EXPERIMENTAL STABILITY OF TELLURIUM AND ITS IMPLICATIONS FOR THE VENUSIAN RADAR ANOMALIES. E. Kohler[1], V. Chevrier[1], P. Gavin[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@email.uark.edu

Introduction: Evidence of radar anomalies on Venus has sparked debate about potential atmospheric interactions with the surface. These high reflectivity (low emissivity) anomalies have been found on the Venusian surface between altitudes of 2.5-4.75km using radar mapping [1-5]. There have been several theoretical studies on the source of these anomalies including increased surface roughness, materials with higher dielectric constants or surface-atmospheric interactions [1, 6]. Additionally, the literature suggests several possibilities of metal compound frosts or low lying clouds/fog. Evidence from Venera 13 and 14 indicates a low layer cloud deck at an altitude of 1-2km that could consist of tellurium, bismuth, or lead compounds [9,14].

Tellurium (Te), with a melting point temperature of 450°C, would be a solid above the critical altitude of 2.5km where the radar anomalies reside. A continuous cold-trap deposition of tellurium, degassed by volcanism could be possible if the tellurium abundance is appreciable above this altitude [10]. Using Earth as a proxy, tellurium could be outgassed from Venusian volcanoes, similar in abundance to Earth. This abundance makes its condensation as possible at an elevation of 46.6km, meaning that a low altitude tellurium cloud layer could be possible [9,11,14]. If this cloud layer exists, then tellurium compound condensates could precipitate onto the surface.

While theoretical studies have been beneficial towards determining the source of these anomalies, few experimental investigations have been done to validate the theories[1,6-8]. This abstract seeks to discuss the stability of tellurium under Venusian conditions with its implications as a possible source of the radar anomalies via experimental applications.

Methods: Stability experiments were conducted in the Venus simulation chamber at the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center. This chamber is approximately twelve inches deep, about five inches in diameter and is constructed of stainless steel. It can maintain temperatures of 467°C and pressures of 95.6 bar for roughly 48 hours under a CO_2 atmosphere [13].

In addition to tellurium, which is present on Venus, mercury sulfide (HgS) was tested as well. Mercury is known to exist on Venus, and is volatile under Venusian conditions likely reacting with either sulfur or tellurium. Additionally, some phases of cinnabar (specifically metacinnabar) are semiconducting, an important aspect of determining the source, thus, it was chosen for this experiment. One gram of each were heated to average Venusian surface conditions, and then to highland conditions (460°C and 90 bar, 380°C and 55 bar respectively). The latter conditions are the anticipated temperature and pressure at the anomalies altitude. After each run, the samples were weighed to determine stability and/or reactivity. Each compound was also tested in a Lindberg tube oven at the University of Arkansas and heated to both 460°C and 380°C at ambient pressure. The oven experiment isolated the effects of temperature. The samples were then analyzed using X-Ray Diffraction (XRD) and Scanning Electron Microscope (SEM).

Results: The oven experiment for tellurium showed an addition of mass while the mercury sulfide vaporized at both temperatures. XRD analysis showed that the sample oxidized forming paratellurite (tellurium oxide, TeO_2). XRD results are found in Fig. 1. The tellurium sample at higher temperature (460°C, 90bar) increased in mass by 165mg and the mercury sulfide volatilized. XRD results at higher temperatures showed the formation of paratellurite and coloradoite (mercury telluride, HgTe). SEM verified the existence of both, Fig. 2A shows a paratellurite crystal from this experiment.

The mercury sulfide sample in the 380°C chamber completely volatilized while the mass of the tellurium sample increased by 498mg. XRD results at lower temperature (380°C, 55bar) showed both paratellurite and coloradoite with a larger amount of coloradoite. SEM confirmed the existence of coloradoite Fig. 2B.

Discussion: The experiments have shown that tellurium is unstable under all Venusian conditions, but that in the presence of volatilized mercury, they will react to form coloradoite. Tellurium has a propensity to combine with oxygen by reacting with the atmospheric CO_2 at temperatures and pressures synonymous with both surface and highland conditions. Pressure was not a factor in this reaction as paratellurite was formed in the oven experiments as well. CO is the likely product of this reaction as there was no evidence of elemental carbon.

Mercury sulfide vaporizes under all Venusian conditions which allows for it to then react with tellurium to form coloradoite. The chamber experiments show that while mercury will be in a vaporous state at all conditions, the Venusian highland temperatures and pressures (380°C, 55bar) make more favorable condi-

tions for the formation of coloradoite. XRD results showed that at high temperature (460°C) approximately 3% of the tellurium sample was coloradoite while at lower temperature (380°C) 30% was coloradoite. Mercury has been found on Venus, and with its volatility, will more likely reside in the atmosphere at high altitudes. Atmospheric tellurium has a inclination to react with oxygen, but with a sufficient mercury abundance, it will form coloradoite.

