CARBON MONOXIDE-NITROGEN ICE MIXTURE MEASUREMENTS IN SIMULATED PLUTO CONDITIONS. C. J. Ahrens[1], M. Souza[2], Z. M. McMahon[1], V. F. Chevrier[1]. [1]Arkansas Center for Space and Planetary Science, University of Arkansas, Fayetteville, AR 72701, [2]Universidade Federal Da Bahia, Salvador, Brazil. (ca006@email.uark.edu).

Introduction: Ice behaves differently depending on the compositions and conditions and therefore plays many roles in the development of mineralogical structure, geological and climatological processes on various planetary surfaces. Pluto in particular has complex global and localized icy processes, as evidenced by the New Horizons' images and gas concentrations [1]. In particular, carbon monoxide and nitrogen play major constituents to the gas concentrations on Pluto [2]. In going further with this study, there is a lack of literature on the phase diagram involved with these two main gases at low temperatures and pressures.

Surface compositions of small outer Solar System bodies are determined mainly through spectroscopic means in the visible and near-infrared (NIR) with visual confirmation [3]. Additional information into surface compositions comes from laboratory simulations to validate theoretical models or to extend the limits of certain known phase diagrams.

In understanding the behavior and structure of these nitrogen and carbon monoxide mixtures, we can then hypothesize the geologic processes of the ice formations and stability thereof. We present the objectives, experimental approach, and preliminary findings.

Experimental Approach: Pluto's surface temperatures range from 33 K – 55 K with a surface pressure of roughly 10 microbar [4-6]. Laboratory simulations under these conditions would be ideal to compare with the New Horizons Linear Etalon Imaging Spectral Array (LEISA) data and for extending theoretical modeling of seasonal effects with ices and gases. The New Horizons LEISA data consists of the observational wavelength range 1.25 um – 2.5 um (Figure 1).

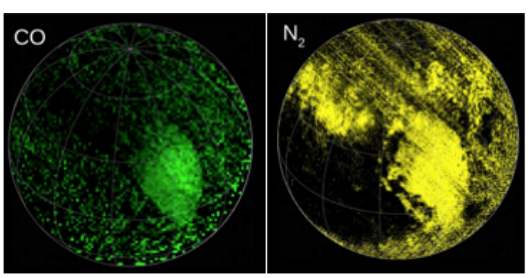

Figure 1: Carbon monoxide (left) and nitrogen (right) components mapped on Pluto as detected from the New Horizons LEISA instrument [7].

The Pluto simulation chamber at the W.M. Keck Laboratory for Space Simulations at the University of Arkansas is approximately 0.45 m. in diameter and 0.56 m. in depth (Figure 2) [8]. This stainless steel vacuum chamber includes FTIR capabilities and a camera system for visual confirmation of the ice production and behavior. Measurements are made by bringing the pressure down to the needed 10-microbar through stages and cooling to the desired temperature of 44 K ± 10 K [9]. We specifically monitor the ice structure from 10K to 60K, for the purpose of a seasonal range and noting phase changes during fracturing or melting processes. The addition of a gas-mixing chamber has been included to control percentages of nitrogen and carbon monoxide before injection into the cryo-chamber for spectral analysis.

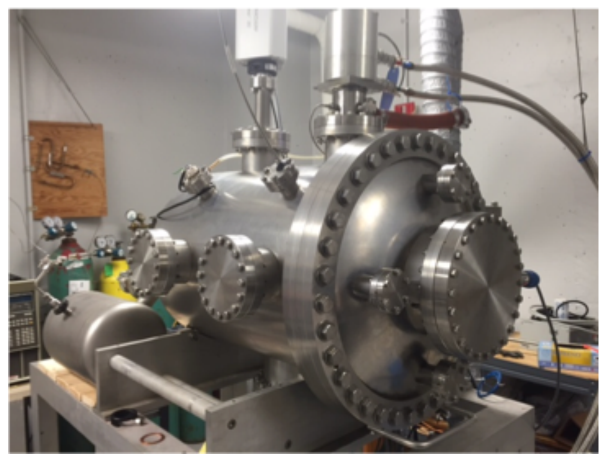

Figure 2: Pluto simulation chamber at the University of Arkansas. The cold-head is placed at the top-front of the chamber and the camera system in the back.

