INNOVATIVE IMAGE ENHANCEMENT AND VISUALIZATION OF VENUS MAGELLAN MISSION DATA. L. Olson[1], R. E. Ernst[1,2], C. Samson[1], [1]Department of Earth Sciences, Carleton University, 1125 Colonel By Drive, Ottawa, ON, Canada K1S 5B6 (LauraDixon@cmail.carleton.ca), [2]Ernst Geosciences, 43 Margrave Avenue, Ottawa, ON, Canada K1T 3Y2.

Introduction: Narrow geological features, such as lineaments [1,2] (graben, fissures, fractures) and small circular to elliptical depressions[3] (pit crater chains), have been mapped from synthetic aperture radar (SAR) images obtained during the Magellan mission to Venus. One of the challenges of mapping with SAR images is identification of such subtle features. Enhancing image contrast and filtering out unwanted image elements to generate binary SAR images mitigates this issue. The altimetry based Magellan data-sets (topography and meter-scale slope data), combined with the enhanced binary SAR images, help with the visualization of geological features within the landscape, and to distinguish ridges from rifts and regions of high and low slope. Various approaches to data visualization have been previously discussed [e.g., 4-7]; here we offer some additional image processing ideas.

Methods: The starting point for the image processing and visualization were the left-look SAR images. These SAR images have a resolution of 1408 pixel/degree. All our image processing and visualization was done with ArcGIS 10. The geological features of interest typically have the highest intensity pixels. The first step was to perform an iso-cluster classification to isolate the high intensity pixels. This tool divides the image pixel into classes, on the basis of intensity - in this case three classes; high, medium and low intensity. The second step was to discard the medium and low intensity classes, leaving only high intensity pixels (displayed in white on a black background).

Once the binary SAR images were created, topography and slope map layers were added. The topography and slope images have a resolution of 22.75 pixel/degree. To create these map layers, an iso-cluster classification was run – this time with six classes. The iso-cluster images were then converted to polygon feature classes. The advantage of a polygon feature class is that many more geoprocessing tools are available for this file type than for raster images. For example, spatial statistic tools can be applied for mapping clusters and outliers. Several display options exist, including selecting only the high (or low) slope or topography polygons; displaying polygons as a semi-transparent layer over the binary SAR image.

Example: Shown in Figures 1 and 2 is a zone (200-210°E, 0-10°N) within the larger Ulfrun Regio area of Venus [2]. This zone was selected because there is a combination of circular and linear geological features – some clustered, others dispersed. In addition, there are areas of high and low topography.

Shown in Figure 1 is a comparison between the raw SAR image (top) and the binary SAR image (bottom). From a quick glance at Figure 1 (bottom), it is clear that the two predominant image elements are a circular feature in the southwest corner, and a cluster of linear features, which span the center of the image to the northeast corner.

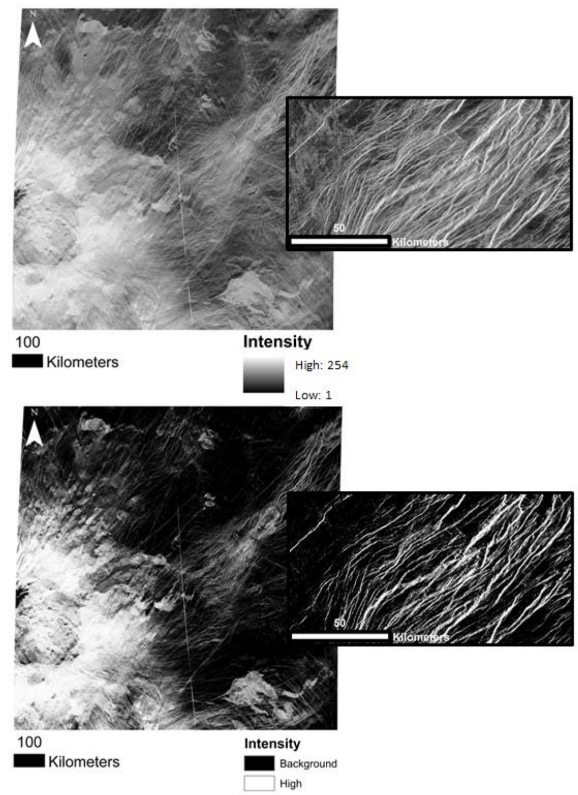

Figure 1: A comparison between the raw SAR image (top) and the enhanced binary SAR image (bottom). Unwanted features are attenuated and contrast is higher which makes it easier to indentify and map geological features of interest. As shown in the insets, a high level of detail is retained in the processed image.

