STABILITY OF MINERALS UNDER VENUSIAN TEMPERATURES: INVESTIGATING THE POTENTIAL SOURCE FOR RADAR ANOMALIES ON VENUS. J. Guandique[1,2], E. Kohler[2], V. Chevrier[2]. [1]Fort Valley State University, Fort Valley, Georgia, 31030; [2]University of Arkansas, Fayetteville, AR, 72701. jonathanguandique@yahoo.com

Introduction: The surface of Venus consists of different rocks and minerals that have yet to be identified. Radar is used to map out the surface since rovers cannot withstand Venusian conditions [1]. When radar scans are analyzed, there are areas on Venus that are identified with a higher reflectivity compared to the surrounding areas [1,2]. These areas of higher reflectance are termed radar anomalies as their source has yet to be established [3]. Because of the temperature of Venus, as well as its immense pressure, rovers that land on Venus do not last very long and cannot return with samples from Venus. Therefore, it is impossible to determine the source of the anomalies. The purpose of these experiments are to test the stability and reactivity of different minerals under Venusian temperatures and atmosphere.

Tellurium (Te), Pyrite (FeS_2), Bismuth Telluride (Bi_2Te_3), and Lead Sulfide (PbS) were chosen by their predicted stability based on thermodynamic modeling, or high reflectivity. Tellurium would have the desired conductivity value, even in small amounts [4]. Tellurobismuthite has a metallic luster and is a likely mineral formed on Venus. Thermodynamic modeling of Venera 13, Venera 14, and Vega 2 data show that iron is one of the major elements present at levels of few mass percent, thus giving pyrite candidancy [5]. Lead sulfide is believed to condense in the Venusian highlands and would also have the required conductivity value [3].

Methods: The experiment procedure used is similar to that shown in Kohler et al., (2012,2013) [6,7]. To conduct these experiments, a Lindberg tube oven is used. The oven is capable of reaching temperatures up to 1000°C (1832°F). It is approximately 24 inches wide and 12 inches tall. A 36 inch ceramic tube runs through the machine, allowing samples to be placed inside the oven. Samples are placed in a small, ceramic sample holder, then placed into the oven. Experiments are conducted at either 460°C or 380°C, simulating Venusian temperature at either the suface or Maxwell Montes respectively. This provides the temperature range of the altitudes at which anomalies reside. Continuous carbon dioxide flow is used to simulate Venusian atmospheric conditions.

For each experiment, one gram of each sample was individually placed into the sample holder. The sample was then placed into the oven at the respective temperature for a period of roughly 16-18 hours. The sample was weighed to determine stability and physical changes were noted. Each sample was analyzed using X-Ray Diffraction (XRD).

Results: The tellurium experiments at both 380°C and 460°C show a slight change in color. At 380°C, tellurium increased .02g in mass. XRD analysis for tellurium shows that at both temperatures, it oxidizes to form paratellurite (tellurium oxide, TeO_2).

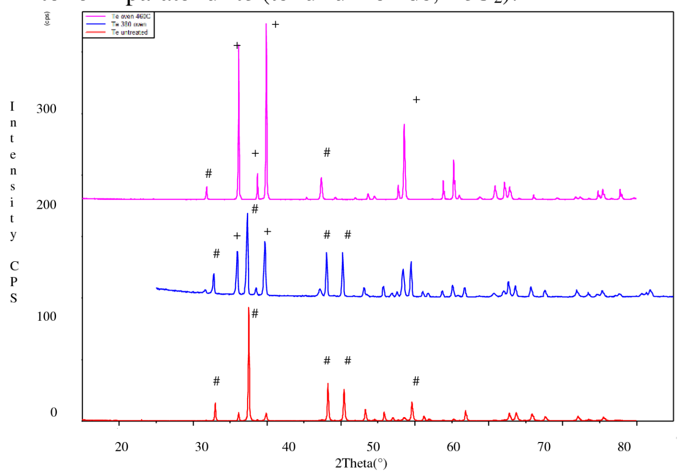

Figure 1: XRD results of tellurium at untreated (bottom), 380°C (middle), and 460°C (top). The (#) sign is untreated tellurium and the (+) sign is paratellurite (TeO_2)

The experiments constructed on tellurobismuthite show an increase in mass of .06 grams at 380°C and .1 grams at 460°C. At 380°C, bismuth telluride is noticeably fainter, while at 460°C, it changes from gray to white. XRD analysis of bismuth telluride shows it oxidizes to form chekhovichite ($Bi_2Te_4O_{11}$) at both temperatures (Fig. 2).

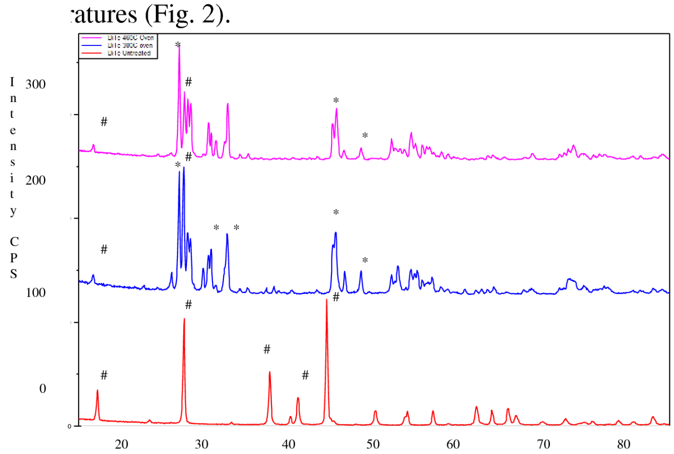

Figure 2: XRD results of bismuth telluride at untreated (bottom), 380°C (middle), and 460°C (top). The (#) sign is untreated lead sulfide and the (=) is anglesite ($PbSO_4$)

The experiments on lead sulfide showed no apparent change in color or texture in either experiment, however, lead sulfide acquires a mass of .03 grams in both experiments. Under XRD analysis, lead sulfide slightly oxidizes to form anglesite ($PbSO_4$) at both temperatures (Fig. 3).

