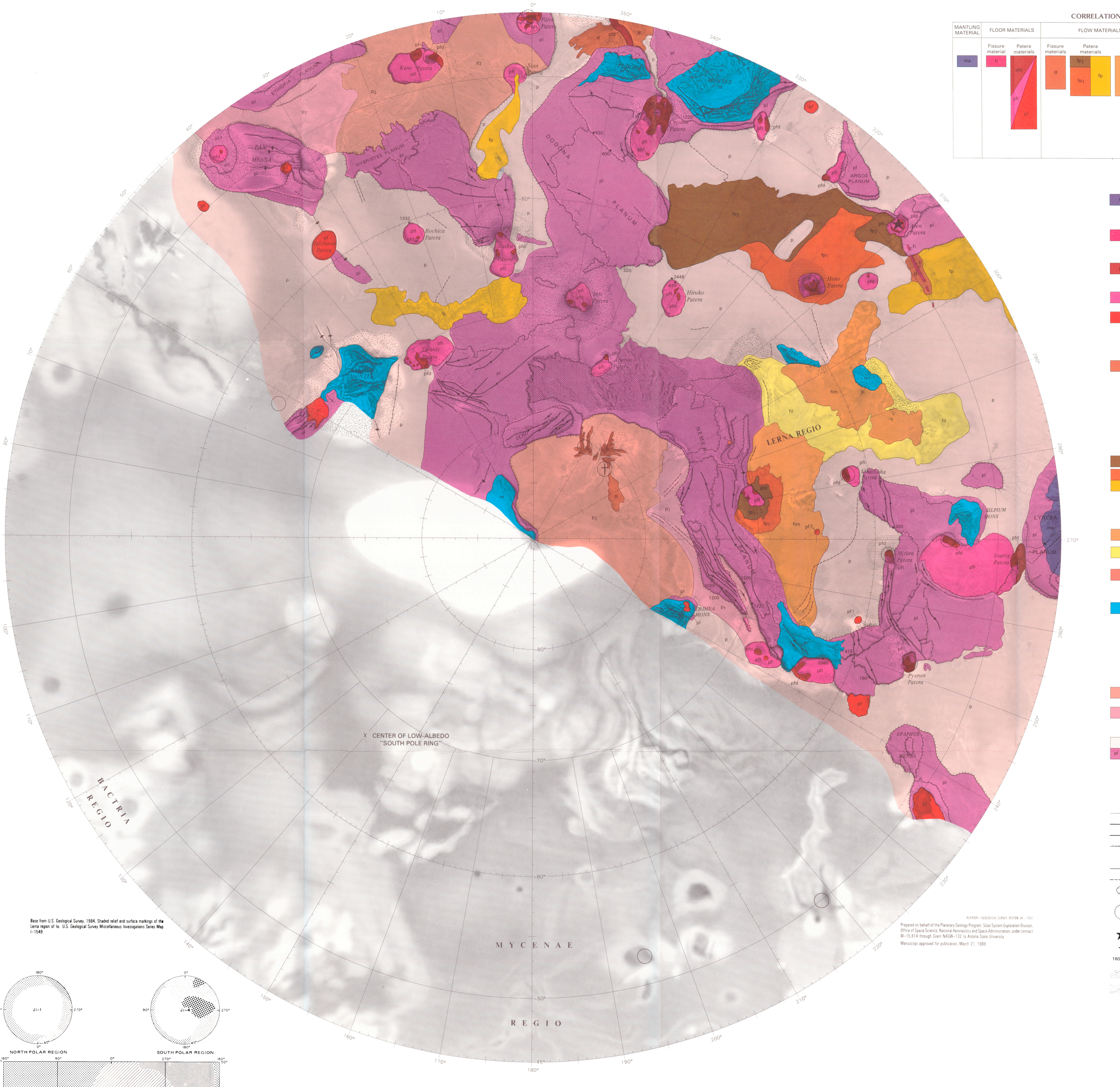
ATLAS OF JOVIAN SATELLITES
GEOLOGIC SERIES
LERNA REGION (Ji–4) I–2055

GEOLOGIC MAP OF THE LERNA REGION (Ji–4) OF IO

By

James L. Whitford-Stark, Peter J. Mouginis-Mark, and James W. Head

1991



Base from U.S. Geological Survey, 1984. Shaded relief and surface markings of the Lerna region of Io. U.S. Geological Survey Miscellaneous Investigations Series Map I-1549

