IONIAN PATERA VOLUMES AND SLOPES DERIVED FROM NEW PHOTOCLINOMETRY AND STEREO PRODUCTS.
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Introduction: Although the volcanic caldera-like structures called *paterae* are a ubiqutious geomorphologic feature on the jovian satellite Io [1] and are the source of most of Io's volcanic thermal emission [2], little work has been done to measure their depths and calculate their volumes of material removed [e.g., 3-7]. A measurement of wall slope can also be used to constrain upper lithospheric strength, and possibly also constrain composition in the form of the relative abundances of silicates, sulphur and SO_2 [7]. In addition to shadow measurements to estimate patera depth, recent work [8, 9] has created new stereo and photoclinometric products from *Voyager* and *Galileo* image data. We are using these products to systematically measure the depths and wall slopes of paterae across Io's surface. Paterae volumes are calculated. This work will allow the global characteristics of paterae to be studied, and formation models [6, 10, 11] can be tested, refined or replaced.

Difficulties: There are many difficulties in processing spaceraft data of Io to extract the desired paremeters due to the high radiation environment impacting the *Galileo* imaging system, uneven longitudinal and latitudinal coverage, and wide ranges of phase angles and spatial resolutions [12]. Additionally, the widely-differeng albedos of surface units in and around numerous paterae make photoclinometry (PC) difficult, although assuming a patera shape and assigning albedo brightnesses to different units allows profiles to be constructed [6].

Methodology: We have so far examined 18 paterae (Table 1). All of these paterae have predominantly light-toned floors. Dark-floored paterae such as Loki Patera are excluded for now as the data yield erroneous PC measurements. The examples in Table 1 are from low-Sun PC images that have corresponding high-Sun albedo images that are used to directly guage the differences in shading at low and high Sun angles. These albedo images are generally of a similar resolution to the PC images, with the exception of that used to make the Haemus DEM (not included in Table 1), which is quite blurred (high Sun images are rare at the poles). Mean diameters have been calculated from a range of profiles taken across the paterae; patera areas are calculated using long and short diameters and by regarding patera shapes as either rectangular or elliptical. All slopes are measured from the slope maps that are created alongside the PC DEMs.

Results: Table 1 shows preliminary estimates of paterae depths, maximum slopes, and estimates of patera volume derived using PC for the three paterae identified in Figure 1 and for 15 other ionian paterae. Figure 1 shows a Digital Elevation Model (DEM) of a region of Io on the anti-jovian hemisphere, with the image centre at roughly 160° W, 20° N, just to the north of Prometheus volcano. Of particular interest are Thomagata, Reshef and Chaac Paterae. The topography image has been coloured and combined with a visible image that was obtained at a low sun angle, so the paterae are easily visible. Figure 2 shows two profiles that pass across the three paterae. There is some undulation across the profiles, but this has little effect on the depths of the paterae themselves. A likely cause of some or all of this undulation is variability of surface albedo, which affects the PC analysis. Despite this, the depths of the paterae can be measured. Of particular interest are the raised rims of the paterae which are hinted at in the visible image and which are evident in the DEM products.

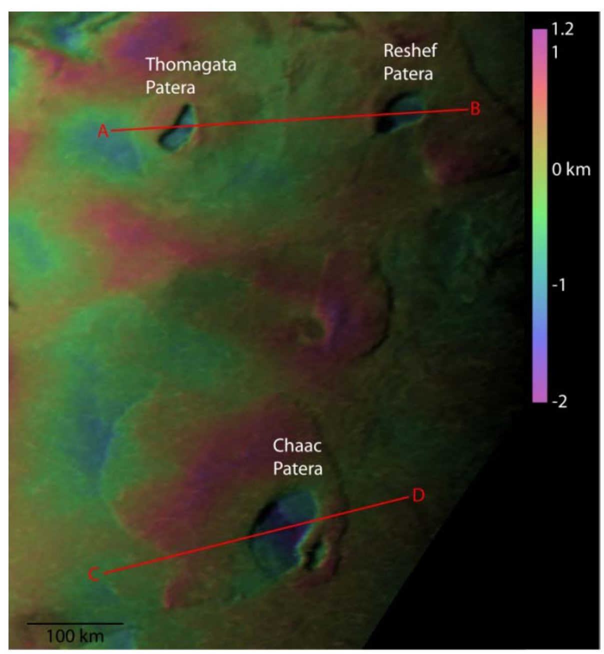

Figure 1. PC-derived Digital Elevation Model (DEM) showing profiles across selected paterae.

