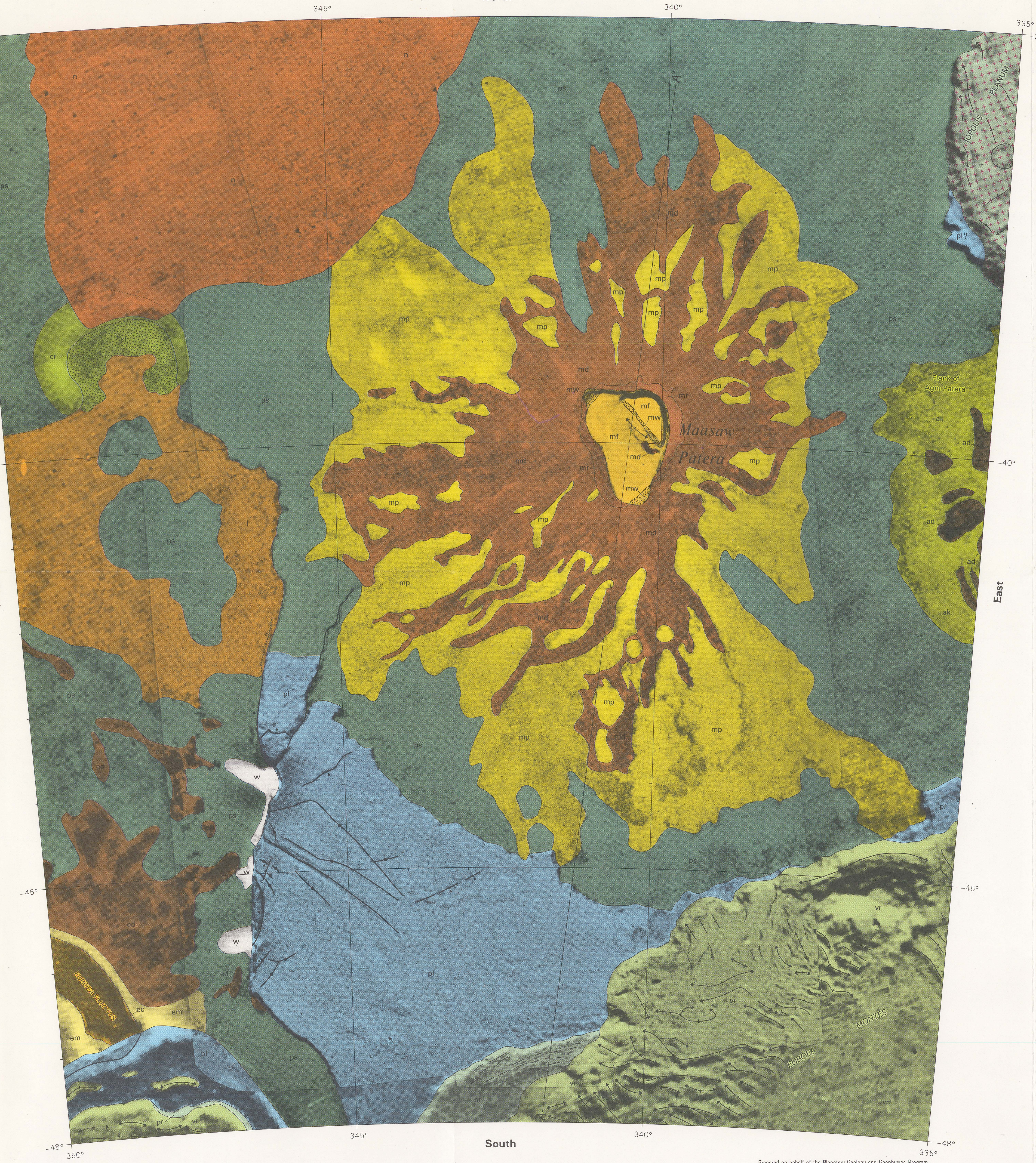
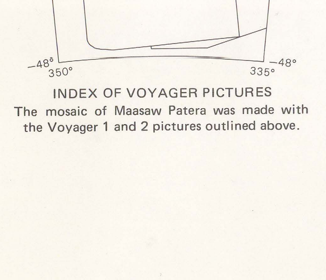
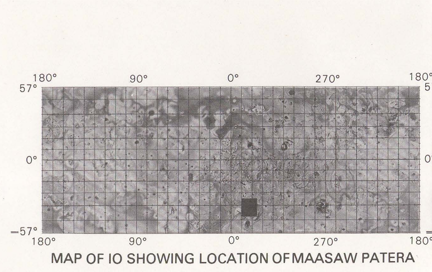
Prepared for the
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

