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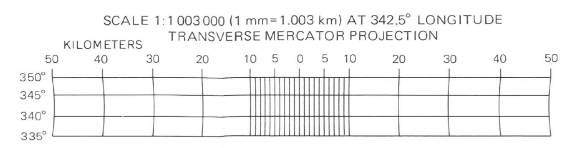
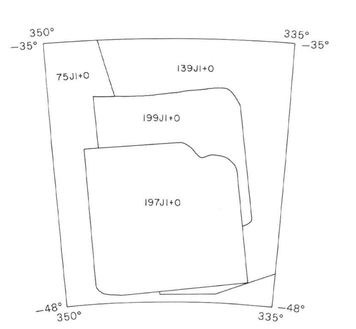
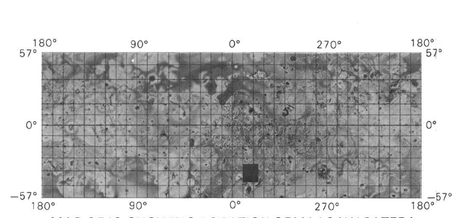
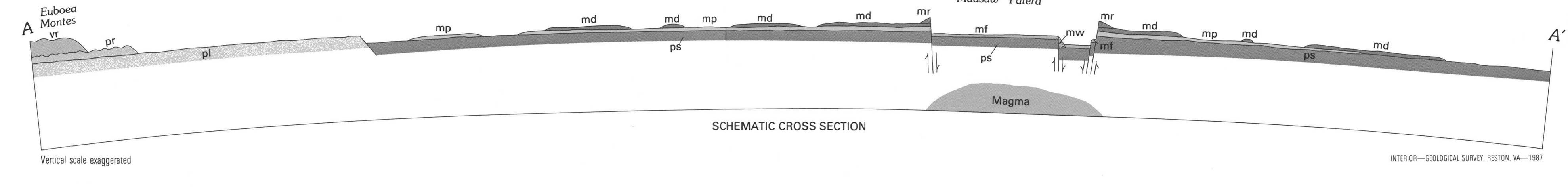




INDEX OF VOYAGER PICTURES
The mosaic of Maasaw Patera was made with the Voyager 1 and 2 pictures outlined above.



MAP OF IO SHOWING LOCATION OF MAASAW PATERA



SCHEMATIC CROSS SECTION

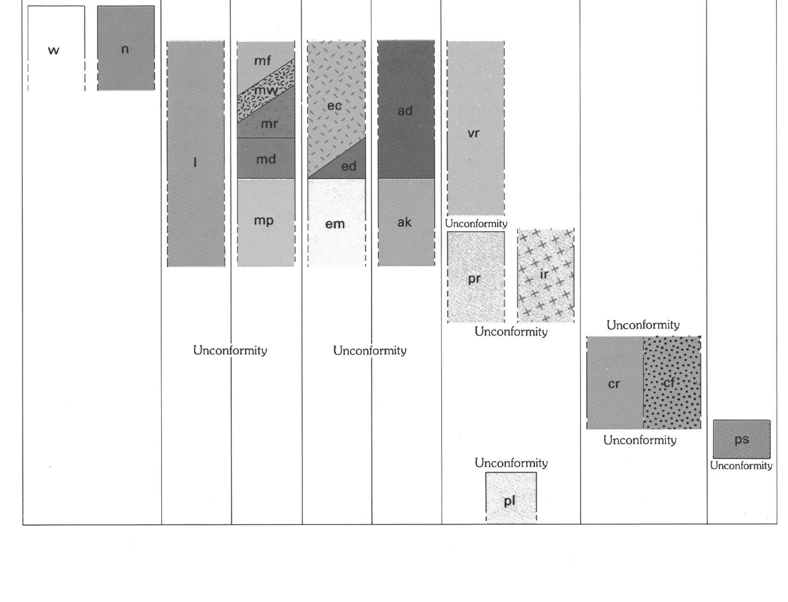
GEOLOGIC MAP OF THE MAASAW PATERA AREA OF IO

By

Henry J. Moore

1987

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

w — WHITE MATERIAL—Very light gray; surfaces appear smooth with no intrinsic relief. Found in southwestern part of map area as four patches between smooth plains and lineated plateau units. Contacts approximately located. *Interpretation:* Condensates from fissures; composed of sulfur dioxide with some sulfur. Superposed on smooth plains unit; color suggests materials are young and largely unmixed

n — NORTHERN PLAINS MATERIAL—Moderate grayish yellow green; smooth with no intrinsic relief. Found in northwestern part of map area and forms circular deposit around Pautiwa Patera to north. Contacts gradational. *Interpretation:* Veneer deposited from plume gases of Pautiwa; composed of sulfur and silicate dust mixed with sulfur dioxide; fresh appearance and distribution around Pautiwa suggest that unit is very young. Superposed on crater rim, smooth plains, and Maasaw peripheral materials

l — LOWLAND PLAINS MATERIAL—Moderate grayish orange; forms smooth, level surfaces at apparently low elevations. *Interpretation:* Volcanic flows in broad, shallow channels and lavas ponded in depressions; may be composed chiefly of sulfur. Superposed on crater floor and smooth plains materials and on northwest end of fault separating smooth plains and lineated plateau units. Younger than lineated plateau material but relations with other units uncertain

