NOAH: A PROGRAM TO VISUALIZE LAVA FLOODING OF THE VENUS CRUST;
James W. Head and Paul Haggerty, Department of Geological Sciences, Brown Univ., Providence RI 02912 USA.

Volcanism is a fundamental contributor to the formation and evolution of the crust of Venus (1). Although it is known that over 80% of the Venus surface consists of volcanic plains, the mode of emplacement and history of these vast plains units is as yet not understood. The issue of the mode of emplacement of the Venus plains is crucial in addressing some of the most critical questions in the understanding of Venus. For example, the present distribution of impact craters on Venus (2,3) permits several alternate scenarios for the style of volcanic resurfacing. Discussions are underway in the literature addressing these issues (1-3), and testable hypotheses have been proposed, but a clear consensus has not yet emerged. Several lines of evidence have led to the hypothesis that Venus was catastrophically volcanically resurfaced on the order of 500 million years ago and that volcanism has been local and of minimal volumetric importance since that time (2). This scenario predicts that the earliest deposits should be extremely voluminous and widespread and that later deposits should be of lower volume and localized. Perspectives on the formation of secondary planetary crusts (derived from partial melting of the mantle) show that Venus is an important part of the picture (4). Lunar maria represent initial stages of secondary crust development (5), while the Earth's oceanic crust represents a young and highly laterally mobile secondary crust with a thin and constantly recycled depleted mantle layer. Venus appears to represent a vertically accreting crust with a potentially significant underlying accumulation of depleted mantle. The evolution of the depleted mantle layer may ultimately result in instabilities and the periodic and catastrophic overturning of the layer leading to several predicted styles of large-scale volcanic resurfacing (6). At the present time, there is insufficient understanding of the nature of the plains to test these and other hypotheses.

In order to understand further the formation and evolution of the plains and to test these hypotheses, we seek to use altimetric data to perform several flooding experiments on existing topography in order to assess the patterns of emplacement and their volume and pattern implications. The strategy of the experiment follows approaches that we have developed for the Moon (7) in which we utilize a preexisting topographic datum and successively flood several typical regions (cratered terrain, basin interiors, etc.) tracking areal extent and accumulated volume. Additional products of this approach are isopach maps which illustrate the areal distribution of thicknesses and are useful in geophysical analyses of loading and flexure, as well as in the understanding of the emplacement of plains.

Here we describe the initial development and testing of the program in which the user defines an area of interest and tracks flow emplacement through a series of thickness and volume steps. The program continues tracking the flooding until all preexisting topography has been obscured. The distribution of map patterns (i.e., kipukas or regions of embayed but unflooded topography) at various stages in these examples provides an important frame of reference for the examination and mapping of plains units on Venus. The volume - thickness - area plots and the isopach maps from this analysis are then contributions to the understanding of plains unit emplacement, and in loading and flexure studies.

The NOAH terrain flooding program is designed to accept Magellan VICAR images (Fig. 1). The left window is used to display the SAR imagery and the underlying topography image, and shows the area chosen for flooding and the graphic results of the flooding operations. The Message Window maintains a constant report of the lat/lon and elevation of the point under the cursor tip. The Plots Window displays topography and image histograms of selected areas. If the user places the cursor on the histogram, the program responds by printing the DN or topo level and the number of points at that level. Also given are the min, max, mean, and standard deviation of the values, and for topography, the range. This window also displays in the plots mode the area/depth and volume/depth graphs (Fig. 2). Each time the user performs a flooding operation, the depth, area flooded, and volume flooded are stored and displayed (Fig. 2); by placing the cursor on any of the squares, the user obtains a readout of the depth and area/volume at that point.

The Flooding Information Window (Fig. 3) reports the current elevation at which flooding will be performed and the step value for changing the flood elevation. At the bottom of the window are three statistics calculated from the flooding operation. At the top the program displays the min/max values for the topography. The user can type in any elevation in the flood level box. By clicking on the flood button, the user initiates the flooding operation which will update the main window by blacking out any pixels that fall below the flood level, thus giving a visual display of the patterns of flooding on the surface of Venus. By pressing the step button, the current flood elevation is changed by the amount shown in the step box. The last three items in the window reflect the status of the current flooding operation (total area selected; total area flooded by the last operation; total volume flooded by the last operation).

The user moves the cursor into the main window and clicks the mouse button to outline the area of interest for analysis, which can be any shape; a final outline of the area will appear on the screen. The File menu has three functions: 1) Load Image. 2) Perform Auto Flood (user selects interval and min/max elevations and the flooding steps are done automatically). 3) Quit. The Views menu has three functions: 1) Show Image/Show Topo (switches

display between SAR image and topography. 2) Show Overlay/Hide Overlay. 3) Clear Flood Graphics (erases all flooding graphics within area of interest). The Graphs menu has seven functions: 1) Image Histogram. 2) Topography Histogram. 3) Thickness vs Area. 4) Thickness vs Volume. 5) Reset Graphs. 6) Save Graphs to Disk. 7) Save Histograms to Disk. The Options Menu has four functions: 1) Choose Contour Style/Choose Flood Style. 2) Specify Contour Width. 3) Set Image Histogram Limits. 4) Set Topo Histogram Limits.

