GEOLOGIC MAP
OF IO

By
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DESCRIPTION OF MAP UNITS

PATERA FLOOR MATERIAL

pf **Patera floor material**—Smooth, generally mottled deposits of low to high albedo in floors of small to large, steep-walled, circular depressions; some deposits associated with observed thermal anomalies. In some areas, such as at Euboea Fluctus (lat 46° S., long 350°), the depressions are elongate and appear to be bounded by subparallel, curvilinear scarps. Type area: lat 53° S., long 344° (Creidne Patera). *Interpretation:* Volcanic flows, pyroclastic deposits, sulfur-rich fumarolic deposits, and possibly active or extinct lava lakes in calderas or fissures; materials may be composed of sulfur, sulfur compounds, or silicates

CONE MATERIAL

c **Cone material**—Forms raised rims surrounding some occurrences of patera floor material. Type area: lat 35° N., long 307° (Amaterasu Patera). *Interpretation:* Rim deposits of silicate pyroclastic materials around volcanic vent, or possibly high-yield-strength material emplaced as lava flow or erosional remnant of layered plains

FLOW MATERIALS

fh **Hummocky material**—Massive, thick deposits with grooved surfaces and lobate distal scarps of considerable relief. Type area: lat 2° N., long 318° (Carancho Patera). *Interpretation:* Viscous lava flows consisting of silicates and possibly sulfur or sulfur compounds; alternatively, lavas extruded at low effusion rates

ff **Fissure material**—Elongate to broad, lobate deposits of low to moderate albedo; originated from linear to curvilinear fissures. Type area: lat 45° S., long 352° (Euboea Fluctus). *Interpretation:* Consists of silicates, sulfur, or both erupted from linear vent. Low-albedo deposits overlie older, higher albedo deposits

fd **Digitate material**—Mottled deposit of apparently moderate relief associated with circular depression and having low-albedo, fingerlike flows emanating from its margins. One occurrence mapped at lat 12° S., long 303° (Kibero Patera). *Interpretation:* Lava flows, pyroclastic flows, or both, consisting of silicates, sulfur, or both

fs **Shield material**—Forms circular feature with outer scarp and central depression. Topographic data obtained by photoclinometry indicate high relief (Moore and others, 1986). Type area: lat 30° S., long 246°. *Interpretation:* Forms shield volcano composed of silicates and possibly sulfur

ft **Tholus material**—Forms circular, shield-shaped features with well-defined outer scarp and central depression. One occurrence at lat 19° S., long 324° has an elongate flow unit extending from near its central depression for more than 200 km to the south. Type area: lat 16° S., long 349° (Inachus Tholus). *Interpretation:* Tholi are low-relief, "discoid," shield volcanoes characterized by central eruptions of lava flows consisting of silicates, sulfur, or both; origin of basal scarp unknown

fl **Lobate material**—Broad to lobate, low- to moderate-albedo, overlapping deposits of low relief commonly associated with moderate-sized to large vents. Type area: lat 19° N., long 275° (Daedalus Patera).

Interpretation: Lava flows, pyroclastic flows, or both, consisting of silicates, sulfur, or both; appears to overlie plains-forming material (unit **fpf)**

fpf **Plains-forming material**—Extensive, moderate- to high-albedo, low-relief deposits commonly originating from moderate-sized to large (>100 km) vents; may appear mottled. Individual flow units from a specific vent commonly cannot be identified within occurrence of this unit. Type area: lat 20° N., long 300° (Loki Patera). *Interpretation:* Lava flows, pyroclastic flows, or both, consisting of silicates, sulfur, or both

fp **Patera material**—Long, narrow, overlapping, low- to high-albedo deposits of moderate relief that commonly originated from vents less than about 50 km across. Unit forms widespread, low-relief shield volcanoes, typically mapped as shield materials and undivided flow materials by Schaber and others (1989) . Individual flows from specific vents commonly identifiable. Type area: lat 8° S., long 325° (Ra Patera). *Interpretation:* Flows of silicates, sulfur, or both; may include pyroclastic material. Low-albedo deposits apparently overlie older, high-albedo deposits; many flows appear channelized

f **Undivided material**—Overlapping deposits of varied albedo with mottled appearance; no discernible relation with specific occurrence of patera floor material. To northeast, precise boundaries of large complexes of unit are unclear due to low resolution of images. Type area: lat 20° S., long 287°. *Interpretation:* Lava flows, pyroclastic flows, or both, consisting of silicates, sulfur, or both; may include patera material (unit **fp**), lobate material (unit **fl**), plains-forming material (unit **fpf**), and fissure material (unit **ff**). Flow deposits cannot confidently be traced to source vent(s)