Illustrated in Figures 2 (top) and 3 (top) are the topography and slope polygon maps, respectively. These polygon maps are displayed as a semi-transparent layer (50% transparent) over the binary SAR image, as shown in Figures 2 (bottom) and 3 (bottom). Illustrated in Figure 2 (bottom), the circular feature in the southwest corner of the image is confined to the higher topography, and is a dome-like structure, rather than a depression; from Figure 3 (bottom) it is clear that the circular feature is in a high slope region. Also shown in Figure 3 (bottom) are a cluster of linear features, which span the center of the image to the northeast corner, associated with high slope. The association with high slope indicates a ridge or a trough. As illustrated in Figure 2 (bottom), near the center of the image, these features are associated with moderate topography, flanked by lower topography; and low topography, bordered by the lowest topography toward the northeast corner. The linear features appear to be a ridge near the centre of the image, and change to a trough toward the northeast.

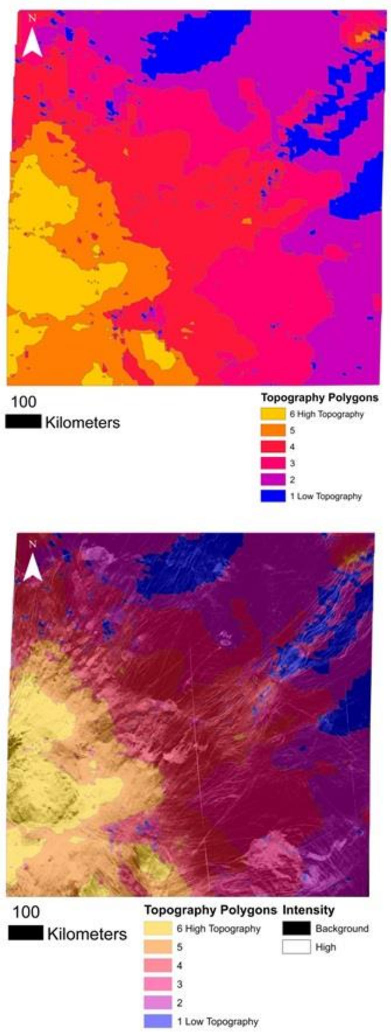

Figure 2: Topography (top) polygon map and semi-transparent topography polygon map layer over binary SAR image (bottom).

Discussion: For the enhanced binary SAR image, shown in Figure 1 (bottom), the contrast is dramatically increased, and unwanted features are minimized – making the geological features easier to see, and in turn, to map. As illustrated in Figures 2 (bottom) and 3 (bottom), by combining the binary SAR images with the semi-transparent topography and slope map layers, the relationship between geology and landscape is illuminated; determining whether a geological feature is a dome or depression, ridge or tough becomes fast, simple, and unequivocal.

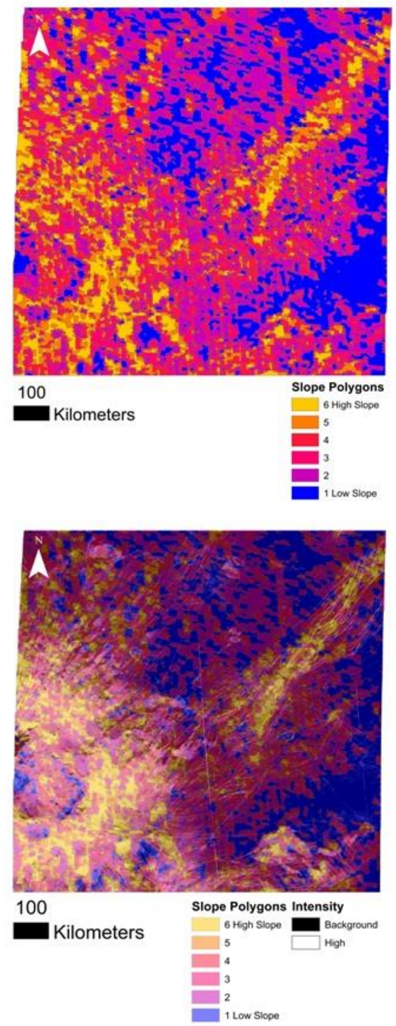

Figure 3: Slope polygon map (top) and semi-transparent slope polygon map layer over the binary SAR image (bottom).

References: [1] Ernst et al. (2003) *Icarus, 164: 282-*316. [2] Studd et al. (2011) *Icarus, 215: 279-291*. [3] Davey et al. (2013) *Can. J. Earth Sci., 50: 109-126*. [4] Kirk et al. (1992) *JGR Planets, 97 (E10): 16371–16380.* [5] Hansen (2000) *EPSL, 176: 527-542*. [6] Bannister & Hansen (2010) *USGS Sci. invest. Map 3099*. [7] Herrick et al. (2010) *LPSC Abstr. 1622*.