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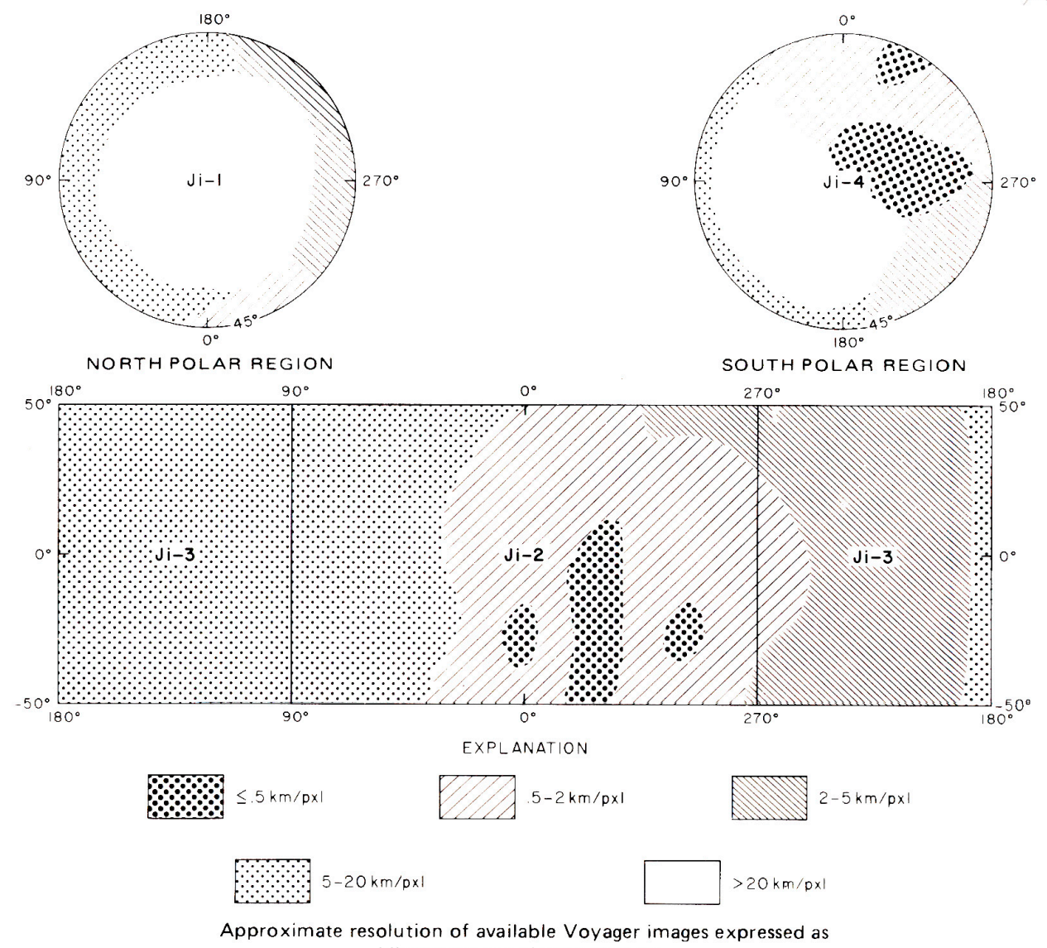
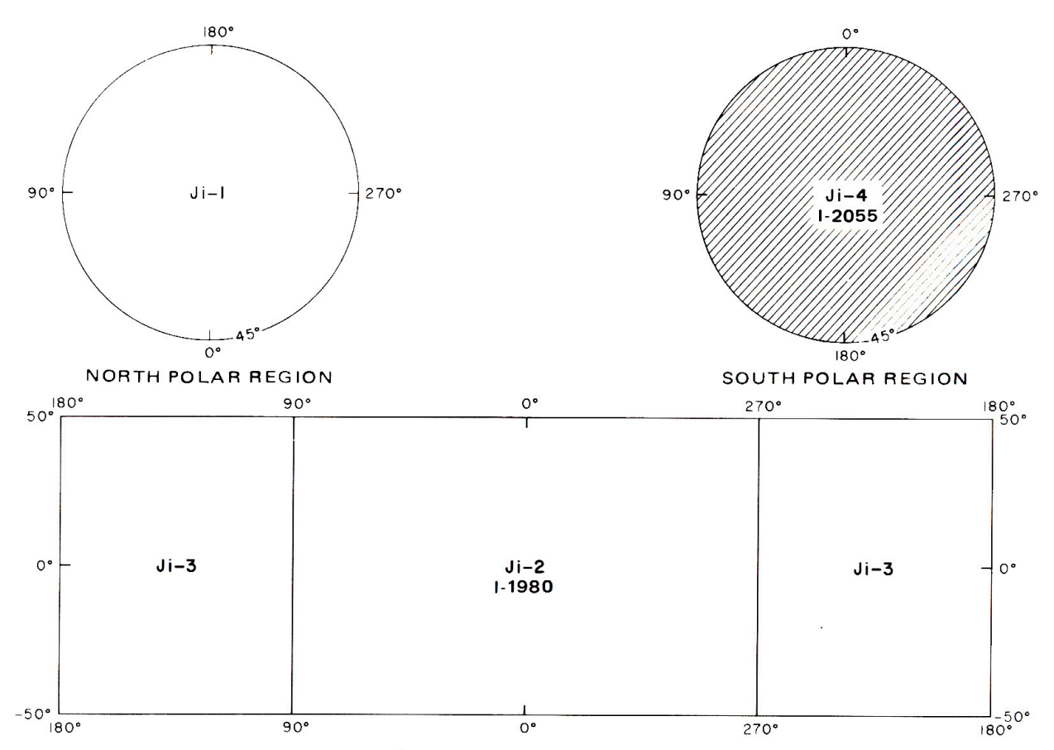
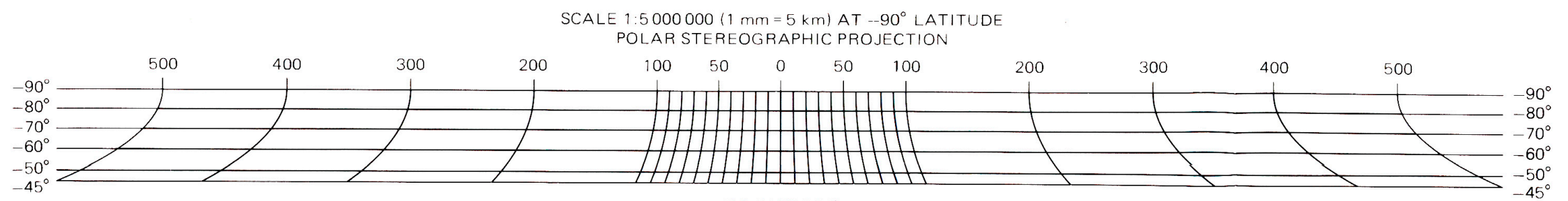
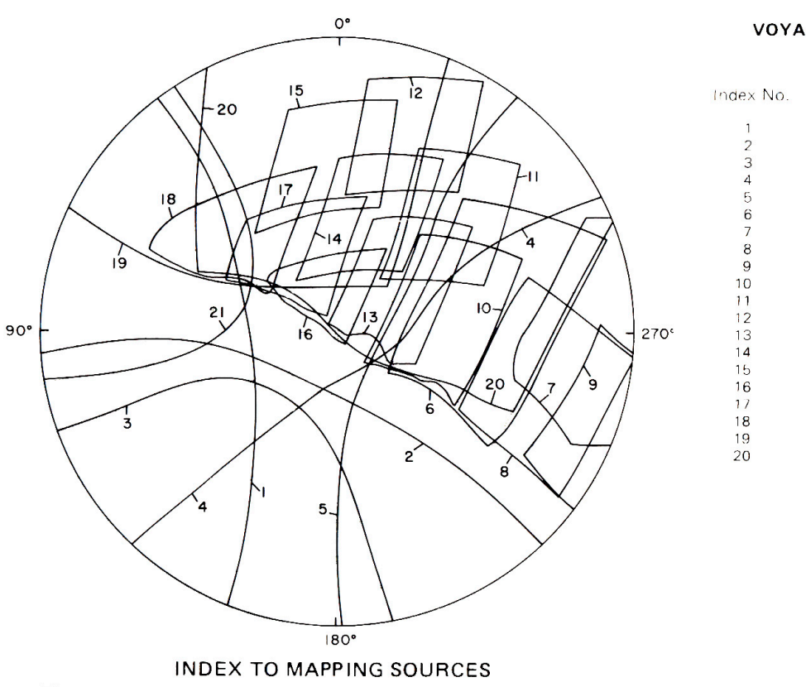