PLAINS MATERIALS

p **Interpatera material**—Vast, generally flat deposits of uniform albedo between paterae; contain rare grabens and other linear features; no flow features visible. Type area: lat 47° S., long 290°. *Interpretation:* Flood lavas, pyroclastic deposits, plume fallout, or combination thereof

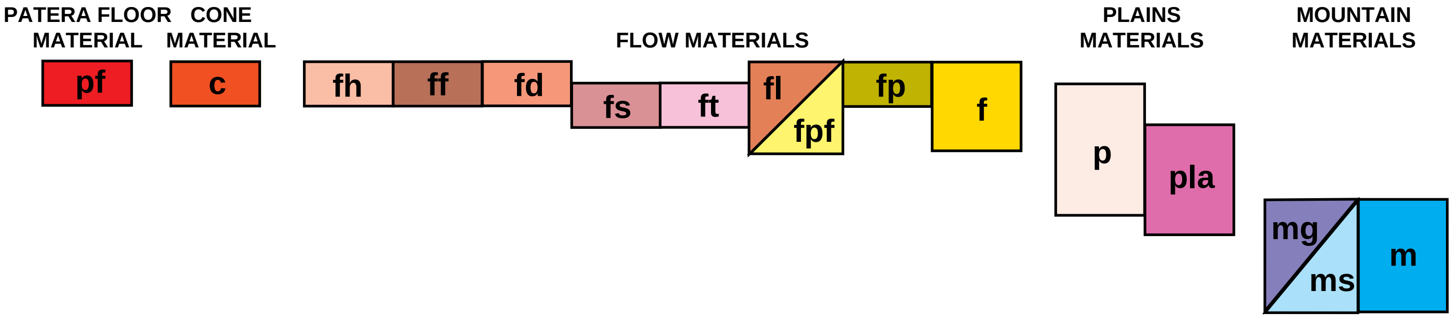
pla **Layered material**—Forms extensive, elevated, layered plains of moderate albedo, generally flat surfaced; bounded by scarps or faults; some grabens and ridges. Where associated with mountain materials, as at Euboea Montes, unit forms series of small plateaus rising from plains to base of mountain; in several areas, as at Nemea Planum, unit makes up many small, isolated plateaus. Unit equivalent to plateau material of Moore (1987), Schaber and others (1989), and Whitford-Stark and others (1990). Type area: lat 43° S., long 245°. *Interpretation:* Flood lavas, pyroclastic deposits, or both, isolated as plateaus by erosional scarps or faults

MOUNTAIN MATERIALS

mg **Grooved material**—Forms rugged, elevated terrain having many parallel linear depressions. Type area: lat 48° S., long 339° (Euboea Montes). *Interpretation:* Tectonically deformed ancient silicate crust or extremely viscous silicate lava flows, possible association with tectonism and local reheating due to thermal anomaly in Creidne Patera (Schaber and others, 1989)

ms	**Smooth material**—Forms elevated, relatively smooth terrain protruding above present surface. Type area: lat 48° S., long 337° (Euboea Montes). *Interpretation:* Part of ancient silicate crust or volcanic construct(s)
m	**Undivided material**—Forms rugged to undulatory elevated terrain protruding above present surface; many linear to curvilinear depressions and scarps. Commonly bordered by layered plains (unit **pla**) and interpatera plains (unit **p**) materials; in some areas appears embayed by adjacent units. Type area: lat 48° S., long 333° (Euboea Montes). *Interpretation:* Ancient silicate crust or volcanic construct(s); detectable volcanic vents rare; tectonically deformed

CORRELATION OF MAP UNITS



Contact—Dashed where approximately located or inferred. Includes boundaries between flow materials of same type but from different source vents; boundaries may terminate without closure

Fault—Bar and ball on downthrown side

Graben—Dashed where inferred. One symbol may represent several grabens in areas of high concentration in layered plains material

Scarp—Line at top of scarp, hachures point downslope; dashed where inferred; used as contact in places