MAASAW PATERA MATERIALS

mf — Floor material—Moderate orange; surfaces appear smooth and level. Floor of subsidiary depression in northeastern part of patera lower and orange hue more vivid than floor of enclosing patera; floors separated by steep scarp 500 m high. *Interpretation:* Lavas and pyroclastic rocks within caldera overlying subsided wall and rim materials. Rocks at surface may be chiefly sulfur, probably underlain by silicates or silicate-sulfur mixtures; produced during late stages of caldera formation

mw — Wall material—Moderate orange; hummocky. Unit forms steep walls of patera and hummocks in caldera at base of walls; intersects rim material. *Interpretation:* Material exposed in caldera walls mixed with slump material; composed of silicates or silicates mixed or coated with sulfur. Unit includes Maasaw volcanic material and older smooth plains unit; exposures of walls and slumping postdate Maasaw rim material

mr — Rim material—Dark orange brown; forms elevated rim of Maasaw; appears to truncate subtle streaks in dark material. Unit absent in southeast and northwest where caldera walls have slumped. Contact with dark material approximately located. *Interpretation:* Intercalated pyroclastic rocks and lava flows; composed of silicates mixed or coated with some sulfur. Superposed on dark material

md — Dark material—Dark orange brown; surfaces appear smooth; positive relief low or absent. Unit surrounds patera rim, but outward forms bands and filaments radial to Maasaw that have irregular to serrated margins; bands and filaments less than 1 to about 10 km across; in high-resolution pictures, distal bands and filaments appear to occupy shallow valleys. Unit surrounds numerous small to large patches of peripheral material and overlies contacts between peripheral and smooth plains materials. Contacts with peripheral and smooth plains materials approximately located. *Interpretation:* Lava flows from Maasaw Patera; may include some pyroclastic deposits from Maasaw. Composed of silicates mixed or coated with some sulfur. Superposed on Maasaw peripheral and smooth plains materials; patches of peripheral unit surrounded by dark material are kipukas

mp — Peripheral material—Moderate to light grayish yellow green. Appears smooth at moderate resolution, but in some high-resolution images appears to form mosaic pattern of lighter, broad, flat surfaces separated by darker patches and sinuous to irregular, narrow strands that may be scarps or shallow depressions. Pattern generally radial to Maasaw; some broad, lighter surfaces widen away from patera. Contacts with smooth plains unit approximately located; contacts with lineated plateau unit accurately located. *Interpretation:* Lava flows and other materials from Maasaw and adjacent areas; may include some pyroclastic deposits from Maasaw. Moderate-grayish-yellow-green color may result from degradation of Maasaw dark material or from a mixture of outcrops of Maasaw dark and smooth plains materials that are below the limit of resolution; islands of lighter values are probably kipukas of smooth plains material. Areal distribution around Maasaw suggests that unit is genetically related to Maasaw and probably younger than smooth plains unit

EUBOEA FLUCTUS MATERIALS

ec — Central material—Moderate grayish orange; forms level, smooth surfaces. Found in southwestern map area within depression bordered by Euboea Fluctus margin material and lineated plateau material. West of map area, unit is very dark grayish yellow green to black and is surrounded by a very light gray material. *Interpretation:* Ponded extrusions and flows; composed chiefly of sulfur. Superposed on Euboea Fluctus margin and lineated plateau materials

ed — Dark material—Dark orange brown; surfaces appear smooth. Found as large dark patch northeast of Euboea Fluctus and as nearby isolated patches on smooth plains unit. Contacts approximately located. *Interpretation:* Overflow lavas from Euboea Fluctus and ponded lavas that issued from fissures and pipes; composed of silicates mixed with some sulfur. Superposed on both Euboea Fluctus margin material and smooth plains material; tentatively correlated in age with similar dark materials of Maasaw and Agni Paterae

em — Margin material—Moderate grayish orange, slightly lighter than central material. Forms elevated rim and flanks of Euboea Fluctus that abut against base of western part of Euboea Montes; flanks have linear ridges and hummocky surfaces. Contacts with dark material and smooth plains unit approximately located. *Interpretation:* Lava flows and pyroclastic deposits; composed chiefly of sulfur. Superposed on smooth plains and lineated plateau materials