Approximate resolution of available Voyager images expressed as kilometers per picture element.



QUADRANGLE LOCATION
Number preceded by I refers to published geologic map





INDEX TO MAPPING SOURCES

The rendition of features on this map was controlled by reference to the primary source pictures outlined above. Supplemental source images used during the compilation are listed separately. Copies of various enhancements of these pictures are available from National Space Science Data Center, Code 601, Goddard Space Flight Center, Greenbelt, MD 20771.

Primary Source

VOYAGER 1		VOYAGER 2	
Index No.	Picture No.	Index No.	Picture No.
1	0084J1-001	21	0129J2+000
2	0552J1-001		
3	0791J1-001		
4	0969J1-001		
5	1368J1-001		
6	0101J1+000		
7	0111J1+000		
8	0113J1+000		
9	0123J1+000		
10	0141J1+000		
11	0143J1+000		
12	0145J1+000		
13	0147J1+000		
14	0149J1+000		
15	0151J1+000		
16	0153J1+000		
17	0155J1+000		
18	0157J1+000		
19	0192J1+000		
20	0196J1+000		

Supplemental Source

VOYAGER 1		VOYAGER 2
Picture No.	Picture No.	Picture No.
1332J1-002	0089J1+000	0963J2-002
1680J1-002	0091J1+000	1326J2-002
0080J1-001	0103J1+000	
0082J1-001	0128J1+000	
0542J1-001	0130J1+000	
0548J1-001	0132J1+000	
0554J1-001	0134J1+000	
0795J1-001	0138J1+000	
0965J1-001	0140J1+000	
1105J1-001	0142J1+000	
1107J1-001	0144J1+000	
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1366J1-001	0150J1+000	
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1384J1-001	0198J1+000	
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0065J1+000	0203J1+000	
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0075J1+000	0218J1+000	
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0079J1+000	0230J1+000	
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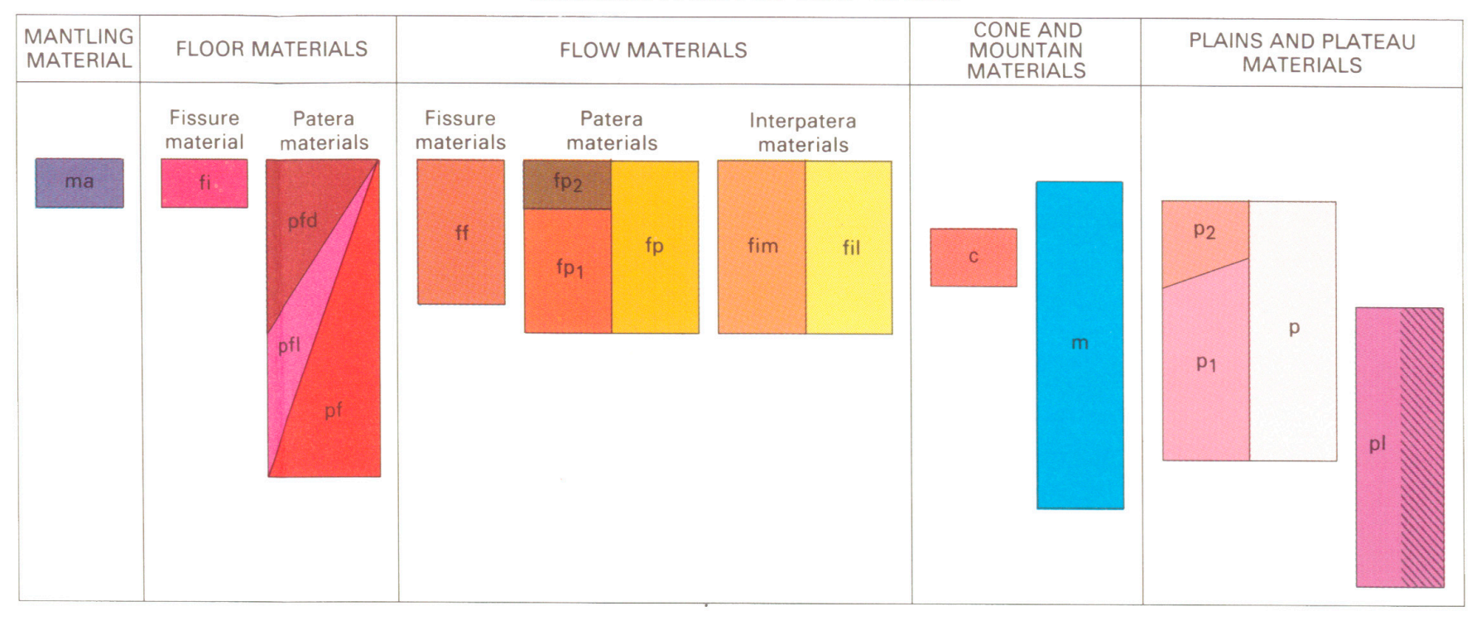
0086J1+000	0234J1+000	
0087J1+000		