Ridge crest

Linear to curvilinear feature of unknown origin

Steep-walled circular depression—Dashed where approximately located or inferred

INTRODUCTION

Io, the innermost of the Galilean satellites of Jupiter, is one of the most geologically active bodies in the Solar System. It is dominated by volcanism and shows only minor surface modification by tectonic processes or erosion. Impact craters are not seen at the resolution of Voyager images, indicating the relative youth of the surface (Smith and others, 1979) and its rapid resurfacing by volcanic eruptions (Johnson and others, 1979). As reviewed by Nash and others (1986), most of our knowledge of Io is based on data obtained by Voyagers 1 and 2, which encountered Io in 1979 and imaged about 35 percent of its surface (fig. 1). Other information was obtained by Pioneer 10, which flew past Jupiter in 1973, and from Earth-based observations and theoretical considerations (Matson and others, 1981; Pearl and Sinton, 1982; Goguen and Sinton, 1985; Lunine and Stevenson, 1985). The general geology of Io was described by Masursky and others (1979), Schaber (l980, l982) and Nash and others (1986). Volcanic aspects have been discussed by Carr and others (1979), Johnson and others (1984, 1988), McEwen and Soderblom (1983), McEwen and others (1985, 1989), and Carr (1986).

MAPPING TECHNIQUES

Four areas of Io have been mapped geologically at larger scales: the Maasaw Paterzi area (lat 35° S. to 48° S., long 335° to 350°) at 1:1,000,000 scale (Moore, 1987); the Ra Patera quadrangle (lat 5° N. to 20° S., long 290° to 340°) at 1:2,000,000 scale (Greeley and others, 1988); the Ruwa Patera quadrangle (lat 50° N. to 50° S., long 270° westward to about long 40°) at 1:5,000,000 scale (Schaber and others, 1989); and the Lerna (south polar) region (lat 45° S. to 90° S.) at 1:5,000,000 scale (Whitford-Stark and others, 1990). The present photogeologic mapping was completed by compilation and synthesis of these maps and of work in progress by C.A. Wood in the Colchis Regio quadrangle and by extension into unmapped areas. Several of the units and contact placements on the 1:15,000,000 map differ from those of the larger scale maps. All photogeologic mapping of Io is based on Voyager 1 and 2 images whose resolutions range from ≤ 0.5 km to >20 km/pixel. (See resolution diagram.)

Conventional planetary photogeological mapping techniques (Wilhelms, 1972) were combined with techniques developed for mapping terrestrial volcanoes. However, the lack of systematic topographic data hindered interpretations, especially in defining superposition relations and flow directions. Individual volcanic centers were identified and their associated flows were mapped. Types of volcanoes and vents were defined by their morphologies to provide a basis for interpreting styles of volcanism and the general volcanic history. As in mapping terrestrial volcanoes, mapping on Io is complicated because flows from adjacent vents coalesce and interfinger, making it difficult to distinguish flow sequences and relative ages of volcanic centers. Anastomosing flows from single vents also complicate mapping of volcanic units. On Io, these problems are compounded by the existence of plume deposits and flows that are derived from great distances and that may interweave with flow units from local sources. Despite these difficulties, many flows and other volcanic units are identified and, where possible, traced to their source vents.

GENERAL GEOLOGY

lo has an overall density of 3.57 gm cm^{-3} (Burns, 1986, p. 14), which suggests a silicate composition, and a diameter of 3,642 km (Gaskell and others, 1988), similar to the diameter of Earth’s moon. Earth-based observations show that Io is the reddest object in the Solar System in the ultraviolet to visible region of the spectrum. Its poles are relatively dark and its equatorial region is bright; the leading hemisphere is brighter than the trailing hemisphere. (Io is in synchronous rotation in its orbit around Jupiter.)

The discovery of active volcanoes on Io is one of the highlights of Solar System exploration. Consideration of the forced eccentricity of Io's orbit between those of Jupiter and Europa and the resulting frictional heat generated within Io led Peale and others (1979) to predict active volcanism on Io. Subsequent analysis of Voyager images by Morabito and others (1979) showed the presence of spectacular volcanic eruption plumes driven by internal heat as high as 300 km above the surface.

Nine active volcanic plumes were observed during the Voyager 1 encounter (table 1; fig. 2). Their geometric and thermal characteristics suggest two different eruption styles; large, Pele-type plumes were emplaced by short-lived (days to weeks), high temperature (~650 K) eruptions, whereas the more common, smaller, Prometheus-type plumes were generated by longer lived (years), lower temperature (<400 K) eruptions (McEwen and Soderblom, 1983). For Pele-type eruptions, velocities as high as 1 km s^{-1} carried sulfurous gases and solids as high as 300 km above the surface. Pyroclastic material was deposited at distances as far as 700 km from its source vents. Of the nine active plumes observed during the Voyager 1 flyby, one had ceased to be active 4 months later when Voyager 2 imaged Io, and deposits from two new plumes were observed. The volcanic plumes are driven by internal heating, possibly by a geyserlike mechanism involving sulfur dioxide (SO_2), sulfur, or both (Kieffer, 1982). Volcanic resur facing rates on Io are estimated to be between 10^{-3} and 10 cm yr^{-1} (Johnson and others, 1979; Johnson and Soderblom, 1982) The upper limit is consistent with rates of surface renewal necessary to account for an absence of impact craters.

