TOPOGRAPHY OF IO: METHODS TO MAPPING LOCAL AND REGIONAL GEOLOGY. R. R. Wilson and P. M. Schenk, Lunar and Planetary Institute, Houston, TX 77058 (rwilson@lpi.usra.edu; schenk@lpi.usra.edu).

Introduction: On such a volcanically active world as Io, topography is especially important for understanding lava emplacement, mountain formation, internal dynamics, and volcanic history. Previously we have described our efforts to map Io's topography at large and small scales. This report is motivated by several new developments, the most important of which are significant upgrades to our stereo topographic mapping software and the successful application of shape-from-shading (photoclinometry, PC) techniques to Io's photometrically complex surface. Here we summarize these developments and the topographic observations and resulting elevation maps of volcanic features completed to date.

Topographic Mapping: Shadow length triangulation and limb profiles are available for Io but the vast bulk of our data is derived from stereo and PC analysis. The digital stereo mapping technique used here is described in detail elsewhere [1], but in brief is based on scene recognition software [e.g., 2]. Although highly successful on other Galilean satellites [3] stereo mapping on Io is complicated by a number of factors unique to that body, principally radiation noise damage to the image, complex and variable photometric properties with phase angle, and temporal changes of volcanic features during the stereo sequence. Other difficulties include the blandness of the extensive Ionian plains in many Voyager and Galileo images. These types of terrain do not have enough spatial detail or contrast for the scene recognition algorithm to work properly. These complications, which manifest themselves as spurious DEM elevation data, are greatly reduced by the use of a Stacked Progressive Cube method of DEM analysis [4]. We also successfully employ a new 2-D photoclinometry (PC) tool to map large areas of Io [4,5]. Key to this success is the use of low-phase images to model local albedo in map regions.

Mountains – Tohil Mons: The dominant topographic features on Io are mountains, volcanic calderas, shield-like volcanoes, and plains. The topography of Io's strategically important mountains was surveyed by Schenk et al. [6]. Io's mountains are now considered to be formed by compressional forces built up in Io's cold lower crust as a result of continual resurfacing at the top [2,6]. Yet numerous questions remain, including the link between volcanism and mountains.

Tohil Mons is the best-observed mountain on Io. High-resolution, high-sun images from orbits I24 and I27 form a stereo mosaic of the mountain proper, as do low resolution C21 and I24 images of Tohil and surrounding areas. In addition, low-sun images from orbit I32 provide high-resolution stereo of the summit of Tohil Mons (Fig. 1) and low sun I32 context images allow for PC-DEM mapping of the entire.

Structurally, Tohil Mons consists of four major sections. An elongate plateau roughly 180 by 115 km long forms the eastern half. This plateau has a gently arching profile rising 3-5 km above the plains. The crest rises steadily from the eastern end to the western end near the center of the mountain, where it reaches a maximum height of ~8 km. This plateau is divided in two sections, a southern smoother part and a northern part scored by parallel graben-like valleys paralleling the topographic trend of the mountain and ~1 km deep on average. The northwestern section is a roughly circular plateau 6 km high crossed by deep graben-like valleys. The southwestern section consists of several lobate shaped plateaus 1-2 km high, arranged in stepwise progression of increasing height.

Where the two halves of Tohil Mons are joined, two large amphitheatres are formed. The northern depression is occupied by a flat dark patera. The southern depression is enclosed by a steep-sided scarp rising 1 to 6 km above the floor, which is itself 1.5 km above the surrounding plains. A narrow ridge 3 to 6 km high further divides the two halves of Tohil Montes.

Calderas: Volcanic calderas are among the most common features on Io. They display a wide range of topographic signatures. Voyager based analysis indicated that at least a few calderas had steep walls and depths of 1-2 km [7], indicating the crust is probably not dominantly sulfur in composition. Our shadow measurements and stereo coverage for 25 additional calderas indicate that these volcanic calderas can have depths from 0 to no more that 3 km [8].

Volcanoes: Radially centered lava flow fields are also common on Io [6]. Most of these volcanoes are centered around dark paterae a few 10's of kilometers across. Although suggestive of shield volcano topography, high volcanic relief of the type common in the Tharsis region of Mars has not been observed on Io. Stereo DEMs of Ionian shield volcanoes confirm they have little topographic. Average slopes are ~0.5 degrees or less. Only 4 examples show any overall relief in excess of 1.5 km. The exceptions include Moore et al.'s [9] ~40 km wide, 2 km high volcano, a shield-like rise at 1°S, 162°W, and two conical volcanoes at Zamama observed at low sun during I32. These later two examples are 2-3 km high and 20-30 km wide.