Depths of paterae derived using the PC method average 1.03 km (± 0.31 km). Rough volume estimates are given in Table 1. The data will undergo further scrutiny, as, for example, previous estimates of wall slope and patera depth at Chaac Patera, which was imaged at high spatial resolution by *Galileo* SSI, has slopes of 70° along at least part of the patera margin, and depths of 2.8 km (e.g., [7]).

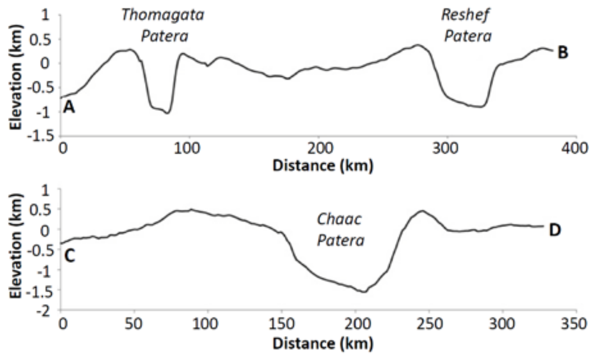

Figure 2. Profiles across the three paterae labelled in Figure 1.

Future Work: This is a work in progress. The next steps are to consider how Io's paterae formed, and if the average patera depth derived so far is an indication of the thickness of a volatile-rich surface layer. Io's paterae have probably formed by a variety of mechanisms. Maasaw Patera, for example, has a nested caldera not dissimilar to those found at some terrestrial and martian basaltic volcanoes, and is therefore quite different, morphologically, to most of the patera examined in this work. We will identify the best candidates for testing formation models utilizing heat exchange between silicate intrusions and overlying volatile layers, while continuing to process more data and generate additional DEMs.

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Table 1. Dimensions of paterae in this analysis

Patera Name	**Centre Latitude (°)**	**Centre Longitude (°W)**	**Mean diameter (km)**	**Depth (km)**	**Maximum wall slope (°)**	**Volume of patera (km^3)**	**Horizontal DEM scale (km/pixel)**
Bochica Patera	-61.1	18.6	53.98	0.95	19.4	2174	1.32
	-23	111.9	79.36	0.81	6	3993	3.85
	48.4	156.3	53.56	0.51	5.3	1149	1.477
Chaac Patera [a]	11.9	157.4	89.46	1.63	15	10246	1.477
Reshef Patera	27.7	158.1	52.20	1.09	9.5	2332	1.477
Thomagata Patera	25.7	165.9	43.82	1.32	13.8	1990	1.477
	-7.8	184.2	65.02	0.69	5.1	2291	3
	-5.5	187.3	68.59	0.69	7.2	2567	3
	-31	187.8	51.63	0.91	7.5	1897	3
	-5.9	190.3	49.16	1.43	12.7	2714	3
Asha Patera	-8.7	225.6	106.73	0.89	7.2	7997	2.612
	-15.1	231.2	59.34	0.99	7.4	2742	2.612
Sêd Patera	-2.9	303.6	46.22	0.89	12.1	1493	2.561
Reshet Patera	0.5	305.5	106.03	1.15	11.2	10154	2.561
Shoshu Patera	-19.3	324.1	41.36	1.09	3.5	1464	2.561
Hiruko Patera	-64.9	328.5	74.26	1.05	23.9	4548	1.32
Aramazd Patera	-73.6	336.8	54.70	1.59	17.1	3736	1.31
Inti Patera	-68.4	347.5	73.38	1.32	21.7	5582	1.31

[a] minimum value of wall slope (see [7]).