EXPERIMENTAL INVESTIGATION INTO THE RADAR ANOMALIES ON THE SURFACE OF VENUS.

E. Kohler[1], P. Gavin[1], V. Chevrier[1], N. Johnson[2]. [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR, 72701; [2]National Aeronautics and Space Administration (NASA) Goddard Space Flight Center, Greenbelt, MD, 20771. enkohler@uark.edu

Introduction: Radar mapping of the surface of Venus shows areas of high reflectivity (low emissivity) in the Venusian highlands at altitudes between 2.5-4.75 kilometers [1-5]. The origin of the radar anomalies found in the Venusian highlands remains unclear. Most explanations of the potential causes for these radar anomalies come from theoretical work [1, 7, 9, 10]. Previous studies suggest increased surface roughness or materials with higher dielectric constants as well as surface-atmospheric interactions [1, 7]. Several possible candidates of high-dielectric materials are tellurium, ferroelectric materials, and lead or bismuth sulfides. While previous studies have been influential in determining possible sources for the Venus anomalies, only a very few hypotheses have been verified via experimentation.

This work intends to experimentally constrain the source of the radar anomalies on Venus. This study proposes to investigate four possible materials that could potentially cause the high reflectivities on the surface of Venus and tests their behavior under simulated Venusian conditions.

Methods: Four volatile compounds potentially present on Venus were chosen for this experiment. One gram of each Tellurium (Te), Bismuth sulfide (Bi_2S_3), Mercury sulfide (HgS) and Lead sulfide (PbS) were heated to the average surface temperature (~460°C) and average surface pressure (~90 bars) in a Venus Simulation Chamber (Fig. 1) [13]. We used the Venus simulation chamber at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center. The chamber has dimensions of slightly less than five inches in diameter and twelve inches deep and is constructed of stainless steel. It can maintain temperatures of 467°C and pressures of 95.6 bars for around 48 hours under a carbon dioxide atmosphere [13]. The temperature data from the 460°C run is shown in Figure 2 and shows that the conditions were maintained for 19 hours. The top line is the associated temperature for the samples at the bottom of the chamber.

Figure 1: The Venus simulation chamber at NASA Goddard.

The samples were then immediately weighted after cooling to determine if they condensed on and/or reacted. Another run was conducted at the average temperature (~380°C) and pressure of the Venusian highlands. In addition to the four samples, one gram of basalt, as an analog of the Venusian surface, was placed in the chamber to test potential reactions of the vaporized samples with the basalt. Once the samples were cooled, these too were weighed to determine condensation and/or reactions.

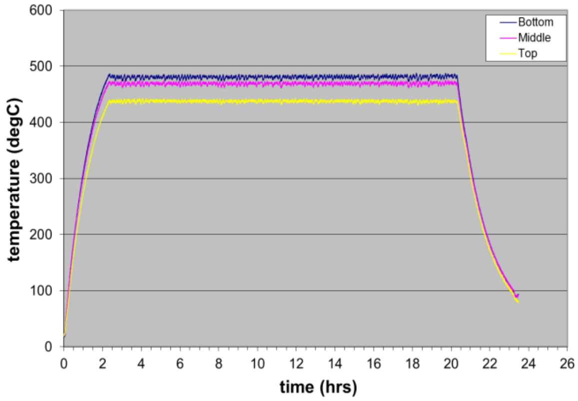

Figure 2: Temperature plot at 460°C in the Venus simulation chamber

Each compound was also individually tested in an oven at the University of Arkansas in order to further isolate possible candidates. The samples were placed in a Lindberg tube oven and heated to 460°C while under a steady CO_2 flow at ambient pressure. A sample of basalt, as a proxy for the Venusian surface, was placed at a spot in the oven at a temperature of ~380°C. Twenty-four hours later the basalt was collected in order to determine if volatilization / condensation had taken place. This experiment isolated effects of temperature without pressure being a factor. The heated samples were then analyzed using X-Ray Diffraction (XRD).

