STEREO IMAGING OF IMPACT CRATERS IN THE BETA-ATLA-THEMIS (BAT) REGION, VENUS.

Audeliz Matias[1], Donna M. Jurdy[1], and Paul R. Stoddard[2], [1]Dept. of Geological Sciences, Northwestern University, Evanston, IL 60208-2150, Dept. of Geology and Environmental Geosciences, Northern Illinois University, DeKalb, IL, 60115-2854, amatias@earth.northwestern.edu

Introduction: The distribution and density of craters has been used to study the resurfacing history and tectonic activity of Venus [e.g. 1, 2, and 3]. Assuming that impact cratering has decreased since the early bombardment period of planet formation, planetary age can be estimated. In the case of Venus, it seems to have undergone a resurfacing event about 300-500 million years ago, perhaps one of a sequence [4, 5].

Venus hosts approximately 940 craters, of which about 158 are "tectonized", and 55 "embayed", but only 19 planetwide are "both tectonized and embayed" [1]. These figures vary according to the database listing used. The highest concentration of modified craters is in the Beta-Atla-Themis (BAT) region (± 30º N, 180º-300º E), the location of three rift zones defined in the global map of Venus [3]. BAT appears to be tectonically active with the planetary geoid highs, profuse volcanism, and numerous coronae. The Beta and Atla Regiones are dominated by rifts and large volcanic edifices, with Atla containing some of the largest volcanoes in the planet (i.e. Maat Mons) and Dali, Paga, Hecate and Ganis Chasmata [6]. Theia Mons, a major volcano on Venus, overlies on the Devana Chasma at the Beta Regio.

In our study we correlated Magellan radar images and topographic data to determine the tilting for both modified and unmodified craters in the BAT region. Here we concentrated on the use of stereo-imaging for those few craters with multiple Magellan cycle coverage to achieve higher resolution. In addition, the construction of basic maps clarified the degree of modification of these features. We used an updated version of the crater catalog by [1] for locations, sizes and modification (R.J. Phillips and N. Izenberg, personal communication, July 1994). Tilting was obtained by fitting planes to the altimetry data.

BAT Craters: Beta and Atla Regiones may be very recent. They have high relative percentages of craters that have been tectonized or embayed. Although just 1/6th of the planetary surface, fully 23% of the modified craters are located in the BAT region; with a total of 30 tectonized-only, 10 embayed-only, 102 pristine, and 11 both tectonized and embayed craters. Of the both tectonized and embayed craters, four are near the crest of Atla Regio, and one on its flanks, while Beta is home to three on its flanks and one on its crest. Overall global distribution of craters approximates random, although these areas with high concentrations of altered craters are clearly more active. Most of the crest of Atla must still be active, otherwise recent craters would be pristine for the most part. Indeed, crater Uvaysi (2.3º N, 198.2º E, d=38.0 km) on Atla, one of only ~ 60 with parabolic dark halos – thought to be the youngest of craters [7] – shows significant modification. It has suffered tectonic disruption and embayment by lava. Besides crater modification, there exists a slight but systematic deficit of about 20-30 craters close to the chasmata [8].

Stereo Imaging: Magellan radar-mapped Venus with 3 cycles, changing direction of illumination and incidence angle for each cycle. Unfortunately the whole planet was not covered by all 3 cycles. However, with multiple cycle coverage over a feature, we can undertake stereo imaging to obtain high resolution elevation (~ 100 times better than altimetry) [9]. In the BAT region we have 13 craters covered by two cycles and a single crater (Warren, d=49.4 km) with three-cycle coverage. Using the incidence angles for both images, elevation can be obtained by the parallax-to-height ratio on opposite-side or same-side stereo images. The radar stereo methodology and incidence angles by cycle and latitude can be obtained from [9]. For our analysis we used Magellan Stereo Toolkit (MST) version 2.0 implemented in batch mode for high-resolution (75m/pixel) images. Following, we show an example of how the topography for a crater, Piscopia, can be improved with stereo imaging.

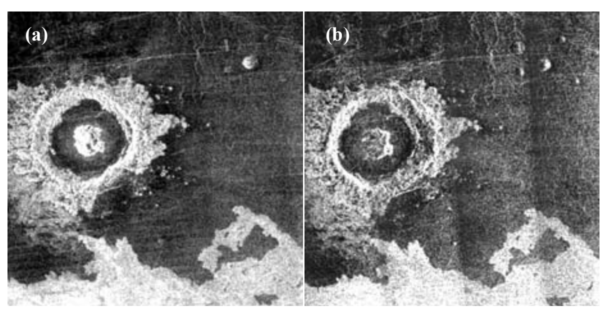

Figure 1. Crater Piscopia (1.5 N, 190.9 E, d=24.8 km) (a) Cycle 1 image with left illumination, incidence angle ~ 45º; (b) Cycle 2, right illumination at ~ 25º.