In general, the average natural color of Io's surface is pale yellow (Young, 1984, 1985; McEwen, 1988), but Io displays a large degree of spectral variability which, when enhanced (particularly in the violet and near ultraviolet) results in various shades of red, yellow, orange and brown. Many of these colors have been attributed to sulfur (Sagan, 1979) or to anhydrous mixtures of sulfur allotropes, SO_2 frost, and sulfurous salts of sodium and potassium (Fanale and others, 1979; McEwen, 1988; McEwen and others, 1988). Pieri and others (1984) described colors for some of the Ra Patera flow units and suggested that these flows may be sulfur allotropes or sulfur-rich compounds; however, Young (1984, 1985) argued that the images used by Pieri and others (1984) do not represent the true colors on Io and do not indicate the presence of sulfur allotropes.

Considerable controversy has arisen regarding the composition of lava flows on Io. Spectral data indicate the presence of sulfur and sulfur-rich compounds (Sagan, 1979; Sill and Clark, 1982, p.175–195). However, these materials may be only thin deposits that mantle silicate flows (Carr and others, 1979). The morphology of the vents and flow materials is, for the most part, typical of silicate volcanism observed on Earth. Sulfur exhibits unusual rheological properties: its viscosity increases as temperature decreases from 320 to 185 °C, then decreases rapidly while cooling to 160 °C; below that temperature the viscosity increases again. This rheologic behavior, as observed in experimental sulfur flows, led Greeley and Fink (1981) and Fink and others (1983) to suggest that the morphologies of some sulfur or sulfur-rich flows may be distinguishable from silicate flows. In addition, Greeley and others (1984) suggested that the spectral data may indicate the presence of secondary deposits of sulfur, such as those associated with terrestrial fumaroles. Several lines of evidence suggest silicate volcanism on Io (Clow and Carr, 1980; Johnson and others, 1988), which would introduce sufficient heat to melt any sulfur that is present and to produce local sulfur flows. These flows may be composed of sulfur that melts at a low temperature (~115 °C) and is very fluid. Analyses of sulfur's thermal properties and temperature-dependent rheology suggest that sulfur flows could retain enough heat to flow long distances, especially if insulated by a chilled crust (Fink and others, 1983). Although mapping of the high-resolution images, as presented here, may shed light on some of these problems, it is unlikely that the controversy will be resolved until better compositional data are obtained.

MATERIAL UNITS

The imaged surface of Io can be subdivided into geologic units of four principal classes: mountain materials, plains materials, volcanic flows, and patera floor material (Schaber, 1980, 1982). All but the mountain materials are attributed to volcanic processes; mountains may be formed of crustal materials not necessarily related directly to volcanism. In addition, various possible erosional features and tectonic structures have been mapped.

Smooth, grooved, and undivided mountain materials (units ms, mg, and m, respectively) form high-standing blocks of rugged relief that can exceed 100 km in length. Mountains rise more than 9 km above the surrounding surface and appear to be evenly distributed in latitude and longitude (Schaber, 1982). Embayment relations with the surrounding plains suggest that mountains comprise the oldest materials on Io. However, Whitford-Stark and others (1990) suggested that the formation of mountain materials may have occurred more recently, because mountain material overlaps layered plains material (called plateau material by Whitford-Stark and others, 1990) at Euboea Montes. (See also Mouginis Mark and others, 1984.) In addition, some mountains, such as Haemus Montes (south polar region), appear to be associated with recently active vents. Clow and Carr (1980) have analyzed the physical properties of sulfur and showed that, on Io, features such as steep scarps, if composed of sulfur, are unstable when their heights exceed 1 km. On the basis of this analysis, mountains and other features of significant relief are interpreted to be composed of silicate materials (Clow and Carr, 1980; Carr, 1986).

