VOLCANISM ON IO: RESULTS FROM GLOBAL GEOLOGIC MAPPING. D.A. Williams[1], L.P. Keszthelyi[2], D.A. Crown[3], P.E. Geissler[2], P.M. Schenk[4], Jessica Yff[2], W.L. Jaeger[2]. [1]School of Earth & Space Exploration, Arizona State University, Tempe, Arizona 85287 (David.Williams@asu.edu); [2]Astrogeology Science Center, U.S. Geological Survey, Flagstaff, Arizona; [3]Planetary Science Institute, Tucson, Arizona; [4]Lunar and Planetary Institute, Houston, Texas.

Introduction: We have completed a new 1:15,000,000 global geologic map of Jupiter's volcanic moon, Io, based on a set of 1 km/pixel combined *Galileo*-*Voyager* mosaics produced by the U.S. Geological Survey [1]. The map was produced over the last three years using ArcGIS™ software, and has undergone peer-review. Here we report some of the key results from our global mapping efforts, and how these results relate to questions regarding the volcano-tectonic evolution of Io.

Previous Work: Previously we reported our techniques for global mapping of Io [2] and on the development of an Io database [3] that will include most Io data sets to address the surface changes due to Io's active volcanism. Previously we also reported the percentage of Io covered by each of 14 process-related geologic material units and structures [4], and last year we presented a stratigraphic correlation of these map units [5]. Here we report results from visual, graphic, and statistical analyses of the map units and structures and discuss insights into the formation of plains, lava flow fields, paterae, mountains, and diffuse deposits.

Results I (Plains): Plains units cover 66.6% of the surface, and (with the exception of a few outliers) are geographically distributed on Io. Red-brown plains dominantly occur >±30˚ latitude, and are thought to result from enhanced radiation-induced alteration of other plains units. White plains (typically enriched in SO_2) occur mostly in the equatorial antijovian region (±30˚, 90˚-230˚W), possibly indicative of a regionally colder part of the satellite to preserve the SO_2. Why is this one region colder such that SO_2 concentrates here? The answer may be related to variations in crustal distribution of magma sources or delivery mechanisms, or perhaps crustal thickness, relative to other parts of Io. Outliers of white, bright, and red-brown plains occurring in other regions likely result from long-term accumulation of white, yellow, and red diffuse deposits, respectively.

Results II (Lava Flows): Lava flows cover 27.8% of the surface, the bulk of which (20.6%) are undivided flows whose original composition (dark silicate or bright sulfur) cannot be determined. Bright flow fields outnumber dark flow fields by a ratio of ~1.5 to 1; both of these are presumed to be the freshest and youngest lava flow types on Io. Only 16.8% of the bright flow fields are adjacent to dark flow fields. The association of adjacent bright and dark flows would be expected if sulfur flows are derived from secondary sulfur volcanism (i.e., melting of sulfur-rich country rock by heat from silicate magmas or lavas [6].) Thus, this result suggests that secondary sulfur volcanism may only have a minor role in Io's current volcanic activity (although there may be a scale-dependence on these processes that requires further investigation). There is an unusual concentration of bright flows at ~45˚-75˚N, ~60-120˚W, perhaps indicative of past, extensive primary sulfur volcanism in this region. However, this stands in stark contrast to the current correlation of active hot spots with surface materials, in which only 1.7% of hot spots correlate with bright flows, suggesting that at present primary sulfur volcanism has a minor role in Io's current activity. 20.3% of hot spots detected by telescopic and spacecraft observations correlate with dark flow fields and another 9.3% correlate with undivided flow fields. Thus, lava flows make up less than one-third of Io's heat sources.

Results III (Paterae): Paterae are circular to irregular volcano-tectonic depressions on Io, thought to be similar to terrestrial calderas [7]. Evidence suggests some of these contain periodically foundering lava lakes [8], whereas others are resurfaced by bright or dark lava flows. We have mapped a total of 425 paterae on Io, an increase from the 417 previously identified by [7]. Yet even though paterae cover only 2.5% of Io's surface (and dark patera floor material covers only 0.5%), Io's hot spots dominantly occur within paterae (63.9% of all hot spots, with 45.3% correlated with dark patera floor material). The fact that 93.5% of Ionian hot spots correlate with either dark (younger) or undivided (older) patera floors or lava flows suggests that silicate materials are the dominant component of Io's recent volcanism.

Results IV (Mountains): Mountains cover only 3.1% of Io's surface, yet are some of the most dramatic features observed in spacecraft images. A majority of Io's mountains, 37.9%, were mapped as undivided mountain materials, in contrast to mapping 27.1% as Lineated mountains, 22.1% as Layered plains, 3.6% as Tholi (volcanic mountains), and 2.9% as Mottled mountains. These results demonstrate that variable imaging coverage of Io's mountains inhibits more accurate mapping of undivided mountains into the other units. As expected, lineated mountains, thought to be tectonically uplifted crustal blocks [9], are generally taller than the more degraded mottled mountains and layered plains. Volcanic tholi are less than 2km tall, indicative of mafic to ultramafic materials that tend not to build tall volcanic edifices. We are working on additional correlations, including the locations and areas of mountains with heights and image resolution, to further identify relationships that can provide insights on the genesis of these features.