Piscopia. This ~ 25 km diameter crater has been diversely classified: both tectonized and embayed [1], slightly embayed [5] and pristine [10] (Figure 1). The well-defined crater is located on the Pl2 unit, defined as "plains with distinct flow morphology preserved" [11]. It displays a central peak, continuous ejecta blanket and flat floor. Figure 2 shows topography for Piscopia as obtained from the Magellan altimetry data and stereo imaging. Note the greater detail in the crater cavity, showing disruption in the northern crater wall. There appears to be evidence both in the radar and the altimetry that the crater suffered deformation, thus is tectonized in addition to embayed. The surrounding region dips to the west, but the crater itself is flatter and dips WSW. Other craters, however, such as nearby Richards, display dips quite independent of their adjacent area, suggesting 2 stages of tilting.

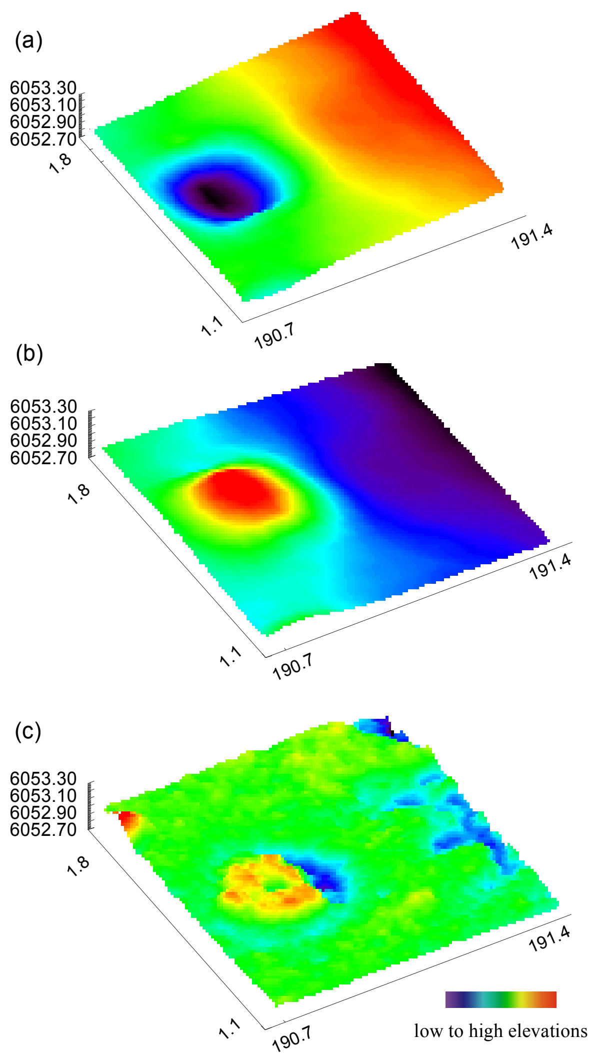

Figure 2. (a) Magellan altimetry for Piscopia. (b) Inverted plot of altimetry data. We invert to better examine the crater floor. (c) Inverted plot of topography from MST (automatching level 4).

Conclusions: Impact craters that have suffered from both tectonism and embayment by lava are strongly concentrated close to chasmata. The coincidence that the BAT region has a deficit in craters and contains the majority (61%) of the both tectonized and embayed craters, documents the primary obliteration of impact craters in this area. Modification of parabolic craters, such as Uvaysi, dates the tectonic and volcanic history as very recent [12]. We may therefore infer that Atla, with a higher percentage of altered craters, (8/17 or 4%, within 30 geoid meters of the summit) is more active or recent feature than Beta (4/14 or 29%, in the same range). Tilting results, for the area outside (± 0.2º from crater center) of the craters, indicate that most of the craters around Atla's geoid high dip away. Beta's geoid high is 20 m lower than Atla and craters are sparser and dip directions more random. Unfortunately, there are no parabolic craters in this area, so we are unable to assess whether deformation and volcanism extend to the most recent time.

Further stereo imaging will be shown with more details about BAT craters. The application of the stereo imaging not only depends on availability of multiple images, but also on the size and stage of the craters, as well as how discernable they are on the images. For instance, stereo-derived topography for crater Uvaysi (covered by Cycle 1 and 2) proved not to be very useful due to low-backscattered differences between areas in the image.

Acknowledgments: We would like to thank Robert R. Herrick (LPI) and Kelly Maurice (JPL) for their invaluable help in installing Magellan Stereo Toolkit V. 2.0 in batch mode.

References: [1] Phillips R.J. et al. (1992) *JGR, 97,* 15923-15948. [2] Namiki N. and Solomon S.C. (1994) *Science, 265,* 929-933. [3] Price M.H. and Suppe J. (1995) *Earth, Moon, and Planets, 71,* 99-145. [4] Phillips R.J. et al. (1991) *Science, 252,* 288-297. [5] Schaber R.J. et al. (1992) *JGR, 97,* 13257-13301. [6] Crumpler et al. (1997) *In*: Venus II, 697-756. [7] Campbell D. B. et al. (1992) *JGR*, *97,* 16249-16277. [8] Stefanick M. and Jurdy D. M. (1996) *JGR*, *101*, 4637-4643. [9] Plaut J.J. (1993) *In:* Guide to Magellan Image Interpretation, 33-44. [10] Herrick H.R. et al. (1997) *In*: Venus II, 1015-1046. [11] Price M. H. (1995) Ph.D. Dissertation, Princeton University, Princeton NJ, 177pp. [12] Basilevsky, A. T. (1993) *Earth, Moon, and Planets, 71*, 99-145.