Plains materials of two types are the most widespread units observed in images of Io. The natural colors of these materials are pale yellow to shades of greenish gray and yellow. However, the spectral variations of the plains (at violet and near-ultraviolet wavelengths) indicate a wider range of colors, shown as combinations of red, orange, yellow, green, and brown on false-color images. Units in the polar areas tend to be darker (Masursky and others, 1979). *Layered plains material* (unit pla) forms smooth, flat surfaces containing grabens and exhibiting scarps as high as 1,700 m, which indicate a composition other than pure sulfur (Clow and Carr, 1980). Although they occur throughout the mapped area, the most conspicuous layered plains are found in the south polar region. Transection by faults, overlap by the interpatera plains unit, and evidence of erosion suggest a complex geologic history. *Interpatera* plains material (unit p) is characterized by smooth surfaces of intermediate albedo with low scarps. This unit constitutes about 40 percent of the area observed by Voyagers 1 and 2. Interpatera plains material was interpreted by Schaber (1982) as fallout deposits from volcanic plumes, interbedded with fumarolic materials and near-vent flows.

McCauley and others (1979) noted that mesas, hills, and remnants of subdued scarps beneath layers of younger plains material suggest multiple cycles of erosion and deposition. These disrupted, "etched" surfaces and their irregular "fretted" margins cannot be attributed to fluvial or eolian processes, given the conditions of the near-surface environment on Io. In addition, because of their relative youth, ionic bombardment from Jupiter cannot account for these features. McCauley and others (1979) proposed a sapping mechanism in which liquid SO_2 is the dominant erosional agent. A hydrostatic condition could be established if the crust were fractured; molten SO_2 would be driven toward the surface, and, at the triple point for SO_2, part of the liquid would begin to crystallize and the system would expand, forming SO_2 vapor. Upon reaching the surface at or near a vent, the solid-fluid mixture could be released at a velocity as high as 350 m s^{-1}. At this velocity, the SO_2 "snow" could be sprayed as far as 70 km from the vent. The many bright patches on Io may have formed by this mechanism. McCauley and others (1979) suggested that newly formed scarps would be rapidly eroded by undercutting and slumping, leading to the formation of irregular, unstable margins. Withdrawal of support from beneath the solid crust would cause collapse, generating irregular surfaces. This sequence of processes would continue until the local source of SO_2 was depleted. Although the surface morphology of many plains regions appears to be erosional, the presence of debris deposits at the bases of scarps, which would be likely in a sapping environment, has not yet been confirmed (Whitford-Stark and others, 1990). Alternatively, thermal erosion by lava flows could form the scarps and erosional remnants observed in layered plains material in the south polar region, as proposed by Mouginis-Mark and others (1984). Whitford-Stark and others (1990) suggested that the layered plains material (referred to as plateau material) consists of stratified pyroclastic deposits that have been modified by a combination of sapping and fluid and thermal erosion.

In addition to eruptive plumes resulting from explosive volcanism, several different types of volcanic flow materials have been identified on Io. *Patera flow material* (unit fp) forms narrow, sinuous flows as much as 300 km long that radiate from central vents and accumulate to form low-relief shield volcanoes. Other abundant flows are composed of plains-forming flow material (unit fpf); these flows are massive, extend as far as 700 km, and emanated from moderate-size to large calderas. The morphology of this unit suggests that the materials were relatively fluid and were erupted at high rates of effusion. Lobate flow material (unit fl) and di~itateflow material (unit fd) have been suggested to have morphologies similar to those of experimental sulfur flows (Greeley and Fink, 1981; Fink and others, 1983). Alternatively, apparent stratigraphic relations indicate that the lobate and plains-forming flow materials could be related and that the lobate flows represent currently active or younger plains-forming flow materials.

Other flow materials on Io (Carr and others, 1979) have accumulated to form *tholus* (unit ft), *shield* (unit fs), *fissure* (unit ff), and *hummocky* (unit fh) *materials*. Most features identified as shields are inferred as such from their planimetric form, but at least one feature that has a classic shield profile has been noted (Moore and others,1986). (Although the large-scale topography of Io is known (Gaskell and others, 1988), the lack of systematic, local topographic information prohibits assessment of more detailed morphology.) Schaber (1982) noted that shieldlike volcanoes tend to be limited to the region between lat 45° S. and 30° N., coinciding approximately with the equatorial band where active volcanic plumes are found (Strom and Schneider, 1982).

Cone material (unit c), which forms raised rims typically surrounding occurrences of patera floor material in equatorial regions of Io, may also have been emplaced as volcanic flows. Due to its apparent relief and its proximity to a vent, the material would presumably have had a high yield strength. Alternatively, these rim deposits may be pyroclastic materials or erosional remnants of the layered plains.