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

MANTLING MATERIAL

ma **Mantling material**—Thin, low-albedo deposit extending from Babbar Patera in adjacent Ruwa Patera quadrangle to near Svarog Patera (lat 47° S., long 267°). *Interpretation:* Pyroclastic deposit; relatively young

FLOOR MATERIALS

fi **Fissure material**—Generally low-albedo material centered at lat 49° S., long 305°; forms elongate features from which flows emanate. *Interpretation:* Silicate or sulfur deposits within linear vents

Patera materials

pfd **Dark material**—Smooth material within circular to elliptical depressions, commonly irregular in outline. Some occur with hot spots. *Interpretation:* Lava lakes of silicates or molten sulfur at various temperatures within calderas

pfl **Light material**—Similar to dark material but has higher albedo. *Interpretation:* Low-temperature lava lakes, possibly solidified, of silicates or sulfur within calderas

pf **Undivided material**—Smooth material within circular to elliptical depressions; no color or textural variation. Includes floors of paterae obscured by shadows or topographic highs. Queried where poor image resolution prevents definitive identification. *Interpretation:* Similar to dark unit

FLOW MATERIALS

ff **Fissure material**—Associated with linear to curvilinear fissures. Overlies plains units. Albedo generally low but varied; lobate margins. Material near lat 80° S., long 330° associated with inferred hot spot. Individual deposits probably of different ages, but lack of superposition relations precludes unique age determination. *Interpretation:* Lava or pyroclastic flows erupted from fissures

Patera materials—Large, lobate, variegated flows; traceable to any one of a number of source paterae; association with source paterae either certain or apparent. Younger and older units recognized on basis of local overlap relations. (Not all deposits of younger (or older) material necessarily of same age.) *Interpretation:* Lava or pyroclastic flows

fp_2 **Younger material**—Individual flow units discernible in some areas, as around Kane Patera

fp_1 **Older material**

fp **Undivided material**—Superposition relations with other patera flow materials not obvious. Superposed on undivided plains material

Interpatera materials—Lobate flows not obviously associated with specific source. *Interpretation:* Lava or pyroclastic flows from undetermined sources. Units may be different facies of same material

fim **Medium-albedo material**—Variegated, though generally medium dark

fil **Light material**—Variegated, though generally has high albedo

CONE AND MOUNTAIN MATERIALS

c **Cone material**—Forms small conical hill at lat 71° S., long 296° near edge of plateau unit. Hill has circular summit depression. *Interpretation:* Hill is small volcano whose material has high yield strength; alternatively, may be erosional remnant of plateau

m **Mountain material**—Forms isolated, high-relief, generally steep-sided features; texture rough to smooth. Commonly overlaps plains and plateau materials; associated with paterae at many places. Queried where low image resolution prevents definitive identification. *Interpretation:* Volcanoes of varied ages composed of material of high yield strength, probably silicic

PLAINS AND PLATEAU MATERIALS

Plains materials—Occur at relatively low elevations; surfaces appear generally smooth and flat; albedo varied. *Interpretation:* Polygenetic materials composed of lava and pyroclastic deposits

p_2 **Younger plains material**—Albedo variegated. Embays older plains material; superposed by fresh and degraded fissure flow material

p_1 **Older plains material**—Cut by curvilinear features, possibly grabens. Appears to be topographically higher than younger material in area around lat 78° S., long 270°. Possibly a subunit of plateau material

p **Undivided material**—Generally brownish yellow

pl **Plateau material**—Forms extensive, moderately high plains. Surfaces generally smooth except where crossed by grabens and ridges; bounded by scarps ranging from 150 to 1,700 m in height (Schaber, 1982) and by faults. Diagonal lines indicate areas that have been heavily eroded. *Interpretation:* Old volcanic deposits, probably largely pyroclastic, deformed by tensional tectonism and eroded

---- **Contact**—Dashed where approximately located or inferred

Fault—Bar and ball on downthrown side

Graben

Scarp—Line at top of scarp, hachures point downslope; used as contact in places. Most scarps interpreted as erosional but some may be structural

Ridge crest

– – – – **Lineament or curvilineament**—Origin unknown

Circular depression—Symbol used as contact; not shown where rim incomplete, possibly eroded. Interpreted as caldera

○ **Low-albedo area inferred to be associated with hot spot**—Symbol may be superposed on symbols below for inferred active vent and Voyager 1 hot spot

★ **Vent inferred to have been active between Voyager 1 and 2 encounters**

† **Hot spot**—Identified from Voyager 1 IRIS data

160 • **Elevation in meters**—Determined by photometry and photoclinometry (Schaber, 1982; Davies and Wilson, 1987)

Bright halo—Medium to high albedo; approximately concentric to paterae and mountains; also occurs at bases of scarps

Dark halo—Low albedo; circular to elongate

INTRODUCTION

Io is the innermost of the Galilean satellites of Jupiter. Io's radius of 1,820 km and density of 3,530 kg/m^3 are about the same as those of Earth's Moon. However, unlike the Moon's surface, which is largely covered by impact craters and basins, the surface of Io is dominated by volcanic landforms (Schaber, 1980, 1982). Moreover, the two 1979 Voyager encounters revealed that Io's volcanoes were actively emitting materials (Morabito and others, 1979), a process that had been predicted prior to image acquisition (Peale and others, 1979). Of the nine active eruptions identified on Voyager 1 images, eight were also active at the time of the Voyager 2 encounter 4 months later. Two additional eruptions were identified as having taken place between encounters (McEwen and Soderblom, 1983). Furthermore, 88 sites of active or recently active volcanism have been identified (McEwen and others, 1985) on the basis of an association between calderas and areas of low albedo (<0.3 in all visual wavelengths). Earth-based observations (Goguen and others, 1987) indicate that Loki Patera (lat 13° N., long 309°) was still active in 1985, 6 years after the Voyager encounters.