AGNI PATERA MATERIALS

ad — Dark material—Dark orange brown; surfaces appear smooth. Forms elongate and equidimensional patches on flanks of Agni. Just east of map border, unit overlies contact of Agni flank material and smooth plains material. Contacts approximately located. *Interpretation:* Lava flows composed of silicates or silicates mixed with some sulfur. Superposed on Agni flank material. Tentatively correlated in age with similar dark materials of Maasaw and Euboea Fluctus

ak — Flank material—Light grayish yellow green and dark orange brown; surfaces appear smooth and slightly elevated above smooth plains material. Contact with smooth plains unit approximately located, defined by dark-orange-brown band. *Interpretation:* Interbedded lava flows and pyroclastic rocks from caldera; composed of silicates mixed with some sulfur. Probably superposed on smooth plains

vr — VERMICULAR RIDGED MOUNTAIN MATERIAL—Light grayish yellow green to moderate grayish orange; forms two facies. First facies makes up that part of Euboea Montes near southeast corner of map area that is smooth, planar, and about 3 to 4 km higher than surrounding area (Schaber, 1980); this surface slopes northwestward. Second facies is northwest of first and in smaller patches near southwest corner of map area; forms sinuous vermicular ridges and lobes 3 to 20 km across and an estimated 1 to 3 km high that trend northwest to west. Unit overlies contact between lineated and ridged plateau materials and, possibly, contact between lineated plateau and smooth plains materials. *Interpretation:* Uplifted, tilted, and deformed block of plateau, plains, and crustal materials; smooth facies is tilted surface of block; ridged facies formed of lower, hotter materials that flowed plastically. South of map area, higher, smooth-facies materials have slumped; alternatively, materials of both facies may be thick volcanic flows that issued from fissures, Creidne Patera, or other source. Unit composed of silicates or silcate-sulfur mixtures. Superposed on lineated and ridged plateau materials and possibly on smooth plains materials

pr — RIDGED PLATEAU MATERIAL—Light grayish yellow green to light greenish gray; surface is level and appears smooth at moderate resolution; high-resolution pictures show closely spaced, northeast-trending ridges 1 to 2 km across. Unit is probably 0.3 to 1.0 km thick; truncates stuctures in lineated plateau material. In canyon just outside south map boundary, unit overlaps contact between lineated plateau and smooth plains materials. *Interpretation:* Lava flows from Creidne Patera area; composed of silicates or silicate-sulfur mixtures. Superposed on lineated plateau and smooth plains materials

ir — IRREGULAR RIDGED MOUNTAIN MATERIAL—Light grayish yellow green; contains long ridges and valleys that trend mostly northwest. Relief above smooth plains unit is estimated at 1 km; margins irregular to arcuate. Forms rugged part of Iopolis Planum and appears to overlap contact between lineated plateau (?) and smooth plains materials. Contains remnants of three paterae: patera within map area is circular (9 km across); those outside map area are elliptical (7 by 12 km) and circular (8 km across). *Interpretation:* Degraded and eroded remnants of volcanic rocks; composed of silicates or silicate-sulfur mixtures. Superposed on lineated plateau (?) and smooth plains materials. Eroded and degraded appearance suggests unit older than ridged plateau and vermicular ridged mountain materials

pl — LINEATED PLATEAU MATERIAL—Light grayish yellow green to light greenish gray; level surface transected by numerous lineations; high-resolution pictures show subtle, irregular ridges and hills as well as narrow, linear to arcuate troughs. Contact with smooth plains unit mostly marked by scarps. Unit forms plateaus topographically higher than smooth plains unit and lower than ridged plateau material; in northeastern map area, probable occurrence of unit is intermediate in elevation between irregular mountain and smooth plains materials. *Interpretation:* Lava flows or other lithosphere materials; composed of silicates or silicate-sulfur mixtures. Unconformably overlain by smooth plains material

CRATER MATERIALS

cr — Rim material—Light grayish yellow green to light greenish gray; surface appears smooth; forms elevated, partial crater rim about 50 km in diameter. Contacts approximately located. *Interpretation:* Probably rim of degraded patera; composed of silicates or silicate-sulfur mixtures. Overlies smooth plains unit

cf — Floor material—Light grayish yellow green to light greenish gray; surface appears hummocky. Partly enclosed by rim material; embayed by lowland material. Contacts approximately located. *Interpretation:* Probably floor of degraded patera; composed of silicates or silicate-sulfur mixtures. Superposed on smooth plains unit

ps — SMOOTH PLAINS MATERIAL—Light grayish yellow green to light greenish gray; appears smooth at moderate resolution, but local high-resolution coverage suggests that it may be a mosaic of irregular, shallow valleys and lighter colored, subtle plateaus of low relief. Unit found at lower elevations than plateau materials from which it is locally separated by scarps. In western part of map area, outliers surrounded by lowland material. Contacts with irregular ridged mountain material and east edge of lowland material accurately located; elsewhere, contacts with overlying units approximately located. *Interpretation:* Lava flows or other lithosphere materials; composed of silicates or silicate-sulfur mixtures. Underlies all units except lineated plateau material

CONTACT—Dotted where concealed. Most contacts approximately located except as noted in unit descriptions

SCARP, INTERPRETED AS FAULT—Dotted where concealed; queried where probable; bar and ball on downthrown side.