Patera floor material (unit pf) includes all units that can be related directly to paterae, interpreted as calderas, and to other vents of various types (including fissure vents). More than 300 vents of all types have been identified (Masursky and others, 1979). Patera floor material constitutes about 5 percent of the total mapped area. Calderas on Io average about 48 km across in the equatorial region and 65 km across in the south polar region (Schaber, 1982), where, although generally larger, they are less common than in lower latitudes. Calderas are more randomly distributed on Io than on Earth, the Moon, or Mars, where the local and global tectonic frameworks control the locations of volcanic vents. Vent distribution on Io indicates that the locations of vents and related “hot spots” (table 2) are not influenced by strongly patterned convection cells.

STRUCTURE

Calderas exhibit complex morphologies suggestive of multiple eruptions and enlargements by wall collapse. Calderas range in depth from 0 km (vents level with the surrounding surface) to more than 2 km (Schaber,1982). The relatively high, steep walls of some calderas may indicate that they are composed dominantly of silicate materials (Clow and Carr, 1980). A correlation between low-albedo calderas, recent or active volcanism, and thermal anomalies (hot spots) detected by Voyager 1 infrared observations has been observed (McEwen and others, 1985). The spectral properties of these dark calderas are consistent with a variety of sulfur-rich materials, including molten sulfur (Nelson and others, 1983). Quenched sulfur allotropes are redder than these low-albedo features and would not exist at the high temperatures associated with hot spots (McEwen and others, 1985). Voyager 1 and 2 images show changes that occurred in the 4-month interval between encounters; parts of the lava lake at Loki Patera may have crusted over, while new vents appear to have developed in other areas (Terrile and others, 1981; McEwen, 1988). Loki Patera has been suggested to be the primary source of excess thermal radiation evident in eclipses of Io (Sinton and Kaminski, 1988).

For a planetary object that is so volcanically active, Io displays relatively few features that can be ascribed to tectonic processes except in the polar layered plains. Some scarps in Nemea Planum and near Babbar Patera may represent faults. These and other scarps are not associated with any obvious volcanic vents, nor do they form patterns diagnostic of largescale tectonic deformation. Grabens are typically not found on the younger units, suggesting that tectonic forces on Io were of greater magnitude in the past, that much of the surface is very young and has not yet undergone deformation, or that only with age do the surface materials become strong enough to deform by brittle failure rather than ductile flow (Whitford-Stark and others, 1990). Another feature, whose sharp boundaries suggest a tectonic origin (McEwen and others, 1985), is the “south pole ring” (table 2), an area of low albedo and elevated temperatures about 1,000 km in diameter.

GEOLOGIC HISTORY

Because most of the units exposed on the surface are relatively young, it is difficult to derive a geologic history for Io based on mapping. Io is assumed to have accreted at the same time as the other satellites in the Jovian system. Together with the various young flows observed, volcanic plumes indicate a highly active body that has been chemically differentiated through geologic time. On the basis of observations of current activity, a mass equivalent to the entire mass of Io is estimated to have been recycled in its lifetime (Johnson and Soderblom, 1982). Volatiles such as water and carbon dioxide would have been lost early in Io’s geologic history, and most heavier materials would have sunk to form a core. Sulfur and various sulfur compounds, mobilized by higher temperature silicate magmas, are constantly recycled, forming the complex surface observed today.

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Only the named features referred to in text or tables are identified on this map. See U.S. Geological Survey (1987) for identification of all other named features.

Table 1. *Volcanic plumes and plume deposits on Io*

[from Strom and Schneider, 1982, and McEwen and others, 1989; coordinates from U.S. Geological Survey, 1987]

Volcanic plume/ plume deposit	Latitude	Longitude
Amirani	28° N.	114°
Aten*	48° S.	311°
Loki (east)	17° N.	301°
Loki (west)	19° N.	305°
Marduk	27° S.	210°
Masubi	44° S.	54°
Maui	19° N.	122°
Pele	19° S.	256°
Prometheus	2° S.	152°
Surt*	45° N.	338°
Volund	23° N.	177°

*Observed by Voyager 2; features without asterisks observed by Voyager 1

Table 2. *Hot spots on Io*

[from Pearl and Sinton, 1982, and McEwen and others, 1985, 1989; coordinates from McEwen and others, 1989] Coordinates of large hot spots are those of their centers.