Volcanic activity is so extensive on Io that not a single impact crater is recognized in the highest resolution Voyager images (about 2 km/line pair; Smith and others, 1979). Io's average surface age, inferred from the burial rate of impact craters, is probably less than 10^6 years (Johnson and Soderblom, 1982). As a consequence, surface features of Io are ephemeral and are therefore expected to have changed by the time of future imaging spacecraft missions.

Io's surface chemical composition appears to differ from those of the terrestrial planets, and it has been a subject of controversy. The spectacular coloration of the surface revealed in the early images led Sagan (1979) to suggest that features resembling terrestrial lava flows might be composed of sulfur. However, Clow and Carr (1980) pointed out that the rheological properties of sulfur are such that it could not support features having an estimated surface relief of nearly 10 km, and Carr (1986) argued that the near-surface materials are composed primarily of silicates. The vivid and contrasting colors—bright reds, black, and orange—depicted on the early images of Io were later shown not to be the true colors of the surface (Young, 1984, 1985; McEwen and others, 1985; McEwen, 1988); the average surface color is pale yellow similar to that in figure 1. Young (1984) has argued that either the features on Io are not composed of quenched sulfur, as the early color images would suggest, or some mechanism other than quenching is required to permit the survival of the different colors of sulfur. He suggested iron compounds as a possible alternative. Sulfur dioxide frost is known to cover most of the surface of Io, but many other materials could be represented according to the available spectral data for the remaining areas (for examples, see McEwen and others, 1985). The presence of sodium and potassium in the clouds surrounding Io (Morrison, 1982) suggests a surface source for these volatiles. Work is currently in progress to determine many substances' spectral characteristics under conditions similar to that of the satellite's surface (an ambient surface temperature of <135 K and an atmospheric pressure of $<10^{-7}$ bar). At present, many investigators, including Schaber (1982) and Greeley and others (1984), appear to have adopted a compromise whereby the magmatism on Io is envisaged as producing a mixture of silicate and sulfur materials.

Conventional planetary photogeologic techniques defined by Wilhelms (1972) were applied to the Voyager images of Io. Color images at resolutions of 2 to 20 km/line pair proved particularly helpful in defining units. Because impact craters are absent, stratigraphic ages were established only by superposition, intersection, and degree of degradation of volcanic units. The areal separation of some of the units precludes unique determination of their relative ages. In some places, boundaries between units of apparently different ages have been mapped, but it was impossible to determine which is the older unit. This problem is particularly true of the plains units.

Images are available for the region between long 60° and 230°, but their resolution is too low to permit unique identification of landforms. (See resolution diagram.) Nevertheless, this region appears dominated by landforms similar to those in the mapped region. It is, however, distinguished from the mapped region by the presence of "the south pole ring"—an area of low albedo and elevated temperatures some 1,000 km in diameter centered at about lat 75° S., long 140° (McEwen and others, 1985). The sharp boundaries of the ring feature have led to the suggestion that it may be of tectonic origin (McEwen and others, 1985).

Two areas that overlap part of the Lerna region were imaged at resolutions of 2 km/line pair or higher and thus can be mapped at scales larger than that of Lerna. The first area includes Maasaw Patera and extends from lat 35° S. to 48° S., long 335° to 350°; it was mapped at 1:1,000,000 scale (Moore, 1987). The second area includes Kane Patera and extends from lat 15° S. to 50° S., long 355° to 20°; it is being mapped at 1:2,000,000 scale (W.E. Elston and F.R. Karner, work in progress).

GENERAL GEOLOGY

PLAINS AND PLATEAU MATERIALS

Materials of the Lerna region were mapped as dark-brown to black plains deposits by Masursky and others (1979). The oldest unit in the region is considered to be the plateau material (unit **pl**). Unlike most other units, it contains ridges and grabens of tectonic origin, which apparently originated before the other materials were emplaced. The plateau material forms areas of elevated relief bounded by high scarps. The largest continuous expanses of plateau material form Nemea Planum (about 3.5X10^5 km^2 in area) and Dodona Planum (about 1.25X10^5 km^2).

The plateau material appears to have been eroded to some degree everywhere in the Lerna region, particularly in the area around lat 72.5° S., long 330°. McCauley and others (1979) suggested that the erosion was caused by sulfur dioxide sapping. In some places, sapping does indeed appear to have occurred, notably where high-albedo deposits appear to originate from the base of plateau-bounding scarps. However, lack of debris at the base of the scarps is difficult to explain by a sapping process: the material of the plateau is sufficiently strong to support scarps as much as 1,700 m high, yet no debris is seen at their bases. Alternatively, Mouginis-Mark and others (1984) suggested that subsequent lava flows eroded the plateau material. Evidence for this type of erosion is the alignment of erosional remnants of the plateau unit at lat 72° S., long 320° (Voyager 1 picture number 0147J1+000); these remnants are several times longer than wide. Additional evidence for erosion by lava is seen in a channellike feature at lat 80° S., long 20°. Sublimation also may have contributed to sculpturing of the plateau material, but we would expect the resultant landscape to be similar to the etched and pitted terrain of Mars, where sublimation of carbon dioxide ice has been invoked as a landscape-forming process (Carr, 1981). The two landscapes, however, are not similar.

