STABILITY OF METALLIC MINERALS UNDER VENUSIAN SURFACE TEMPERATURES: INVESTIGATING THE POTENTIAL SOURCE OF RADAR ANOMALIES. J. Guandique[1,2], E. Kohler[1], V. Chevrier[1]. [1]Arkansas Center for Space and Planetary Sciences, University of Arkansas, Fayetteville, AR, 72701; [2]Fort Valley State University, Fort Valley, Georgia, 31030. 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]. Radar analysis identified high reflectivity anomalies at high altitudes, compared to the surrounding areas [1,2], suggesting the possible condensation of a semi-metallic compound [REF]. However, the nature of the material responsible for these high reflectivity has yet to be established [3]. Because of the high pressure and temperature of Venus' surface, situ analyses of the surface have remained extremely limited. Therefore, it is impossible to directly determine the source of the anomalies. The purpose of these experiments are to test the stability and reactivity of different potential mineral candidates under Venusian temperatures and atmosphere.

Tellurium (Te), Pyrite (FeS_2), Tellurobismuthite (Bi_2Te_3), and Galena (PbS) were chosen by their predicted stability based on thermodynamic modeling, or high reflectivity [4-7]. Tellurium has the desired conductivity value, even in small amounts [8]. Tellurobismuthite has semi-metallic characteristics and is a likely mineral present on Venus [9]. Analysis of Venera 13, Venera 14, and Vega 2 data showed that iron is one of the major elements present at levels of few mass percent, thus suggesting pyrite as a possible candidate [10], although thermodynamic models suggests it might be unstable under Venus' surface conditions [11]. Lead sulfide is believed to condense in the Venusian highlands and would also have the required conductivity value [3].

Methods: The experimental procedure used is similar to that shown in Kohler et al., (2012, 2013) [12, 13]. A Lindberg tube oven is used to reach temperatures up to 1000°C (1832°F). 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 typical highlands such as Maxwell Montes, respectively. This provides the temperature range of the altitudes at which anomalies reside. Continuous carbon dioxide is flowed to simulate Venusian atmospheric composition.

For each experiment, one gram of each mineral was 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 then weighted and physical changes were noted. Each sample was analyzed using X-Ray Diffraction (XRD) to determine mineralogical alterations.

Results: The tellurium experiments at both 380°C and 460°C show a slight change in color from a dark gray to a lighter gray. At 380°C, tellurium increased .02g in mass. At 460°C, tellurium increased .02g in mass as well. XRD analysis shows that at both temperatures, tellurium oxidizes to form paratellurite (TeO_2 Fig. 1).

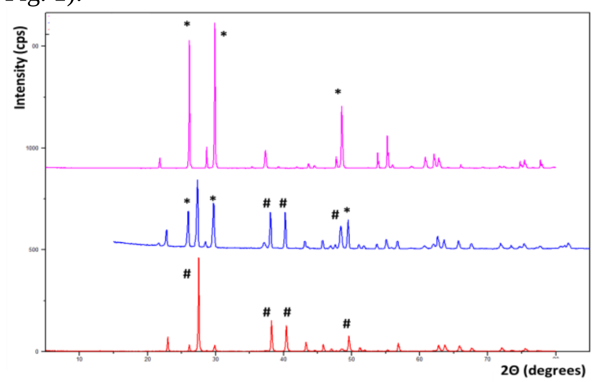

Figure 1. XRD results of tellurium at untreated (bottom, red), 380°C (middle, blue), and 460°C (top, pink) indicates major peaks of untreated tellurium and paratellurite (TeO_2).

The experiments on tellurobismuthite show an increase in mass of .06 grams at 380°C and .1 grams at 460°C. At 380°C, tellurobismuthite appears noticeably fainter, while at 460°C, it changes from gray to white. XRD analysis show oxidation into chekhovichite ($Bi_2Te^{4+}{}_4O_{11}$) and smirnite ($Bi_2Te^{4+}O_5$) at both temperatures (Fig. 2).