LINEAR DEPRESSION—Interpreted as narrow graben, fissure, or fracture

LONG RIDGE CREST—Arrow indicates abrupt termination; absence of arrow indicates gradual termination

SHORT RIDGE CREST

PATERA RIM CREST—Interpretated to coincide generally with faults; arrows in cross section indicate relative movement of faulted units

CIRCULAR DEPRESSION—Interpreted as degraded patera

INTRODUCTION

Io, the innermost Galilean satellite of Jupiter, is about the same size as the Earth's Moon, but its surface properties and geologic processes are significantly different. Impact craters and basins, which dominate the lunar surface, are absent on Io. Instead, volcanic landforms abound (Carr and others, 1979; Smith and others, 1979b), and some volcanoes are active (Morabito and others, 1979; Strom and Schneider, 1982). Unlike the gray Moon, Io is brightly colored (fig. 1*A*), chiefly in shades of orange, yellow, and gray with a greenish tinge (Young, 1984). Spectra suggest the ubiquitous presence of sulfur and sulfur compounds at the surface (Soderblom and others, 1980).

PHYSIOGRAPHIC SETTING

Several landforms in the map area are noteworthy. Of these, Maasaw Patera is the most significant. Near the center of the area, it is a complex rimmed depression measuring 30 by 43 km. A subsidiary depression, 11 by 22 km, lies within its northeastern part. From the north rim, the maximum relief of this smaller depression is 2,200 m and that of the enclosing patera is 700 m (Schaber, 1980). The magnitude of external relief is unknown. The interior of the patera displays hues of orange (fig. 1*A*). Around it are radiating bands and filaments of dark orange brown on a background of light to moderate grayish yellow green.

Other major landforms that are found partly within the map area are Euboea Fluctus, the Euboea Montes, and a large unnamed canyon (fig. 1*B*). The part of Euboea Fluctus that is in the southwestern part of the area is a rimmed, linear depression that terminates abruptly at the base of the Euboea Montes. The Euboea Montes have an elevated planar surface whose relief is as great as 4 km, large lobate ridges, and subjacent plateaus whose scarps are 300 to 600 m high (Schaber, 1980); the montes are moderate grayish orange to light greenish gray. The unnamed canyon, 25 km across, is near the southwest corner of the map area.

Several features that have bearing on the geology of the area are found mostly outside its boundaries (fig. 1*B*). Agni Patera, 12 by 22 km, is centered about 8 km east of the east boundary at lat 40.5° S., long 334.5°. Iopolis Planum, centered just northeast of the map area, has sizeable relief and is locally rugged. Creidne Patera, 75 by 150 km, is centered 65 km south of the map area. Pautiwa Patera, about 80 km across, is centered 60 km to the north.

In the rugged southern part of Iopolis Planum, three small features may represent a sequence of morphologic degradation. A degraded circular patera, 9 km across, is mapped. Two degraded depressions are nearby (east of map border): one elliptical (7 by 12 km, at lat 35.5° S., long 332.5°) and one circular (8 km across).

RELATION OF PREVIOUS TO PRESENT WORK

On preliminary geologic maps (Schaber, 1980, 1982), the materials of Io were grouped into three broad categories: mountain, plains, and vent materials. Plains materials were subdivided into intervent, layered, and eroded layered plains units. Vent materials were subdivided into vent walls and floors, pit-crater flows, shield-crater flows, fissure flows, and crater cones. Those units that are found in the Maasaw Patera area are further subdivided on this map as follows:

(1) Mountain materials: vermicular and irregular ridged.
(2) Plains (intervent) materials: northern, lowland, and smooth.
(3) Plains (layered) materials: ridged plateau and lineated plateau.
(4) Vent (patera) materials: floor, wall, rim, dark, peripheral, and flank.

Dark material is further subdivided and identified by the names of its associated landforms. Additional units are white, Euboea Fluctus, crater rim, and crater floor materials.

PHOTOGRAPHIC COVERAGE AND COLOR DATA

Six photographs were used in the preparation of this map (table 1). One is a color composite of three wide-angle images taken through violet, blue, and orange filters (fig. 1*A*). This composite is one source of the assigned brightnesses and colors of the map units shown in figure 2, where the sums of the data numbers give approximate relative brightnesses, which are divided into five broad categories: very light, light, moderate, dark, and very dark. The ratios of data numbers for the orange- and violet-filter images give approximate relative colors, which are divided into six broad categories: orange, orange brown, grayish orange, grayish yellow green, grayish green, and gray (includes white and black). Two frames that cover the entire map area at resolutions near 1.0 and 1.6 km/pixel were the primary source of morphologic information. They were supplemented by three frames, with resolutions better than 0.7 km/pixel, that cover parts of the map area; the morphologic details of a given unit portrayed on these high-resolution frames are inferred to be present on the same map unit elsewhere.