Results V (Diffuse Deposits): Diffuse deposits (DD) that mantle the other units cover ~18.2% of Io's surface, and are distributed as follows: red (47.2% of all DD), white (37.9%), yellow (11.5%), black (3.3%), and green (~0.1%). Red DD are thought to be derived by condensation of S_2 gas and recrystallization to short-chain sulfur (S_3-S_4 ± chlorides) from volcanic vents. These are dominated by ring-like units resulting from outbursts, except for that found surrounding volcanoes such as Pele that are continuously replenished by ongoing activity. White DD, mostly irregular in shape and often surrounding lava flow boundaries, result from vaporization, condensation, and reaccumulation of SO_2 frosts around warm flow margins. The relative lack of pyroclast-bearing DD, i.e., dark (black) DD (thought to be derived from silicate pyroclasts) and yellow DD (thought to be derived from sulfur pyroclasts) compared to gas-derived White and Red DD (14.8% vs. 85.1%) may suggest that sulfur and SO_2 do not have a major role as volatiles that disrupt or interact with sulfur or silicate magmas.

References: [1] Becker, T. and P. Geissler (2005), *LPS XXXVI*, Abstract #1862. [2] Williams, D.A. et al. (2007), *Icarus*, *186*, 204-217. [3] Rathbun, J.A. and S.E. Barrett (2007), *LPS XXXVIII*, Abstract #2123. [4] Williams, D.A. et al. (2008), *LPS XXXIX*, Abstract #1003. [5] Williams, D.A. et al. (2009), *LPS XL*, Abstract #1403. [6] Greeley, R., et al. (1984), *Icarus 60*, 189-199. [7] Radebaugh, J., et al. (2001), *JGR 106, E12*, 33,005-33,020. [8] Lopes, R.M.C., et al. (2004), *Icarus 169*, 140-174. [9] Schenk, P. and Bulmer, M. (1998), *Science, 279*, 1514-1517.

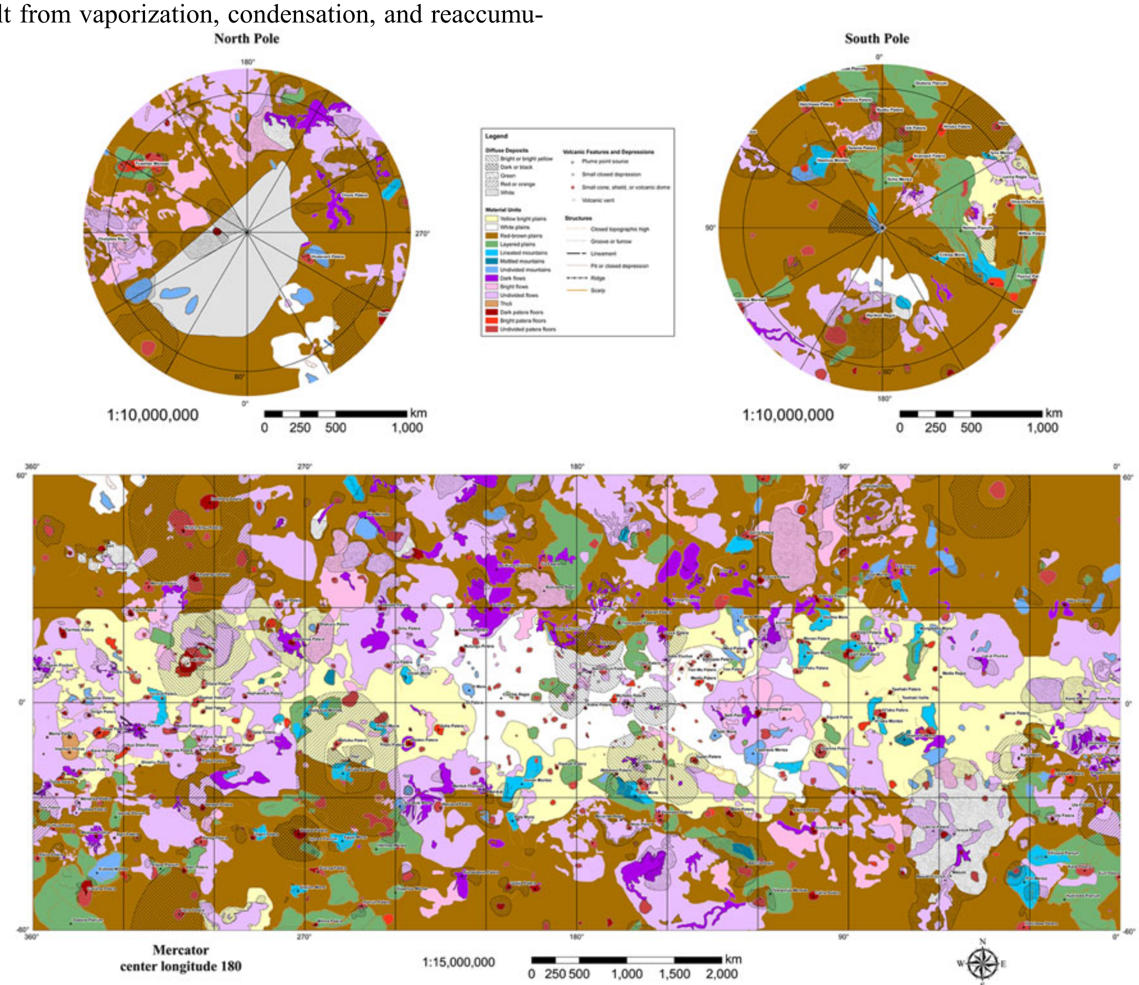

Figure 1. The global geologic map of Io, produced using ArcGIS™ software based on the combined *Galileo-Voyager* mosaics produced by the U.S. Geological Survey [1]. For additional information on mapping strategy, areal coverage of map units, and stratigraphic correlation of map units, see [2, 4, 5].