Where the plateau material has been less eroded, it is characterized by generally smooth and featureless surfaces except where crossed by grabens and ridges. At least five distinct topographic levels of the plateau unit can be recognized, in places forming a steplike topography. The different topographic levels probably mark stratigraphic boundaries between subunits of contrasting physical properties, which have been differentially eroded. This interpretation is supported by the observation that vertical relief of some scarps changes as little as 20 m over distances of 50 km or more (Schaber, 1982, fig. 15.12).

We suggest that the plateau material may have originally been continuous across the entire Lerna region and that the unit has been eroded back to its present form by a combination of sapping and fluid or thermal erosion. The plateau material is probably pyroclastic deposits, because (1) its surfaces are generally featureless, (2) it is distributed over areas exceeding 10^5 km^2, and (3) it shows apparently horizontal stratification. Such a composition is supported by the dramatic visual evidence of the 250-km-high, 1,000-km-diameter eruption plumes that have been observed on Io. Low-viscosity flows erupted at high rates are another possibility, because they would produce a landscape of similar morphology.

The plains materials have generally featureless surfaces of uniform albedo and occupy large, low areas between paterae. Because the plains units contain circular depressions as deep as 2 km, Clow and Carr (1980) suggested that these units are composed of material of high yield strength. The plains materials are interpreted to be polygenetic, composed of a varied mixture of flow and pyroclastic deposits that cannot be assigned to any specific eruption center. The older plains material (unit p_1) lacks lobate outlines but contains curvilinear features of unknown but possibly tectonic origin. The younger plains material (unit p_2) has distinct lobate boundaries suggesting little modification since emplacement. If the curvilinear features in the older unit are indeed tectonic, their absence in the younger unit substantiates that unit's age assignment. The undivided plains material (unit **p**) is mapped in areas where evidence for age relations is lacking.

CONE AND MOUNTAIN MATERIALS

The mountain material (unit **m**) is characterized by relief that locally exceeds 9 ± 1 km (Schaber, 1982) and by extremely rugged surfaces of alternating ridges and troughs. Some mountains, such as Haemus Montes, have associated craters; others, such as Silpium Mons, do not. Euboea Montes exhibit evidence of downhill motion of the mountain surface material (Schaber, 1982); the characteristics of flowage, such as high, steep, lobate flow fronts, indicate that the material has a high yield strength (Moore, 1987). The high relief and high yield strength indicate that the mountains are more likely to be composed of silicates than of sulfur.

The mountain material was suggested by Smith and others (1979) to be a part of the silicate subcrust protruding through a dominantly sulfur layer. This interpretation was questioned by Whitford-Stark (1982a), who proposed that some mountains are volcanoes younger than, and superposed on, the plateau material. The mountains are apparently of diverse ages, but their isolated occurrences preclude an age assignment relative to ages of other map units. If, as we suggested above, the plateau material was originally continuous, Haemus Montes must postdate its erosion, because they rest directly on plains material. Unfortunately, the west edge of Haemus Montes, where the plateau and mountain materials are juxtaposed, is at the terminator, and we cannot determine which overlaps the other. At Euboea Montes, the mountain material overlaps several terraces of the plateau material. If the mountain material there is a primary deposit, it must be younger than the plateau material. Alternatively, the mountain material may have been emplaced by slumping (Moore, 1987). The formation of the mountain material is poorly constrained in time; it may span the entire period of Io's interpretable history.

The only occurrence of cone material (unit **c**) in the region is a small conical feature at lat 71° S., long 296°. It has a summit depression and may be a volcano, but it is not associated with any materials obviously indicative of a volcanic eruption, such as surrounding lava flows or tephra.

FLOW MATERIALS

The large extent of many flows indicates their emplacement as low-viscosity fluids. Calculation of the volumes of the flows is not possible because their thicknesses are unknown. Some flows, however, rival in area the largest terrestrial flood basalts and pyroclastic sheets.

The medium-albedo and light interpatera flow materials (units **fim** and **fil**, respectively), which form a large part of Lerna Regio, are distinguished purely on the basis of albedo. (Because colors differ within individual flows, color boundaries do not necessarily reflect flow boundaries.) These units cannot be related to a specific source, but the caldera at lat 70° S., long 280° is a likely candidate.

All of the patera materials appear to be associated with individual paterae. Where mutual superposition relations are clear, the materials are mapped as older (unit fp_1) or younger (unit fp_2); elsewhere, the material is mapped as undivided (unit **fp**). Lobate flows radiate outward in all directions from Kane Patera. However, colors of the patera at lat 70° S., long 280° are concentrically arranged, suggesting radiating flows that are possibly topographically subdued; image resolution is insufficient to detect lobate flow boundaries. The flow from Nusku Patera, however, exhibits no evidence for multiple flow units, but rather it appears to be a single large flow.

The fissure material (unit **ff**) is dark relative to its immediate surroundings; most exposures are small (about 80 km long) and have lobate margins.

The colors and color patterns of the flow materials indicate that they were emplaced either as sulfur flows or as silicate flows with a surface coating of sulfur-rich materials (Pieri and others, 1984). Alternatively, with the possible exception of the fissure material, many of the flows might be of pyroclastic origin. Pyroclastic flows are morphologically similar to lava flows and can mount topographic rises. Also, the "auras" (high-albedo halos) seen around some of the flows elsewhere on Io (Baloga and others, 1983, and described below) may result from jetting of fines at the forward edge of pyroclastic flows, a feature common to terrestrial examples such as Santiago Volcano, Chile (Walker, 1983).