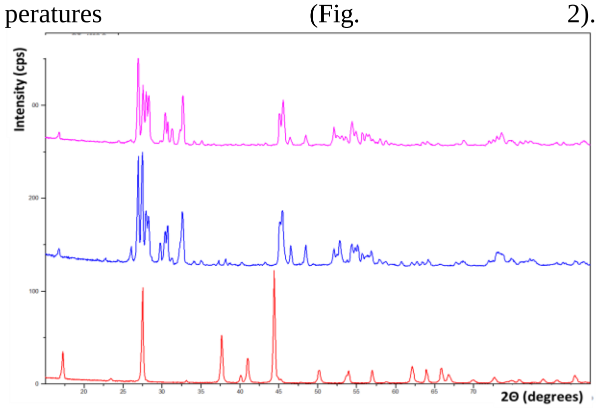

Figure 2. XRD results of tellurobismuthite at untreated (bottom, red), 380°C (middle, blue), and 460°C (top, pink).

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

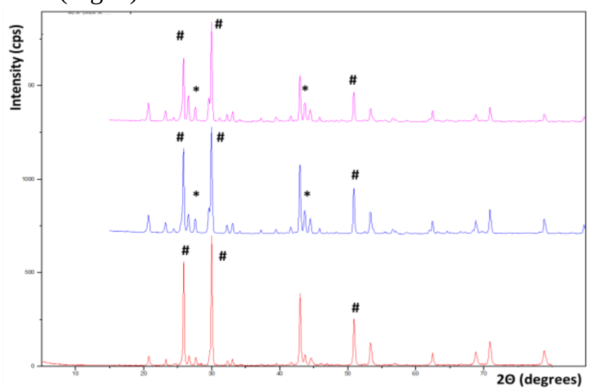

Figure 3. XRD results of galena at untreated (bottom), 380°C (middle), and 460°C (top). # indicates untreated galena and * anglesite ($PbSO_4$).

The experiments on pyrite showed changes in color between untreated pyrite, pyrite heated at 380°C and 460°C. XRD analysis show that pyrite oxidizes to form iron (III) oxide (hematite Fe_2O_3) at both high and low temperatures (Fig. 4). Pyrite lost a mass of .05 grams at 380°C and .39 grams at 460°C.

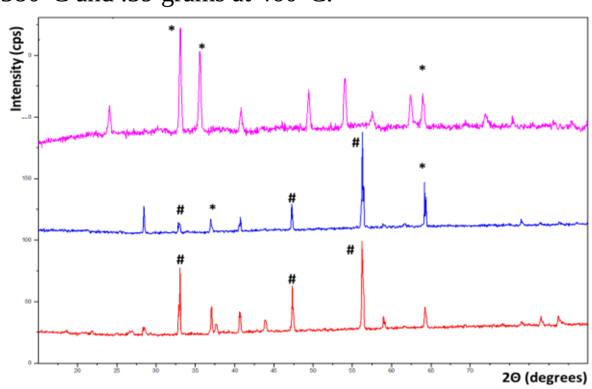

Figure 4. XRD results of pyrite at untreated (bottom, red), 380°C (middle, blue), and 460°C (top, pink).). untreated pyrite and * iron (III) oxide (hematite).

Discussion: The experiments show that tellurium, tellurobismuthite, galena, and pyrite are all unstable under Venusian surface conditions. Although some are not as prone to transformations as others, all minerals had some form of reaction under 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 completely transforms at both temperatures into Te, Bi oxides chekhovichite and smirnite. Galena oxidizes into anglesite at both temperatures. At 380°C, 50% of the sample transformed into anglesite, while 54% of the sample oxidized at 460°C. Finally, the pyrite samples oxidized into hematite at both temperatures, with complete transformation at 460°C, compared to 22% at 380°C. We suppose that the source of oxygen is probably CO_2, although some oxygen contamination may have affected some of the minerals during the experiments. Nevertheless, previous tests in a Venus simulation chamber at high pressure and temperature suggests that CO_2 is able to oxidize samples [12-13].

Conclusion: The minerals tested proved to all be unstable under Venusian temperatures. Tellurium, tellurobismuthite, galena, and pyrite all react with oxygen to form oxidized compound. The oxidations imply that these minerals would not be stable under Venusian surface conditions, thus preventing them from being responsible for the radar anamolies observed on Venus. However, it must be noted that the experiments could have undergone some oxygen contamination. This may be linked to some of the more exaggerated effects to oxygen, such as those found with tellurobismuthite. Galena, is more stable than the other minerals and is less likely to oxidize under Venusian temperatures. However, it would need to be tested under Venusian pressures as well before it can be considered a candidate. Moreover, other phases (bismuthinite Bi_2S_3, coloradoite HgTe, and other Pb,Bi sulfosalts) could also be responsible for the radar anomalies and will be tested in the future.

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