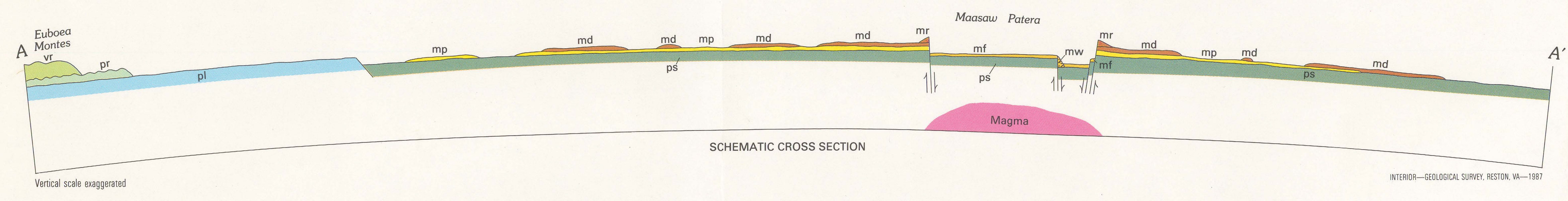




INDEX OF VOYAGER PICTURES
The mosaic of Maasaw Patera was made with the Voyager 1 and 2 pictures outlined above.



MAP OF IO SHOWING LOCATION OF MAASAW PATERA



SCHEMATIC CROSS SECTION

Vertical scale exaggerated

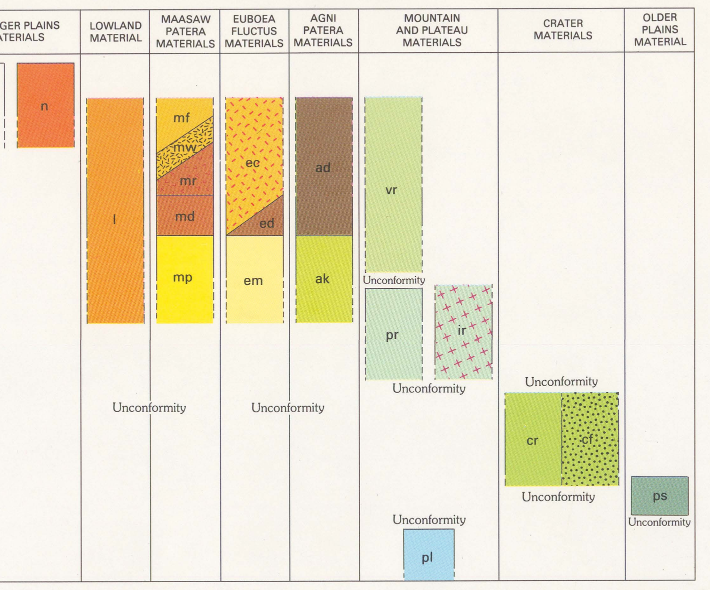
GEOLOGIC MAP OF THE MAASAW PATERA AREA OF IO

By

Henry J. Moore

1987

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

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.

COMPOSITIONS OF GEOLOGIC UNITS

GEOLOGIC PROCESSES

REFERENCES CITED

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 J1 WA[2]	Blue	31,906	2.2	These three frames used to produce the color photograph (fig. 1A).
0198 J1 WA	Violet	30,803	2.1	
0200 J1 WA	Orange	29,753	2.1	
0216 J1 WA	Green	22,684	1.6	Covers map area and surrounding region.
0075 J1 NA[2]	Clear	108,715	1.0	Highest resolution covering entire map area.
0139 J1 NA	Clear	66,519	0.62	Covers eastern part of map area.
0197 J1 NA	Clear	30,165	0.28	Highest resolution of Maasaw Patera.
0199 J1 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.