The objective of this experimental data will bring more observations for geophysical modeling, mechanisms of ice mixtures, and constrain seasonal ice processes on Pluto. We use combinations of previous phase diagrams and ice-behavior theories to relate our primary objectives to study the geomorphological processes on Pluto's surface. Nitrogen has a lower melting point (63.15K) than carbon monoxide (68.13K), which we think may be one cause of certain phase behaviors as the combined freezing points influence the constraints of phase changes [10].

Preliminary Results: Preliminary experiments with mixing different percentages of nitrogen and carbon monoxide under Pluto conditions were recorded with the FTIR and visual confirmations, each at different temperatures from the range 10K to 60K. We then plotted our results and compared to previous carbon-monoxide/nitrogen phase diagram data. Our finds were relatively similar to those done previously within the range of 30-80 K.

A study by Angwin and Wasserman [10] showed percentage concentrations of carbon monoxide in nitrogen and labeled areas of phase changes in the ice lattice between 35K to 60K range from 0% to 100% carbon monoxide. However, lower percentages done by this study were deemed theoretical due to experimentation limitations. Our instrumentation has provided additional information at these other ratio percentages for Pluto geology.

However, lower concentrations of carbon monoxide in nitrogen were found to have an unknown phase behavior below 30K, resulting in further exploration. The ice behavior at low concentrations below 30% carbon monoxide in nitrogen at below 35K have shown a starting phase of amorphous-like structures (Figure 3), then re-freezing to an ice when only slightly heated. This preliminary phase was then verified with the FTIR to show strong signals of carbon monoxide with more scattering effects. As the temperature rises, the re-frozen ice then shows less scattering effects. As the temperature rises more to 50K-60K, the first signs of melting are recorded (Figure 4). These melting recordings match with the previous work completed by Angwin and Wasserman [10].

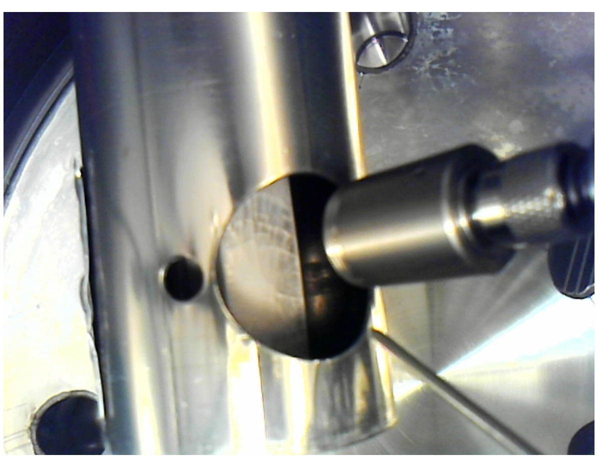

Figure 3: Visual example inside the Pluto simulation chamber of 5% carbon monoxide, 95% nitrogen at 10K and 14 microbar pressure. FTIR probe on right.

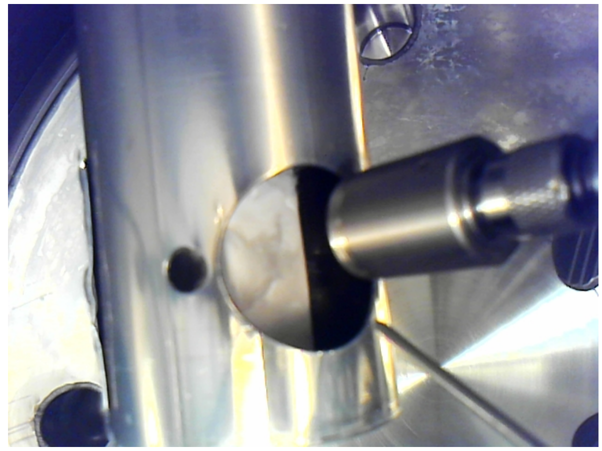

Figure 4: Visual example inside the simulation chamber of the first signs of the ice-mixture melting and peeling off the cold head at around 60K. FTIR probe on right.

Future Work: Our preliminary studies will continue to enhance the constraints of the amorphous-phase and ice-phases for a better understanding of temperature-pressure limitations. These findings will then be cross-checked with geological features observed on Pluto. Our results can also be used to study the behavior of ice on other icy bodies with varying temperatures and pressures than Pluto. Further results will use the Raman spectrometer to observe the amorphous-phase and components thereof.

References:

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