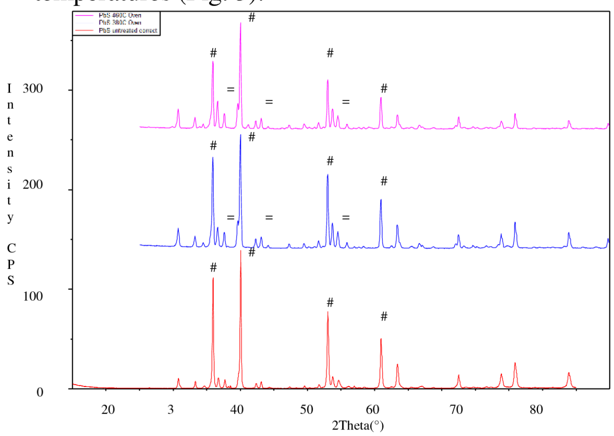

Figure 3: XRD results of lead sulfide at untreated (bottom), 380°C (middle), and 460°C (top) The (@) sign is cerium uranium oxide. The (^) sign is iron (III) oxide.

The experiments on pyrite showed changes in color between pyrite at untreated and 380°C and at 460°C. Under XRD analysis, pyrite oxidizes at 380°C to form cerium uranium oxide and at 460°C to form iron (III) oxide. Pyrite lost a mass of .05 grams at 380°C and .39 grams at 460°C.

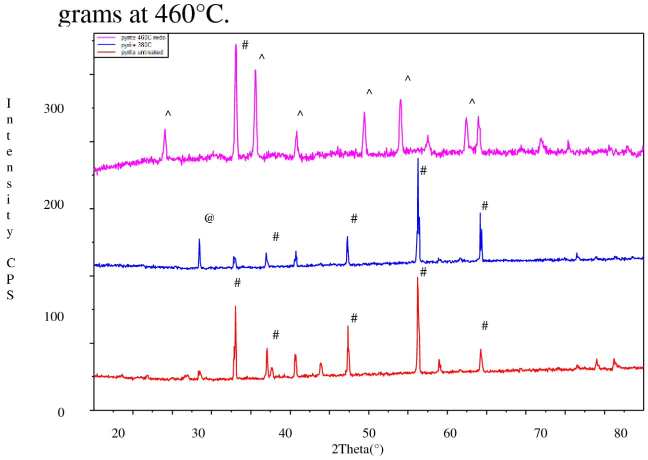

Figure 4: XRD results of lead sulfide at untreated (bottom), 380°C (middle), and 460°C (top). The (#) sign is untreated bismuth telluride. The (*) sign is chekhovichite ($Bi_2Te_4O_{11}$)

Discussion: The experiments show that tellurium, bismuth telluride, lead sulfide, and pyrite are all unstable under Venusian conditions. Although some are not as prone to change as others, all minerals had some form of reaction with the simulated temperatures and atmosphere of Venus.

Tellurium tends to partially react with oxygen at 380°C while still retaining some of its original properties and oxidize fully at 460°C to form paratellurite. At 380°C, 46% of the sample oxidized into parattellurite while 54% of the sample remained as tellurium. Tellurobismuthite oxidizes readily at both temperatures and forms chekhovichite. They show complete oxidation at both temperatures, with none of the bismuth telluride remaining. Lead sulfide combines with oxygen to form anglesite at both temperatures. At 380°C, 50% of the sample formed anglesite, while the remaining 50% remained lead sulfide. At 460°C, 54% of the sample oxidized to anglesite, while the remaining 46% stayed unreacted. The pyrite samples oxidized at 380°C and at 460°C. At 380°C, 78% of the sample oxidized into cerium uranium oxide, while only 22% remained as pyrite. At 460°C, the sample of pyrite completely oxidized to form iron (III) oxide. Oxygen contamination may have affected some of the minerals during the experiment.

Conclusion: The minerals tested proved to all be unstable under Venusian temperatures. Tellurium, bismuth telluride, lead sulfide, and pyrite all react with oxygen to form another, oxidized compound. The oxidations imply that these minerals would not be able to sustain their natural state under Venusian conditions, thus deterring them from possible candidancy for the radar anamolies found on Venus. However, it must be noted that the experiments could have been suspect to oxygen contamination. This may be linked to some of the more exaggerated effects to oxygen, such as those found with bismuth telluride. Lead sulfide, is more stable than the other minerals and is less likely to react with oxygen under Venusian temperatures. However, it would need to be tested under Venusian pressures as well before it can be considered a candidate.

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References: [1] Ford, P., G., and Pettenhill, G., H., (1983) Science, 220, 1379-1381. [2] Garvin, B., J., et al. (1985) JGR, 90, 6859-6871. [3] Fegley, B., Jr., (1997) Icarus, 128, 474-479. [4] Kerr R., A., (1996) Science, 271, 28. [5] Fegley B., Jr., et al. (1992) PLPS, 22, 3-19. [6] Kohler, et al., (2012), LPSC XLIII, abs. #2749. [7] Kohler, et al., (2013), LPSC XLIV, abs. #2951