STRATIGRAPHY

In the absence of impact craters, the sole sources of stratigraphic information in the map area are superposition and intersection relations and degree of degradation. Geographic separation of some units precludes determination of their relative ages by superposition and intersection. As a result, some estimates are based on relative degradation and are less certain.

A major unconformity separates the mountain, ridged plateau, younger plains, patera, lowland, and Euboea Fluctus units from the older smooth plains and lineated plateau materials. Smooth plains material (unit ps) is inferred to overlie unconformably the lineated plateau material (unit pl) because fissures, faults, and grabens in the lineated plateau material are truncated at the contact of the two units. Unconformable superposition of ridged plateau material (unit pr) on the smooth plains and lineated plateau units is shown in the unnamed canyon just south of the map area (fig. 3), where ridged plateau material overlaps the contact between lineated plateau and smooth plains materials. Within the map area, the ridged plateau unit is separated from the lineated plateau unit by a scarp, and some subtle ridges of the lineated plateau material seem to disappear beneath the scarp, also indicating that the ridged plateau material overlies the lineated plateau material.

Vermicular ridged mountain material (unit vr), which makes up part of the Euboea Montes, unconformably overlies the plateau units. This material has two facies. The first, near the southeast corner of the map area, has an elevated, planar, relatively smooth surface that slopes toward the northwest. The second facies forms a ridged surface whose edges are lobate; this facies borders the smooth facies on the northwest and is also present near the southwest corner of the map area. The lobate edges of this mountain unit overlap contacts between ridged and lineated plateau materials and, possibly, the contact between lineated plateau and smooth plains materials. Near the northeast corner of the map area, irregular ridged mountain material (unit ir) overlaps the contact between the smooth plains material and a plateau unit tentatively correlated with the lineated plateau material, and is thus younger than these plains and plateau units. Crater floor (unit cf) and rim (unit cr) materials are younger than the smooth plains material that they intersect, but older than the northern plains (unit n) and lowland plains (unit l) materials that partly cover them.

Materials of Agni Patera, Euboea Fluctus, Maasaw Patera, and the lowland plains are not in contact with one another, and thus their mutual superposition cannot be determined. Lowland plains material and at least the basal unit of each of the other material groups appear to be superposed on smooth plains material; all of these units appear undegraded.

Superposition of Agni Patera flank material (unit ak) on the smooth plains unit cannot be demonstrated, but their contact is overlain by bands of Agni Patera dark material (unit ad) just east of the map area (fig. 1*B*), indicating that the dark material is younger than both.

Raised rims along the sides of Euboea Fluctus are inferred to be present from brightness patterns. The inferred rims and their flanks are composed of Euboea Fluctus margin material (unit em), which is genetically related to the adjacent Euboea Fluctus dark material (unit ed); because the dark material can be seen to overlie the smooth plains unit, the margin material is inferred to overlie it also. The dark material also overlies the contact between the margin material and the smooth plains unit, and thus is younger than the margin material as well. Outliers of dark material appear to be ponded in local depressions on the smooth plains unit. The Euboea Fluctus central material (unit ec) is contained within the depression formed by the margin material and lineated plateau material and must be younger than both.

Maasaw Patera appears to be encircled by a narrow raised rim of relatively high local relief. (The rim is brighter on the upsun side than on the downsun side.) The rim material (unit mr) appears to overlie and truncate subtle radial streaks of Maasaw dark material (unit md). This dark material is nearly continuous near the rim, but at greater distances it forms bands radial to the patera and appears to occupy shallow valleys in the subjacent Maasaw peripheral material (unit mp) and smooth plains material. The dark material also overlaps contacts between these two units and is thus younger than both. The distribution of the Maasaw peripheral unit around the patera indicates that it is genetically related to other Maasaw units, and thus it also is inferred to be younger than smooth plains material. The youngest Maasaw units are wall material (unit mw) and floor material (unit mf).

For lack of other evidence, the dark materials of Maasaw and Agni Paterae and Euboea Fluctus are tentatively correlated in age because of their similar dark-orange-brown color.

Northern plains material overlaps the crater rim, smooth plains, and Maasaw peripheral materials; its lack of degradation and symmetrical distribution around Pautiwa Patera (north of map border, fig. 1*B*) suggest that it is a very young plume deposit. The brightness of white material (unit w) suggests that it has not been degraded and mixed by subsequent events and is also very young.