Hot spot	Latitude	Longitude
Amaterasu	38° N.	307°
Amirani/Maui	22° N.	120°
Babbar	40° S.	272°
Creidne	53° S.	344°
Loki	12° N.	309°
Nemea Planum	81° S.	330°
NW Colchis	31° N.	208°
Pele	18° S.	256°
"South pole ring"	67° S.	100°- 180°
Svarog	48° S.	268°
Ulgen	40° S.	289°

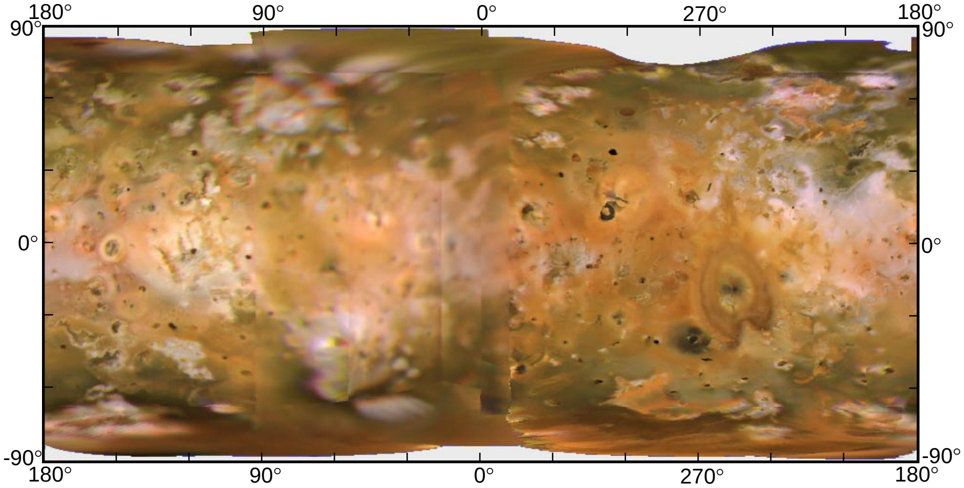


Figure 1. Global photomosaic of Io in simple cylindrical projection. Orange-, blue-, and violet-filter mosaics have each been linearly stretched to maximize contrast (McEwen, 1988). Mosaic courtesy of Alfred McEwen.