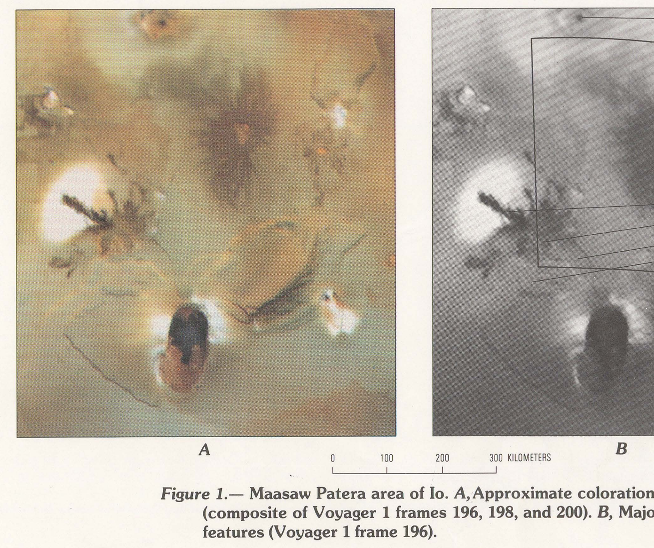


Figure 1.—Maasaw Patera area of Io. A, Approximate colorations (composite of Voyager 1 frames 196, 198, and 200). B, Major features (Voyager 1 frame 196).

ASSIGNED APPROXIMATE COLORS FROM COLOR COMPOSITE

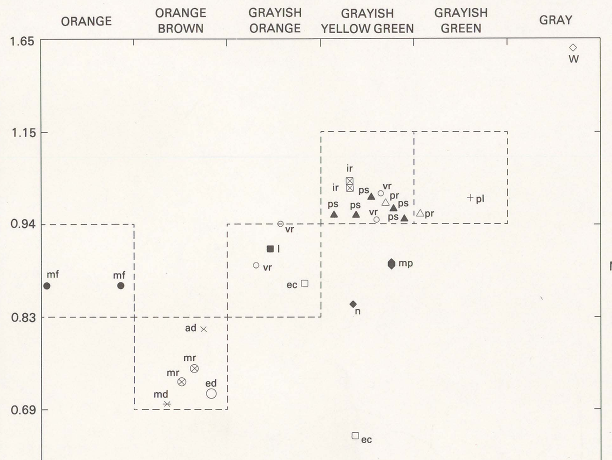


Figure 2.—Assigned brightnesses and colors of geologic map units in Maasaw Patera map area. These assigned values are based on visual inspection of color composite (fig. 1A), work by Young (1984) that indicates an overall greenish cast for Io, and a rock-color chart (Goddard and others, 1948). Bin boundaries 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. 1A and table 1.)

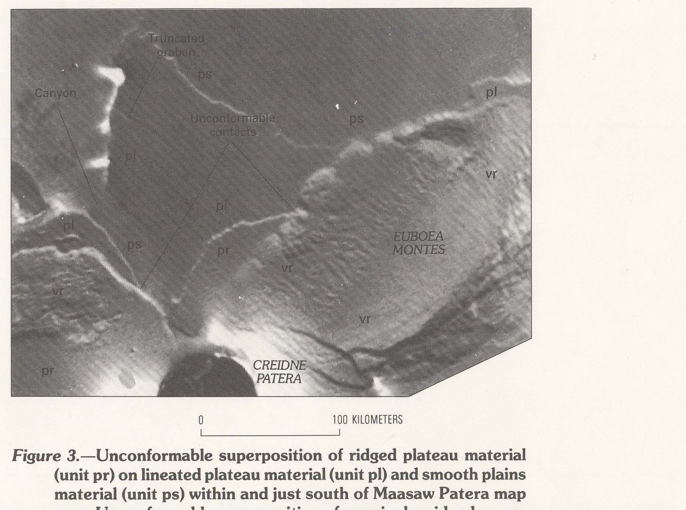


Figure 3.—Unconformable superposition of ridged plateau material (unit pr) on lineated plateau material (unit pl) and smooth plains material (unit ps) within and just south of Maasaw Patera map area. Unconformable superposition of vermicular ridged mountain material (unit vr) on ridged (unit pr) and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