STRUCTURE

Structural deformation, abetted by high temperatures, probably produced the vermicular ridged mountain material. The southeastern part of this unit, the smooth facies, may be interpreted to be an uplifted diamond-shaped block of plateau and crustal materials with deformed margins. Its ridged facies, deformed by thermal creep, unconformably overlies ridged and lineated plateau materials. The elevated planar surface of the smooth facies is tilted to the northwest and, at places outside the map area where one would expect to find a reversal of slope and more ridges and lobate fronts, one finds instead large down-faulted slices, scarps about 1 to 3 km high, and hummocky surfaces of slumped blocks resting on plateaus.

Small fissures, faults, and grabens in the largest exposure of the lineated plateau unit are truncated at its west contact by smooth plains material. Faults buried by the smooth plains unit may parallel this contact, the canyon sides, and the contact of the lineated plateau unit elsewhere in the map area.

The termination of Euboea Fluctus is puzzling; it simply abuts against down-faulted lineated plateau material. A fissure within Euboea Fluctus may have been the source of the central material; alternatively, materials from elsewhere may have simply ponded in a rimmed depression.

Interpretations of other structures appear to be straightforward. The broad ridge of smooth plains and lineated plateau materials in the west-central part of the map area is bounded on three sides by a scarp. The ridge is interpreted to be a fault slice whose maximum relief is about 1 km, diminishing northward. The depressed floors of Maasaw Patera may be due to subsidence and downfaulting; locally the walls have failed and slumped. The degraded circular structure in the irregular ridged mountain unit is an old eroded patera.

COMPOSITIONS OF GEOLOGIC UNITS

Colors and ultraviolet reflectances of Io are consistent with a surface composed of a variety of allotropes of sulfur admixed with sulfur dioxide in variable amounts (Soderblom and others, 1980). Other factors, such as the temperature of the sulfur, grain size, and surface roughness, may later force alternative conclusions, but the photometry of the orange regions is consistent with sulfur (Gradie and Veverka, 1984). Although we have no spectral evidence for silicates, Io's bulk density (3,530 kg/m^3) requires them. The best evidence for silicates is found in Maasaw Patera, where the relief of steeply sloping walls is on the order of 2.2 km. For a local heat flow in excess of 1 to 2 $W m^{-2}$ (Pearl and Sinton, 1982), which might be expected for Maasaw, sulfur would melt at depths of about 60 m, whereas silicates would be stable (Clow and Carr, 1980). Marginal stability of the patera slopes is implied by local slumping and suggests the possibility of mixtures of silicates and sulfur.

Flow lobes of the vermicular ridged mountain unit also suggest silicate-rich materials. Lobe widths (3 to 20 km), estimated lobe thickness (1 km), an acceleration of gravity of 1.8 m/s^2, and an assumed density of 2,000 kg/m^3 imply yield strengths on the order of 10^5 to 10^6 Pa, if the materials are plastic. Here again, pure sulfur appears improbable and silicates, or possibly sulfur-silicate mixtures, appear to be more probable (Moore and others, 1978).

Silicates are probably the major constituent of the units that sustain high local relief in scarps and ridges—the lineated plateau and mountain materials. These units are spectrally similar and mostly light grayish yellow green to greenish gray; the moderate grayish orange of parts of the vermicular ridged mountain unit could be caused by a local sulfur-rich veneer. The composition of smooth plains material is probably the same as that of the spectrally similar plateau and mountain materials. The moderate-grayish-orange lowland unit and Euboea Fluctus central material have little or no local relief and could be ponded sulfur and sulfur flows (Sagan, 1979); the similarly colored Euboea Fluctus margin material has low relief and could be sulfur pyroclastics and flows. Maasaw's moderate-orange wall and floor materials could be a mixture of sulfur and sulfur dioxide. Dark-orange-brown units such as Maasaw's dark and rim materials could be explained as mixtures of red and brown sulfur and sulfur dioxide, but the relief of the patera rim suggests that silicates may be dominant. White material could be chiefly sulfur dioxide, whereas the northern plains material could be brown or red sulfur or silicate dust admixed with considerable amounts of sulfur dioxide.

