LONG-TERM MONITORING OF VENUS VOLCANISM USING EARTH-BASED RADAR.

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Introduction: Given the similar size of Earth and Venus, it has long been assumed that they have similar internal heat sources. The absence of evidence for active plate tectonic processes on Venus means that much of this internal heat must escape by a combination of conduction through the crust and eruptions of magma onto the surface. While specific variations in regional age are still a topic of debate, the population of impact craters implies a surface that is on average less than ~700 million years old. The Magellan data show that over 80% of the surface formed via volcanism – vast sheet flows that formed plains, domes and small shield volcanoes with surrounding flow fields, circular volcano-tectonic features called coronae, and giant shield volcanoes similar to Mauna Loa or the Tharsis Montes. It is thus reasonable to search for evidence of recent lava flows, particularly from the major volcanic centers. The Venus Express spacecraft used coarse-resolution radiometric data to suggest such possibly recent volcanism [1], but cannot provide detailed geologic mapping necessary to identify "new" flows.

Earth-based radar is the only current way to monitor volcanic areas for surface change. Radar mapping using the Arecibo telescope in 1988 provided the first 1-2 km resolution Earth-based image of Venus [2-3] (Fig. 1). The Magellan mission, over the next several years, mapped almost the entire planet at a spatial resolution of about 100 m. At the close approach in June 2012, we thus have a 24-year baseline to search for surface changes due to volcanic processes. We will use the Arecibo S-band transmitter and Green Bank Telescope (GBT) receivers for six days near close approach. The advantage of using the GBT is that we can transmit continuously over the observing window, without having to shut down for a receiving period. This allows for longer coherent integration periods, and thus finer spatial resolution in the "azimuth" axis. The time resolution will be 4 μs, allowing for 1-2 km resolution radar mapping of the visible hemisphere [5].

The result will be a comparison between the 1988 and 2012 datasets, Magellan data, and lower-SNR Arecibo-GBT data from 1999-2004 [4], to show any areas of possible change. A close examination of Magellan data, and 3-d rendering of the Arecibo data (Fig. 1), will be used to establish the geologic context of anomalous areas.

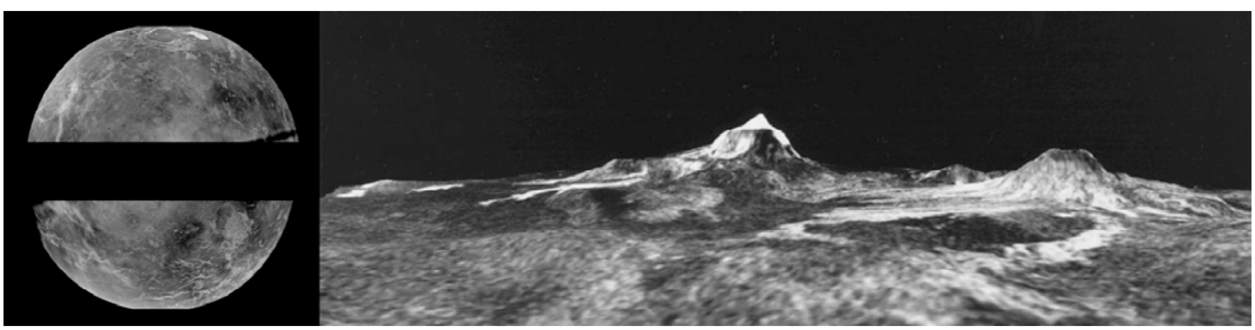

Fig. 1. (Left) 1988 radar map of Venus produced using the Arecibo Observatory S-band system. The black band is region where no practical imaging is possible due to N-S ambiguity and coarse range or frequency resolution. (Right) View of Sif and Gula Montes volcanoes from the 1988 Arecibo data, draped over topography.

Volcanic Change: How much volcanism could occur in 20-25 years? The Pu'u O'o eruption on Kilauea alone covered 117 km^2 in 24 years (1983-2007; Fig. 2), a scale of change easily noted in Earth-based mapping of Venus. Seeing a change will depend upon variations in the radar brightness, which can arise from both the decimeter-scale morphology of the new flows (rougher or smoother than the existing terrain) and their lack of superposed fine-grained weathered material relative to older units.

Detection of such features would provide the first definitive evidence of active volcanism on a terrestrial planet (as opposed to the tidally-driven volcanism on Io) other than Earth. Additional inferences about the likely eruption conditions could come from comparisons with estimates of regional compensation and flexure from Magellan topography and gravity data. The likelihood of detection cannot be quantified – the Venus Express data provide only hints of recent activity – but the potential importance of detecting recent eruptions seems well worth the effort.