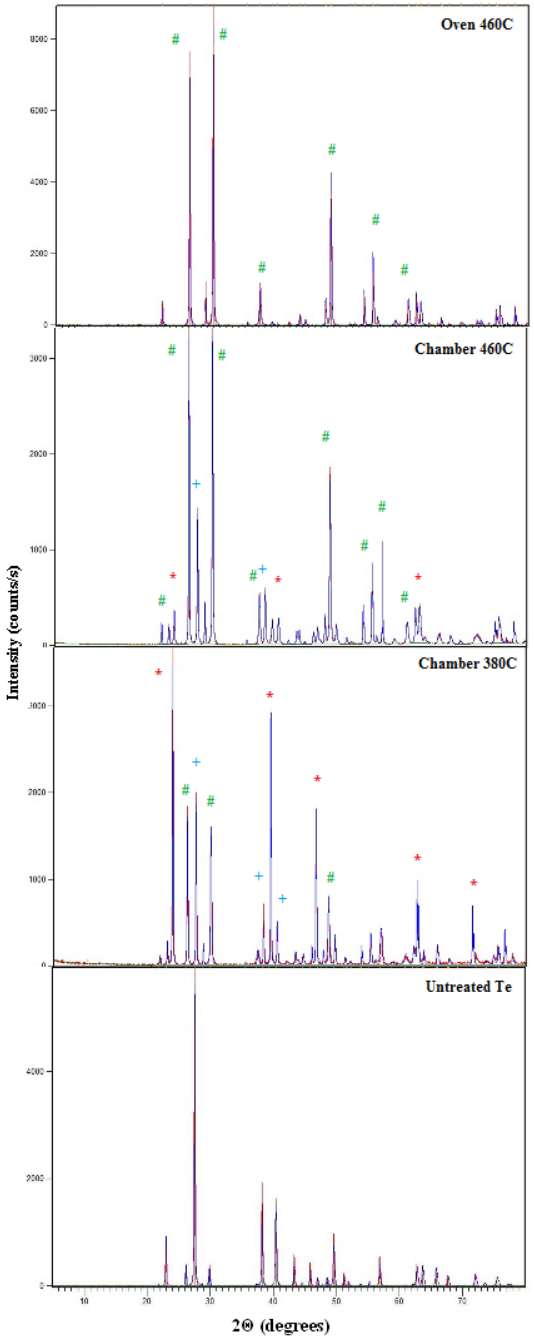

Figure 1: XRD results of tellurium for three situations. The + sign indicated elemental tellurium, # is paratellurite and * is mercury telluride.

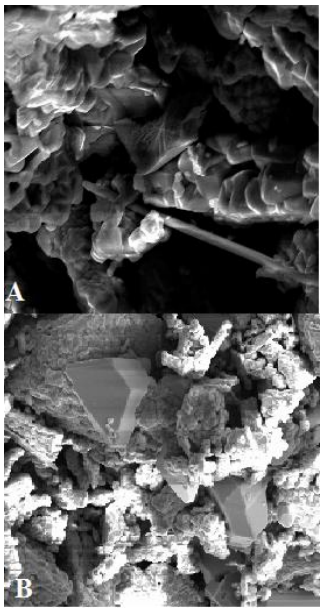

Figure 2: SEM images of tellurium samples. A is at 380C in the chamber. It shows evidence of mercury telluride crystals against a background of tellurium. B is from 460C in the chamber. At bottom right is a paratellurite crystal.

Conclusion: The formation of HgTe, from mercury and tellurium, both unstable under all Venusian environments, is significant to this investigation because this compound forms at conditions that correlate to radar anomaly altitudes. While theoretical work has not mentioned the possibility of coloradoite, with the correct abundance, it could form as a condensate in the Venusian highlands. This compound would then have a higher dielectric value than the surrounding and low-lying basalt, creating a different radar signature. With coloradoite's high stability and formation aptitude, as well as its semiconductor status means it should be a candidate for the radar anomalies on Venus [10, 14].

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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] Tryka, K.A. and Muhleman, D.O., (1992), *J. Geophys. Res., 97*, 13,379-13,394. [7] Shepard, M.K., et al., (1994), *Geophys. Res. Lett., 21*, 469-472. [8] Brackett, R.A., et al., (1995), *J. Geophys. Res., 100*, 1553-1563. [9] Grieger, B., et al.,(2003),: *BAAS, 35*,1487. [10] Pettengill, G.H., et al., (1996), *Science, 272*, 1628–1631. [11] Schaefer, L. and Fegley, B., Jr. (2004), *Icarus*, 168, 215-219. [12] Pettengill, G.H., et al., (1992), *J. Geophys. Res., 97*, 13,091-13,102. [13] Johnson, N.M. and Wegel, D.C. (2011), *LPSC XLII*, abs. #1434. [14] Kerr, R.A., (1996), *Science, 271*, 28-29. [15] Kohler, et al., (2012), LPSC XLIII., abs. #2749.