GEOLOGIC PROCESSES

In view of Io's active volcanism, the large observed heat flows, and probable huge tides (Peale and others, 1979), most surface modifications are likely due to a combination of magmatic-volcanic processes, tectonism, and mass wasting abetted by high temperatures. For example, the following scenario might account for formation of the southeastern vermicular ridged mountains. Lavas flowed from a caldera at the present site of Creidne Patera (fig. 3) across the lineated plateau unit and onto the smooth plains material to form the ridged plateau unit. Then, a diamond-shaped block of these and subjacent crustal materials, elongate to the northeast, was uplifted by interactions of tidal forces in the crust and magma at depth. Initial tilt of the fault block was to the northwest. Because of a large local heat flow beneath the tilted block, isotherms within it corresponding to temperatures required for plastic flow were asymmetrical (nearer to the surface on the northwest side than on the southeast side). This asymmetry permitted plastic flow of materials within the northwestern part of the block onto the subjacent plateaus; slumping, instead of plastic flow, occurred on the higher, cooler southeast side. This scenario, which is similar to that of Whitford-Stark (1982), allows the margins of the mountain to rest upon plateaus. A similar explanation might apply to the other occurrences of vermicular ridged mountain material in the southwestern part of the map area, but their limited areal extent would require a very localized heat source and the outliers imply erosion of material. An alternative hypothesis for the origin of the vermicular ridged mountain unit is that it is volcanic material extruded onto plateau materials from local fractures, Creidne, or some other structure.

Significant erosion appears to be required to account for the relief and morphology of irregular ridged mountain material. In contrast to the relatively smooth appearance of the Agni Patera flank material, which is taken to represent a youthful patera, one degraded oval patera in the irregular mountain material of Iopolis Planum (fig. 1*B*) and its radial ridges stand out in positive relief; two circular paterae nearby (at and just east of map border) are also degraded. Rounded ridges and valleys surround these paterae. The east edge of Iopolis Planum is ridged and terraced. Agents that could erode the surfaces at higher elevations and deposit the materials at lower elevations include gases as well as dust and debris entrained in rapidly moving gases of plumes from vents (Johnson and others, 1979). A sapping process that involves venting along fissures and faults of sulfur dioxide gas from aquifers containing liquid sulfur dioxide could also have caused erosion (McCauley and others, 1979). Another agent may be sputtering induced by impacting magnetospheric ions (Ness and others, 1979).

The remaining geologic units are readily accounted for by volcanic processes. Lowland material appears to consist of flows that moved and ponded in broad, shallow channels and depressions. All of the Euboea Fluctus materials can be attributed to flows, in part ponded, and to ejecta (all with admixed condensates). Likewise, Agni and its deposits can be attributed to volcanic processes. Ridged plateau materials are probably lava flows. The northern plains materials are interpreted as plume deposits from Pautiwa Patera (Strom and others, 1979; McEwen and Soderblom, 1983).

Maasaw Patera, the central feature in the area, deserves more detailed comment. Its dark, raised rim could be pyroclastic deposits ejected from the caldera (Reynolds and others, 1980), lava flows, or intercalations of the two; the bands and filaments of dark material that radiate from Maasaw are probably lava flows, but pyroclastic rocks may also be present (Reynolds and others, 1980; Strom and Schneider, 1982). Ejections and effusions of rim, dark, and peripheral materials produced an initial caldera. Subsequent magma withdrawal produced additional subsidence of the floors and local slumping of the walls. Sulfur-rich materials were deposited on the floor during the waning stages. The relief from the rim to the lower floor of Maasaw suggests materials of considerable strength (Clow and Carr, 1980) and does not support a postulated near-surface ocean of sulfur overlain by an upper crust, possibly kilometers thick, of porous sulfur and liquid sulfur dioxide (Smith and others, 1979a). If this sulfur ocean had existed, the whole patera would have collapsed because of the high temperatures, and ponded sulfur should be present on the floor. Rather, the high relief of many landforms suggests that a hot silicate lithosphere, as postulated by McEwen and Soderblom (1983), is at or near the surface in most places in the Maasaw area.

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Table 1.— ***Photographic coverage of the Maasaw Patera area obtained by Voyager 1***

Frame number and lens	Filter	Range (km)	Resolution[1] (km/pixel)	Remarks
0196 J 1 WA[2]	Blue	31,906	2.2	These three frames used
0198 J 1 WA	Violet	30,803	2.1	to produce the color
0200 J 1 WA	Orange	29,753	2.1	photograph (fig. 1*A*).
0216 J 1 WA	Green	22,684	1.6	Covers map area and surrounding region.
0075 J 1 NA[2]	Clear	108,715	1.0	Highest resolution covering entire map area.
0139 J 1 NA	Clear	66,519	0.62	Covers eastern part of map area.
0197 J 1 NA	Clear	30,165	0.28	Highest resolution of Maasaw Patera.
0199 J 1 NA	Clear	31,204	0.29	High resolution of Maasaw Patera.

[1] The resolutions have been calculated from the data of Smith and others (1979b); effects of smear are not included. The dimensions of landforms that can be recognized are generally two to five times the calculated resolution. Recognition of landforms also depends on conditions such as illumination, viewing angles, the photometric properties of the surface, and the topography of the scene.
[2] WA denotes wide-angle camera; NA denotes narrow-angle camera.