These volcanoes all have very small summit cones. The absence of shield volcano topography might be explained by post-volcanic subsidence of topography by deflation of magma chambers or viscous creep of the lithosphere. Two observations argue against this hypothesis. One is the absence of graben or moats. Although ongoing volcanism could bury some of these features, some evidence would be expected at younger volcanoes. Second, the lithosphere of Io is probably thick and cold [10]. This implies that shield volcano topography should be supportable by flexural rigidity. Even low viscosity lavas can build volcanic constructs but this may not occur on Io if the longevity of volcanic centers is sufficiently short.

Lava channels are an important aspect of flow field emplacement. The best resolved example is the >150 km long channel extending due southeast of the edge of Emakong Patera [11]. Two high-resolution high-sun images mosaics provide stereo coverage with vertical resolution of ~50 meters. Although, this is insufficient to detect the depth of this channel.

A lava channel observed in orbit I25 is the only known example observed in low-sun images. Located at 0°N, 73°W, this channel is at least 175 km long. Although, the source cannot be identified. Like the Emakong channel, this example is variable in width (0.5 to 5 km) and occasionally branches into two short channels that rejoin, forming topographic islands. The low-sun angles and bland albedo characteristics of this region make this an ideal target for PC mapping. Our PC-DEM indicates this channel is ~40 meters deep.

Plains: *Regional Topography.* Voyager-based evidence for regional topographic variations of a few kilometers [12] have yet to be verified by Galileo analysis. We have analyzed a hemispheric scale stereo mapping sequence from orbits C21 and I24 at ~1-1.5 km/pixel, covering most of the anti-jovian hemisphere. This observation was compromised by excessive radiation noise at the bottom of the frames that makes image registration difficult at best. Although the 'final' DEM suggests that equatorial regions are depressed ~1 km, repeated efforts failed to eliminate misregistration "fault lines" along image boundaries in our DEM. Our solution is to use a lower resolution stereo pair of the same territory allowing us to map regional topography in one contiguous swath. Preliminary analysis of this DEM also suggests that equatorial areas appear to be ~1 km lower in elevation, but this is only in reference to the base ellipsoid used in our control net.

Sub-jovian hemisphere regional mapping is dependent on Voyager imaging, which is handicapped by subtle uncertainties in the geometric characteristics of Voyager vidicon images. Despite this, three Voyager stereo mosaics over Loki region each suggest that this persistently active region is centered on a broad low roughly 1 km deep. This could be consistent with a thinner lithosphere in the Loki region.

In general, we do not find regional topographic variations in excess of 1 km. Some regional elevation variations near Talos Patera may correlate with geology. That both the Colchis regio and Loki region lows coincide with regions with less than average mountain concentrations [6] is interesting, however.

References: [1] Schenk, P. (2003) Topography of Europa, in preparation. [2] Schenk P. and M. Bulmer (1998) *Science* **279**, 1514. [3] Schenk P. (2002) *Nature* **417,** 419. [4] Wilson, R. and Schenk, P. (2003) *LPSC XXXIV*. [5] Schenk, P. (2003) this workshop. [6] Schenk, P., et al. (2001) *JGR* **106**, 33,201. [7] Clow, G. and Carr, M. (1980) *Icarus*, **44**, 268. [8] Wilson, R. and Schenk, P. (2002) *LPSC XXXIII*. [9] Moore, J., et al. (1986) *Icarus*, **67**, 181. [10] McEwen, A., et al. (2003) in *Jupiter*, Cambridge Univ. Press., in press. [11] Williams, D. A., et al. (2001) *JGR* **106**, 33,161. [12] Gaskell, R. et al. (1988) *GRL* **15**, 581.

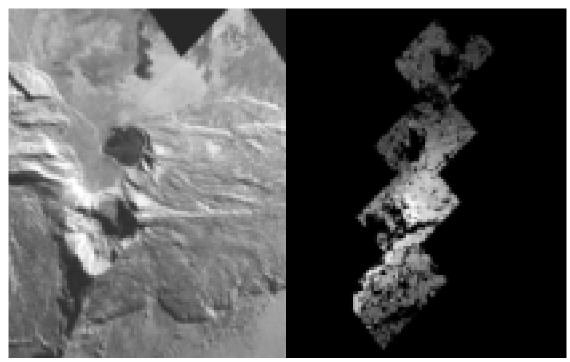

Fig. 1. Preliminary DEM of the crest of Tohil Mons. Left view is an I32 Galileo image at 320 m/pixel showing the central region of the mountain. The right view is a DEM of part of this region derived from the I32 stereo mapping sequence. Topographic range displayed is 12 km.