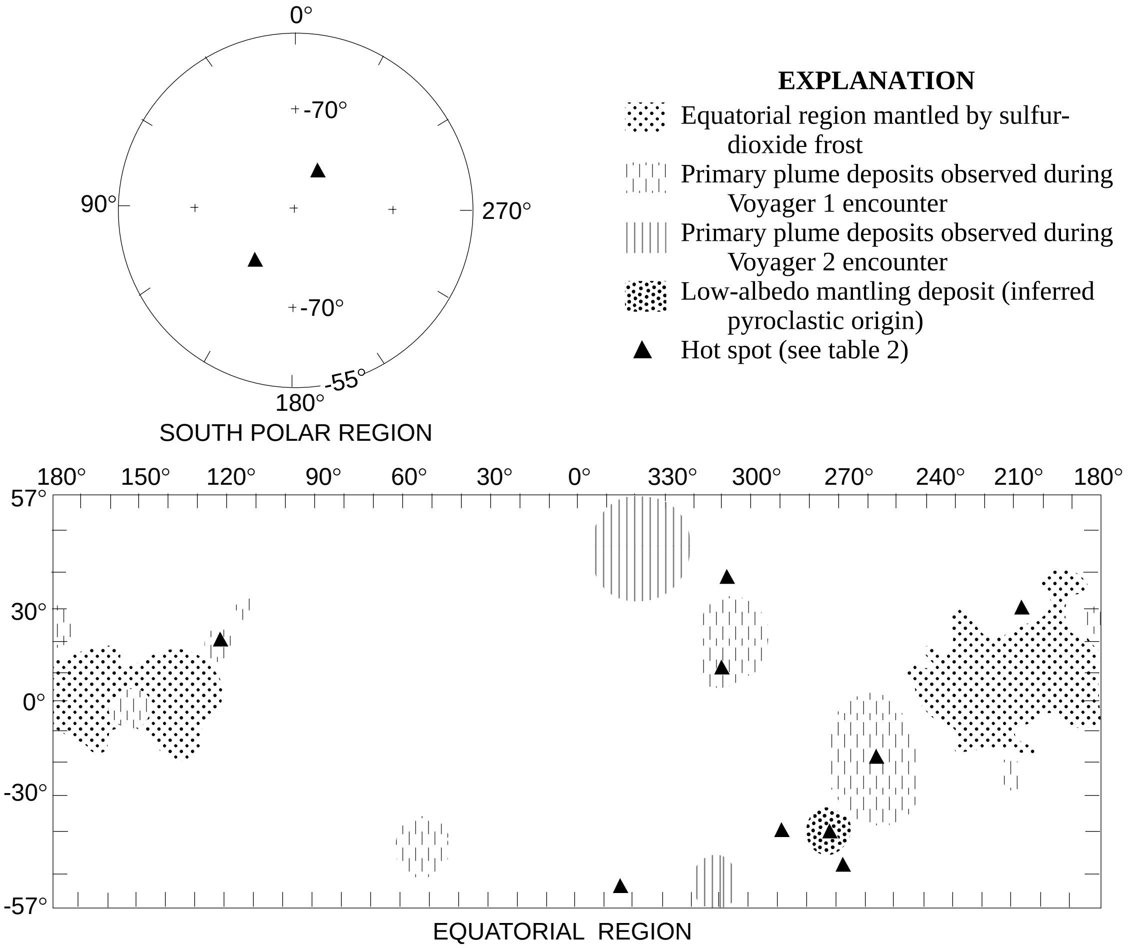
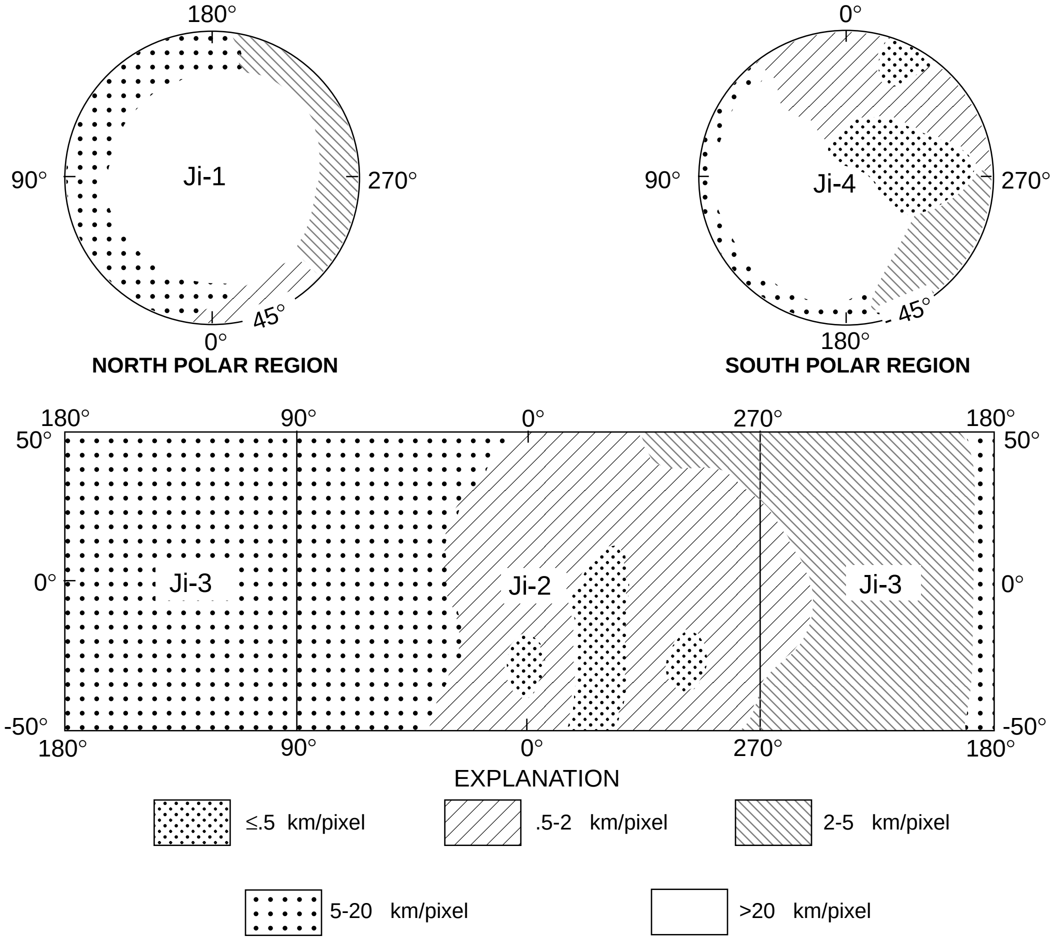


Figure 2. Distribution of active plumes associated with plume deposits, and hot spots on Io as observed by Voyagers 1 and 2. Plumes and plume deposits from Loki Patera are combined. Mantling deposit at Babbar Patera and sulfur-dioxide mantle in equatorial region also shown. See tables 1 and 2 for geographic names and precise locations of features.



Approximate resolution of available Voyager images expressed as kilometers per pixel element