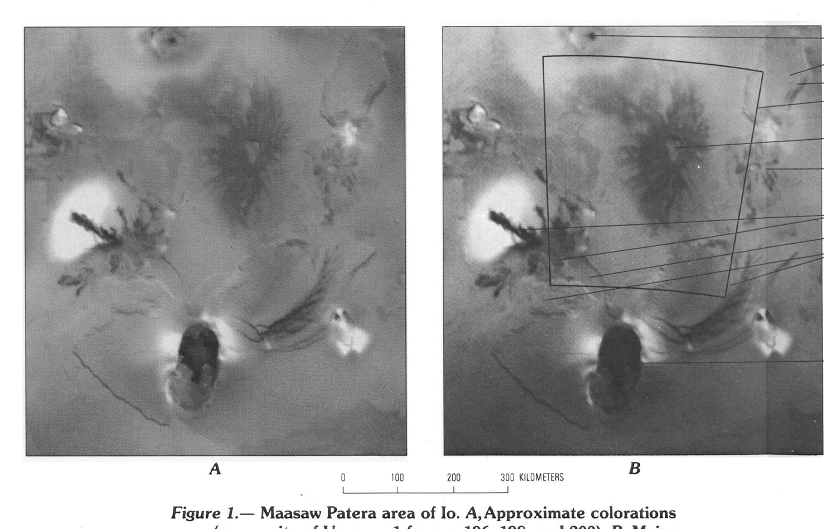

Figure 1.— **Maasaw Patera area of Io. *A*, Approximate colorations (composite of Voyager 1 frames 196, 198, and 200). *B*, Major features (Voyager 1 frame 196).**

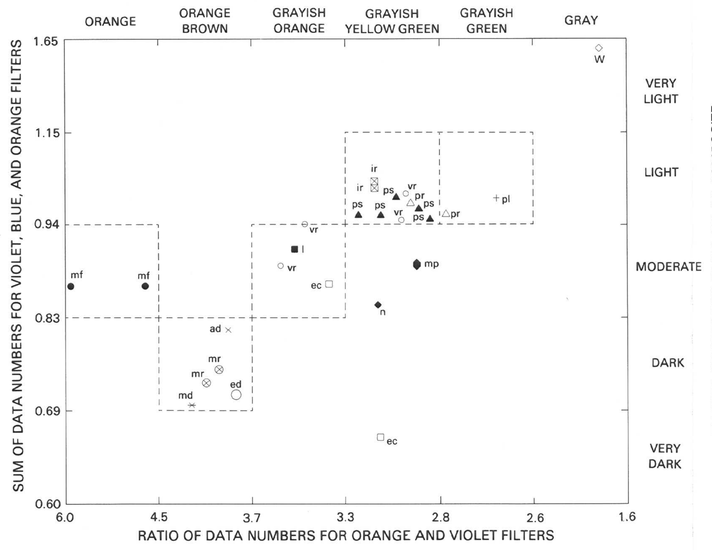

Figure 2.—**Assigned brightnesses and colors of geologic map units in Maasaw Patera map area. These assigned values are based on visual inspection of color composite (fig. 1*A*), work by Young (1984) that indicates an overall greenish cast for Io, and a rock-color chart (Goddard and others, 1948). Bin boundaries drawn on basis of these color and brightness criteria. Plotted data points correspond to samples of map units indicated by symbols used on map. Samples of data numbers obtained by A.S. McEwen, U.S. Geological Survey, from composite of Voyager 1 frames 196, 198, and 200. (See fig. 1*A* and table 1.)**

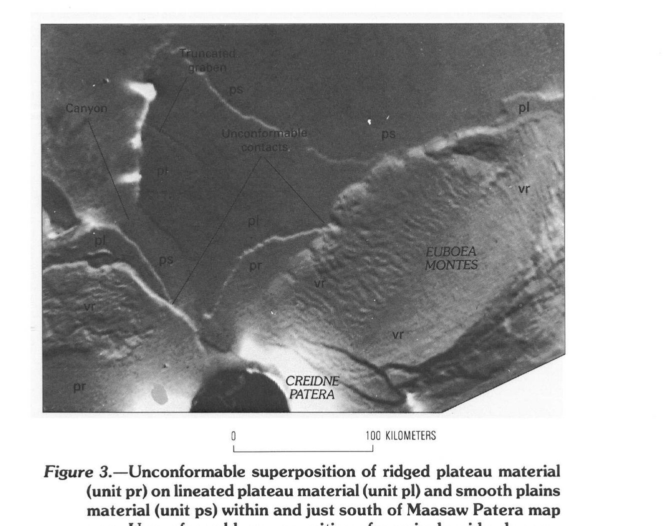

Figure 3.—**Unconformable superposition of ridged plateau material (unit pr) on lineated plateau material (unit pl) and smooth plains material (unit ps) within and just south of Maasaw Patera map area. Unconformable superposition of vermicular ridged mountain material (unit vr) on ridged (unit pr) and lineated (unit pl) plateau materials also shown (Voyager 1 frame 75).**

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