AN ENVIRONMENT CHAMBER FOR MEASUREMENT OF THE SPECTRAL PROPERTIES ADSORBED METHANE. C. Ferrari-Wong[1], C. H Honniball[2], P. G. Lucey[1] [1]Hawaii Institute of Geophysics and Planetology, University of Hawai`i at Mānoa, Honolulu, HI (cfw@hawaii.edu), [2]NASA Goddard Space Flight Center, Greenbelt, MD.

Introduction: Indigenous lunar methane was reported in Apollo 11 and 12 lunar fines [1], the lunar exosphere as measured by the Apollo 17 Lunar Atmosphere Composition Experiment [2], and the NMS on LADEE[3]. [1] and [2] hypothesized that methane originates from solar wind carbon impacting the surface where some will combine with solar wind hydrogen to create methane. [3] showed that there is sufficient carbon in the solar wind to account for all the methane detected in the exosphere, though meteorites also contribute some carbon. The methane diffuses out of the soil and resides in the exosphere for a short time (mean residence time 1.05 days) before being lost via photodissociation [3] or cold trapped on cold shadowed surfaces.

LADEE detected exospheric methane from a nearly equatorial orbit [3]. Methane adsorbs onto the lunar surface during nighttime and desorbs soon after the sun rises resulting in a bulge in exospheric methane abundance around 07:00 lunar local time [3]. Though methane has been detected in abundances of ~400 mol/cm^3 no work has been done to understand the spectral behavior of methane adsorbed on the surface of the Moon. At these latitudes around 07:00 the surface temperatures average 250 K. At latitudes above 70˚, many surfaces will be near or below 250 K and or in shadow and [2] hypothesized that methane could concentrate at the polar regions owing to the lower temperatures. While the abundance of methane that absorbs onto the surface in a single night is small, the permanently shadowed regions, including microcold traps, will experience a constant supply of methane that will remain on the surface for long periods, and regolith overturn will constantly present fresh material to this methane influx potentially enabling a large volume of regolith to be methane enriched. The delivery of methane to the lunar poles and the photodissociation lifetime of methane in the exosphere is similar to that of water [3,5,6]. Similarly, the loss of methane can be estimated from the ice mass loss from [7]. Using this similarity and estimates of water influx and loss rates adjusted for methane, the PSR methane influx is ~50 times more than the estimated loss rate. Methane should therefore be in net adsorption accumulation in PSRs and will cease accumulating when the surface area of the soil is saturated. If the PSR surface is saturated with a monolayer of methane (the surface area of lunar regolith is ~1 m^2/g [8] owing to the extremely long exposure time and constant agitation of the surface at small scales, as much as 200 ppm methane [9] may be present in the optical surface (and deeper).

In addition to methane being adsorbed onto the surface of grains and readily exchangeable with the exosphere; it could be incorporated into impact glass which constitutes 30% of mature lunar soil and unable to vary. Liu et al 2012 [10] detected absorption bands due to an organic in agglutinate glass (Fig. 1), and while they attributed this to contamination, they did not rule out the possibility that the glass may contain indigenous organic material.

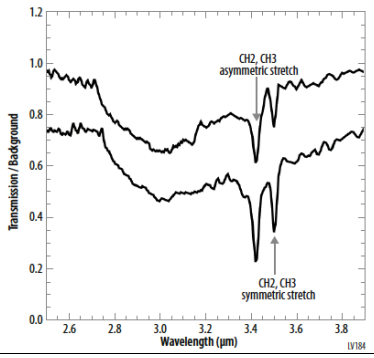

Figure 1. Organic bands in lunar agglutinate glass (Liu et al. 2012)

Both VIPER and Lunar Trailblazer will carry spectrometers to the Moon that may be able to detect adsorbed methane in the polar regions. However, there are no measurements of the spectral properties of methane adsorbed to a silicate substrate. To support VIPER and Trailblazer observations we are completing an environment chamber designed to measure absorption near 3.4 microns due to adsorbed methane.

Methane Chamber: A small infrared detector liquid nitrogen dewar was repurposed for this use (Fig. 2). We equipped the chamber with a pair of windows for IR illumination and measurement with a phase angle of 90 degrees. A copper cold finger supports a small sample cup for cooling to LN_2 temperatures. Because particulate samples are highly insulating, the optical surface will come into radiative equilibrium with the warm chamber walls [8]. To reduce this effect, the sample is placed in a small windowed internal chamber with calcium fluoride windows [8]. The window will admit the IR illumination and allow viewing of the sample, but the bulk of thermal radiance is eliminated because the windows do not trans-

mit past 7 microns. A small amount of heating is expected from both the surroundings and the illuminator, but we will measure this using particulate olivine as a thermometer [8].

Figure 2. Methane adsorption chamber (windows are 1.5 inches in diameter for scale).

With the dewar cover removed, the sample is placed on the cold finger in its radiative control chamber and the dewar is evacuated. When at suitable pressure, the dewar is filled with liquid nitrogen and allowed to equilibrate. Once the system is in thermal equilibrium, we will introduce small titers of methane gas into the chamber through a small pipe that is directed at the sample surface. Data are collected with the vacuum pump engaged to remove methane gas that is not cold trapped.

The spectrometer used is a Designs and Prototypes Model 102 that collects data from 2-14 microns; the illuminator is a 50 watt bare filament with a parabolic reflector.

Samples to be used will be a variety of lunar and other simulants with a range of albedos that will affect the ability to detect the adsorbed methane.

We have modeled the strength of the expected methane band, and while weak, is within the capabilities of the spectrometer (Fig.3). Data collection will begin in early September 2022.

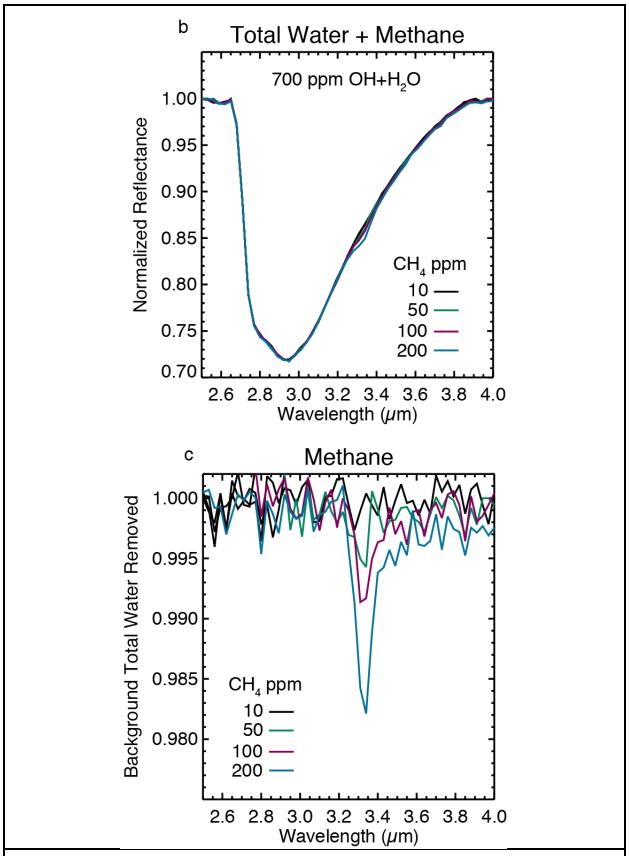

Figure 3. Model spectra of methane adsorbed on a hydroxyl-bearing substrate.

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