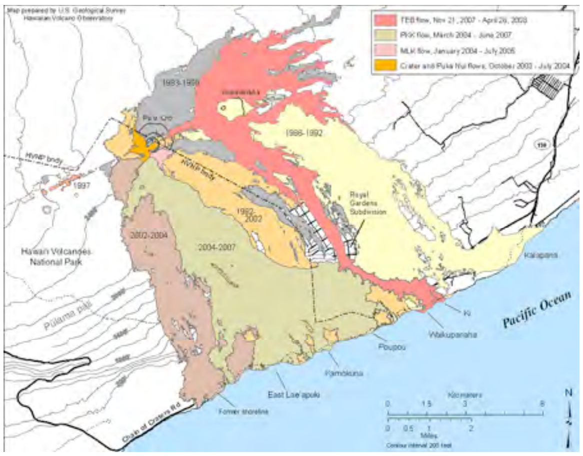

Fig. 2. USGS map of the Pu'u O'o eruption of Kilauea Volcano, Hawaii. The area covered by the eruption since 1983 is shown by the colored outlines.

Target Regions: Areas of major interest in this study include the large shield volcanoes Sif and Gula Montes, which will be well imaged at both opportunities (Fig. 3), the vast volcanic plains of Mylitta Fluctus in the southern hemisphere and Neago Fluctus in the north, Hathor and Innini Montes [1], and the western flanks of Beta Regio. The latter region is part of the Beta-Atla-Themis region, which appears to be younger than other parts of the surface based on the crater population. Our image base includes the large volcano Theia Mons, which has a "collar" of highly reflective material above ~6053 km planetary radius. Any recent flows in the summit area would likely not have equilibrated with the high-dielectric phase that forms at these altitudes, and thus should stand out very well.

References: [1] Smrekar, S.E., et al., Science, 30, 605-608, doi:10.1126/science.1186785, 2010.; [2] Campbell, D.B. et al. 1989. Science, 246, 373-377; [3] Campbell, B.A. and Campbell, D.B. 1992. JGR, 97, 16,293-16,314; [4] Carter, L.M., et al., *JGR*, 111, doi: 10.1029/2005JE002519, 2006; [5] Campbell, B.A., et al., *IEEE Trans. Geosci Rem Sensing,* 45(12),4032-4042, doi:10.1109/TGRS.2007.906582, 2007.

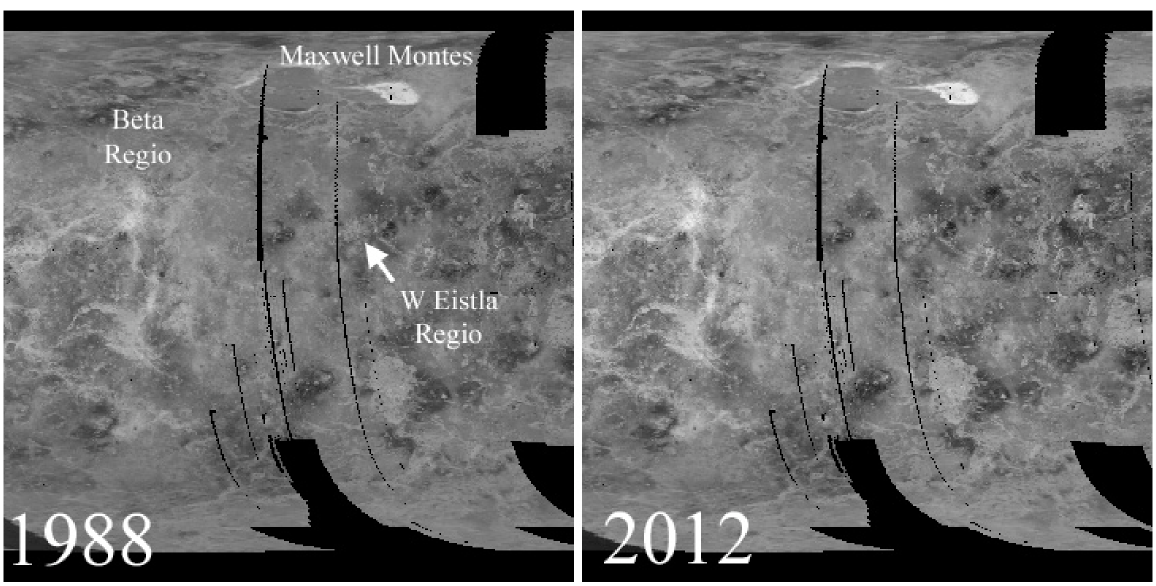

Fig. 3. Maps of Venus from Magellan data, showing the radar-illuminated regions during the 1988 and 2012 Arecibo observations. Simple cylindrical projection.