FLOOR MATERIALS

Each deposit of the patera materials is surrounded by an approximately circular to elliptical, inward-facing boundary scarp or scarp segments, forming paterae interpreted as calderas. Their floors are typically 1.5 to 2.5 km below the level of their rims (Davies and Wilson, 1987). Some paterae are very large: for instance, the floor material of Creidne Patera occupies an area of 8,000 km^2, roughly four-fifths the area of the Big Island of Hawaii.

Patera floor materials are subdivided into generally light (unit **pfl**), dark (unit **pfd**), and undivided (unit **pf**) deposits. (The first two designations represent a fairly wide spectrum of albedos and are only locally applicable; that is, a light unit in one patera may have the equivalent albedo of a dark unit in another patera.) The undivided material makes up the floors of paterae that are uniformly colored or that were imaged at an angle so oblique that shadows masked the floor.

Hot spots were determined by the Voyager 1 infrared interferometer spectrometer (IRIS) to be associated with some patera floors (Pearl and Sinton, 1982). Later investigations (McEwen and others, 1985) showed that the hot spots are specifically associated with the dark parts of the patera floors. Even though the composition of the material forming the floors has not been uniquely determined, the proportion of the floor covered by dark material may be used as an indicator of the floor's relative age; that is, floors that are completely covered by dark material are younger, whereas those covered by light material are older. Where dark material occupies but a small part of the floors, it is commonly close to the bounding walls (for example, at Bochica, Nusku, Inti, and Viracocha Paterae), perhaps indicating higher heat flow from vents along bounding scarps.

Except where circular depressions occur on mountains, paterae do not appear to be associated with pronounced shields. We noted above that at Kane Patera, individual lobes of the patera flow materials radiate outward from the patera in all directions, indicating that the patera surmounts a topographic rise. Almost all the other paterae appear to be incised into level terrain or to lie on shields whose topographic relief is barely discernible (Wood, 1984; Moore and others, 1986). Thus these paterae may have formed by collapse without construction of a topographic edifice. The lack of significant topographic relief is typical of large terrestrial volcanoes that have been the source of ignimbrites (Aldis and Ghazali, 1984).

Although the paterae do not appear to be preferentially aligned, patera centers in the plains are spaced, with remarkable consistency, about 250 km apart. This spacing does not likely reflect the magma source depth, as proposed for the Tharsis region of Mars (Whitford-Stark, 1982b), because Io's lithosphere is probably about 8 to 100 km thick (Carr, 1986).

The fissure floor material (unit **fi**) occurs at lat 49° S., long 305°. It is composed of at least four discrete parts having an overall length of more than 150 km and a width of about 2 km. The material is detectable by its very low albedo and the highly contrasting flows that surround it. A second and similar feature at lat 46° S., long 348° is about 40 km long and 15 km wide and could be interpreted as an elongate patera, like the plume source of Loki (lat 18° N., long 300°–307°, northeast of Loki Patera).

MANTLING MATERIAL

Mantling material (unit **ma**) has a very low albedo and forms a thin deposit that does not mask the underlying topography. The unit occurs mainly around Babbar Patera (centered at lat 39° S., long 272°), a major hot spot in the adjacent Ruwa Patera quadrangle. The unit has been interpreted by McEwen and others (1985) as cooling pyroclastic deposits.

HALOS

At least three types of bright halos are found on color images of the Lerna region (fig. 1). Baloga and others (1983) have suggested that bright halos, which they call "auras," around lava flows on Io were produced when the flows initiated volatile release from the underlying regolith. The darkest type is found around some paterae and around point sources within some paterae. These halos are generally greenish brown and tend to decrease in intensity at their outer edges, gradually merging with the background. This type of halo is interpreted as particulate or gaseous material in an active plume or as the deposits from a plume that became inactive immediately before the Voyager flybys. Such halos are associated with Aramazd (fig. 1) and Mithra Paterae. Accordingly, we interpret these paterae to be some of the youngest geologic features in the Lerna region.

The second type of bright halo is much smaller and brighter and tends to occur at the base of scarps or at point sources along patera walls. Individual halos range from fan-shaped to elliptical and are as long as 70 km. Halos from closely spaced sources tend to merge, disguising their individual plumelike outlines. Particularly conspicuous halos occur at scarp bases along the edge of Nemea Planum and are also associated with paterae, especially Creidne. This type is believed to result from the near-surface flow of gaseous or particulate matter. Lee and Thomas (1980) suggested that some plumelike outlines of this type result from the interaction between local vent eruptions and surface gases produced by the large plume eruptions such as Pele.

A third type of bright halo surrounds and mimics the outline of Haemus Montes. This halo is similar in brightness to the second type of halo and is blue gray on the color image (fig. 1). We suggest that this halo could result from the regolith degassing (Baloga and others, 1983) noted above; here the degassing may have been initiated by pressure exerted by the mass of the mountain.

Circular dark halos around point sources appear to be either particulate material above active vents or deposits from recently active vents such as those at Nusku, Heno, and Mithra Paterae. None of these calderas were identified as active by McEwen and others (1985), so the dark halos may well be surficial deposits. Elongate dark areas, such as those around the base of Haemus Montes (inside the bright halo), appear to be low-albedo equivalents of the second type of bright halo; they may have originated in a similar manner but may differ in composition.