Shown in Fig. 4 is an example from an intermediate step in a flooding program for Lavinia Planitia. An outgrowth of this analysis will be the determination of the typical size of topographically closed basins on Venus. The statistics of basin size and geometry will be one way of determining the potential for regional plains development from individual sources. One of the products of this will be a set of templates which represent sequential flooding of real Venus topography and the associated volume, thickness and areal coverage data. These templates will then be compared to several areas of Venus plains to estimate their stage of burial and evolution. Following the completion of initial testing the program will be released to users for Venus and other planetary applications. For information on how to obtain a final copy contact head@pggipl.geo.brown.edu.

REFERENCES: 1) J. Head *et al.* (1992) *JGR, 97*, 13,153; 2) G. Schaber *et al.* (1992) *JGR, 97*, 13,257; 3) R. Phillips *et al.* (1992) *JGR, 97*, 15923; 4) J. Head (1990) *Earth, Moon Planets, 50/51*, 25; 5) J. Head and L. Wilson (1992) *G&C A, 56*, 2155; 6) Parmentier and Hess (1992) *GRL, 19*, 2015; 7) J. Head (1982) *Moon and Planets, 26*, 61.

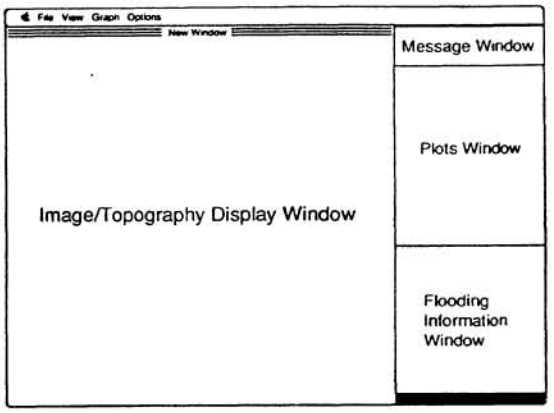

Fig. 1. Layout of Terrain Flooding Windows

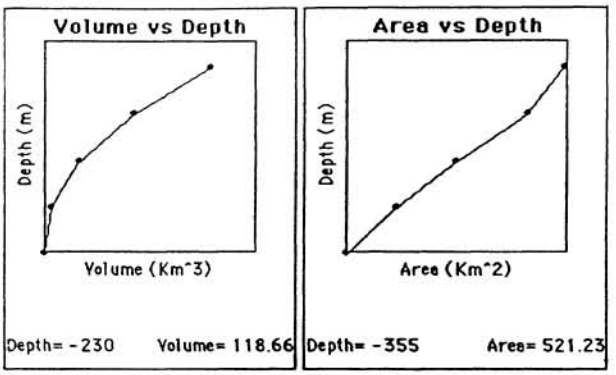

Fig. 2. The Plotting Window in Plots Mode

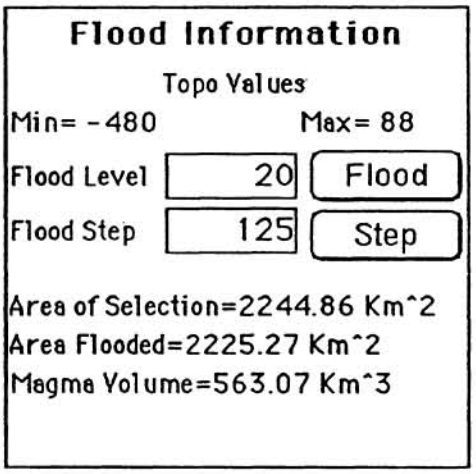

Fig. 3. The Flood Information Window

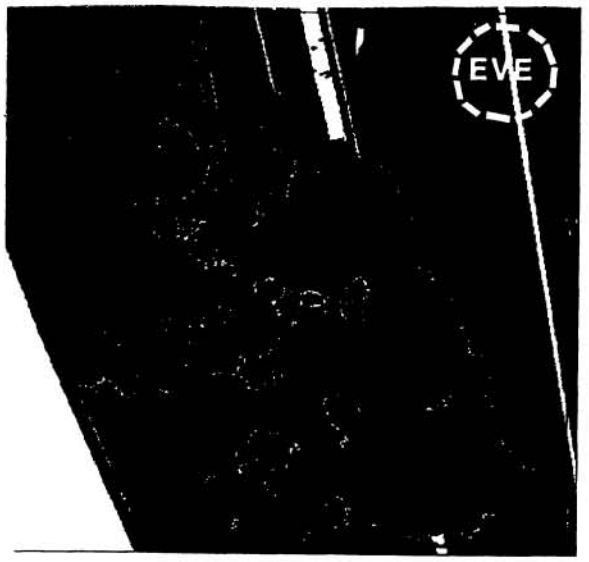

Fig. 4. Display of partial flooding of Lavinia Planitia. Black area represents region flooded from present topography up to a depth of -900 m below MPR. Outlined in the upper right corner is the 330 km diameter Eve corona.