Results & Discussion: In both of the simulation chamber runs, the mercury sulfide almost vaporized completely (Table 1) indicating that it would be unstable at Venusian conditions. The tellurium, bismuth sulfide and lead sulfide all showed a color change after the experimental runs which could imply a phase change at Venusian temperatures and pressures. Figure 3 shows that the preliminary XRD data for bismuth sulfide. This indicates a complex structure and that no major phase change occurred in the chamber but several peaks still need to be resolved and compared to the database. Detailed analysis still needs to be done.

Table 1: Sample mass difference after the simulation experiment at 460°C and 380°C.

Sample (with sample holder)	Mass Change at 460°C (mg)	Mass Change at 380°C (mg)
Tellurium	+ 164.64	+ 498.28
Mercury Sulfide	- 1006.867	- 870.821
Bismuth Sulfide	+ 1.892	+ 23.198
Lead Sulfide	+ 11.977	+ 8.068
Sample Holder	+ 1.242	-----------
Basalt	------------	- 13.399

The fact that mercury sulfide was more stable at lower temperatures is very important for this study and will be investigated further as well at determining if a phase change occurred in the bismuth sulfide, tellurium and lead sulfide.

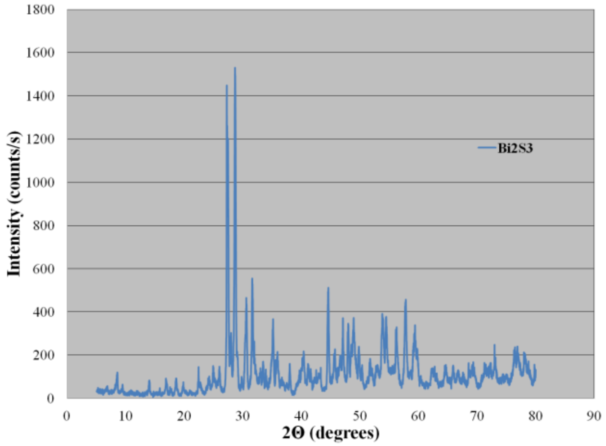

Figure 3: Preliminary XRD results for bismuth sulfide

Future Work: The four compounds tested in the Venus simulation chamber will be further analyzed with XRD, as well as with an environmental scanning electron microscope (ESEM) to determine compositional changes. More experiments will be conducted in the ovens at the University of Arkansas by testing the stability of each compound individually in order to isolate the effects of temperature. The oven experiment will be run under a steady CO_2 flow, but a mixture of CO_2 and SO_2 will also be utilized in order to better simulate the atmosphere of Venus. Finally, the dielectric constant of each sample used and each resulting product from the experiments will be measured/calculated and compared to the values required for the observed anomalies in the Venusian highlands.

Acknowledgements: This study was supported by the Arkansas Space Grant Consortium grant number UAF2140 YR 21.

References: [1]Rogers, A. and Ingalls, R., (1970) *Radio Science, 5,* 425-433. [2]Pettengill, G.H., et al., (1982) *Science, 217*, 640-642. [3]Pettengill, G.H., et al., (1988) *J. Geophys .Res., 93*, 14,881-14,892. [4]Ford, P.G., and Pettengill, G.H., (1983) *Science*, *220*, 1379-1381. [5]Garvin, J.B., et al., (1985) *J. Geophys. Res., 90*, 6859-6871. [6]Pettengill, G.H., et al., (1992), *J. Geophys. Res., 97*, 13,091-13,102. [7]Tryka, K.A. and Muhleman, D.O., (1992), *J. Geophys. Res., 97,* 13,379-13, 394. [8]Pettengill, G.H., et al., (1996), *Science, 272*, 1628–1631. [9]Shepard, M.K., et al., (1994), *Geophys. Res. Lett., 21,* 469-472. [10]Brackett, R.A., et al., (1995), *J. Geophys. Res., 100,* 1553-1563. [11]Schaefer, L. and Fegley, B., Jr. (2004), *Icarus*, 168, 215-219[12]Kitts, K., and Lodders, K. (1998), *Meteorit. Planet.Sci. 33*, A197–A213. [13] Johnson, N.M. and Wegel, D.C. (2011), *LPSC XLII*, abs. #1434