STRUCTURE

The dominant structural elements in the Lerna region are grabens. Some are longer than 400 km; they have fairly constant widths of about 2 km except where widened by erosion. Grabens are confined almost exclusively to the plateaus and, to a large degree, they have controlled the erosion of the plateau material. At the west end of Nemea Planum, a graben set trending N. 45° E. intersects a set trending N. 45° W., forming an orthogonal network. On Earth's Moon, a similar orthogonal network known as the "lunar grid" has been ascribed to several causes, including tidal stresses (Gash, 1978). Likewise, Schaber (1982) has suggested that the grabens on Io may result from tidal flexing of the satellite. If so, tidal flexing has been more efficient in the past than at present, because the grabens are absent on the younger units. Also (or alternatively), the plateau material may possess considerably more cohesive strength than the other units, so that it deformed by brittle fracture rather than ductile flow. A third alternative is that the smooth units are so young that they have not yet developed grabens. Other graben sets within the plateau material trend N. 80° W., N. 80° E., and N. 60° E. The significance of these trends is unknown.

Other structural elements on Io include fault scarps around paterae and at the south end of Euboea Montes and ridges, also largely within plateau material, particularly north of Nusku Patera and on Pan Mensa.

GEOLOGIC HISTORY

The earliest event still decipherable in the Lerna region was the production of the plateau material, possibly as large pyroclastic deposits from unidentified sources. The region was then subjected to tension, resulting in the formation of horsts and grabens. The plateau was subsequently eroded, and lava flows and pyroclastic materials were emplaced by volcanic eruptions. At least two distinctly different styles of volcanism occurred: one style formed mountains as high as 10 km with rugged surfaces, and the other style produced large paterae atop edifices with only slight relief.

Aten Patera is inferred to have erupted between the two Voyager encounters, and Creidne and Svarog Paterae were identified as hot spots from IRIS data (Pearl and Sinton, 1982) and may be the site of active sulfur lakes. In the south polar region, eleven other paterae within the map area, as well as three outside it, were also identified as sites of possible volcanism on the basis of their low albedos (McEwen and others, 1985). The surface of Io is thus in a state of constant flux, and much of the surface viewed by the Voyager spacecraft will have probably changed by the time of the Galileo encounter.

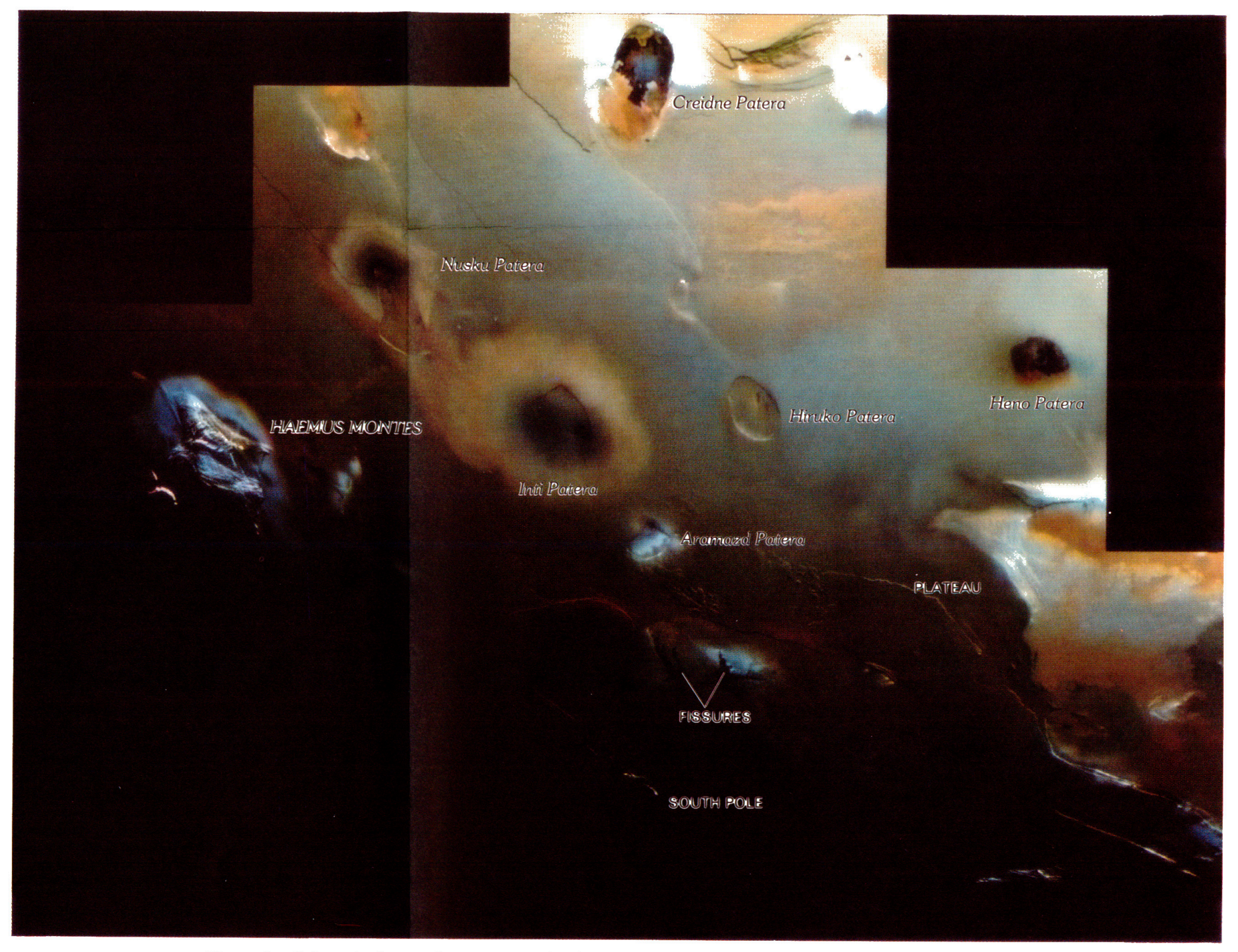


Figure 1. False-color image of area near south pole of Io. Heavily dissected plateau can be seen in lower central part of image. South of the plateau are two low-albedo fissures. Scale about two-thirds that of geologic map. Image generated by A.S. McEwen.

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