A NEW SPECTROSCOPIC FACILITY AT UMASS AMHERST M. Parente[1], A.M. Saranathan[1], D. Dyar[2], [1]Department of Electrical & Computer Engineering, University of Massachusetts, Amherst MA 01003 USA (mparente@ecs.umass.edu) and [2]Mount Holyoke College.

Introduction: Reflectance spectroscopy has been an invaluable tool to determine mineralogy on planetary surfaces. To fully leverage the information available by remote sensing researchers have often studied the effects of determinant factors such as grain size, illumination and acquisition geometry, temperature on the reflectance spectra of planetary analog samples, which are observed in the lab under controlled conditions. Since the effect of such factors is wavelength dependent (e.g. [1]) researchers have often explored the characteristics of reflectance spectra over several wavelength ranges, for example combined observations of spectra in the Visible and Near InfraRed (VNIR) and Mid InfraRed (MidIR) have been performed for the characterization of surface species on Mars (reference).

The spectral characterization of mineral species in different ranges generally requires accurate intercalibrated data from different instrument, often from different laboratories. Many variations and inconsistencies in the measurements exist. Reflectance geometries (biconical vs. bidirectional), instrument apertures, measurement conditions are highly variable, depending on facilities at the labs where spectra were acquired resulting in inconsistencies in the spectra when considered over a large range of wavelengths.

We have established a spectroscopy lab at the University of Massachusetts, Amherst to characterize the spectral and optical properties of minerals at different ranges using only one instrument and the same set up. Our instrument has the capability to acquire reflectance and transmittance measurements of samples in the visible, near-IR, mid-IR and far-IR from 25000 to 10 cm^{-1}, (0.4 to 1000 μm). The spectrometer operates under vacuum and can automatically set the illumination and observation angles. The spectrometer can perform both Biconical (or quasi-bidirectional) reflectance measurements at room temperature and under vacuum and transmission measurements at room temperature and under vacuum.

The Instrument Setup:

The backbone of the setup is a Bruker Vertex 80V FTIR spectrometer. The Vertex 80V can be operated under vacuum conditions which eliminates the effects of the atmosphere from the measured spectra. The complete setup is shown in Figure **??**. The Vertex 80 is equipped with VISNIR and MidIR light sources, with the liquid nitrogen cooled MCT detector ($12000 - 600$ cm^{-1} or $0.833 - 16.666$ μm) and the room temperature Silicon Diode, which covers a range between $25000 - 9000$ cm^{-1}, ($0.4 - 11.111$ μm). A CaF_2

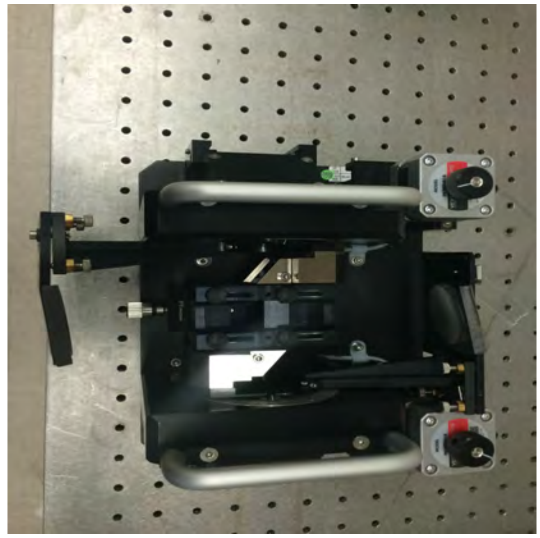

Figure 1: A513/QA reflectance accessory

beamsplitter is used for the visible and near infra-red measurements i.e. in the range $25000 - 9000$ cm^{-1} ($0.4 - 3$ μm) while a KBr beamsplitter is used for the MidIR wavelength ranges. The instrument capabilities are also extended to cover the Far Infrared (FIR) with an externally adapted Hg-arc FIR source, a Terahertz bolometric external detector and the possibility of 3 different ranges: 25 μm Mylar beamsplitter, with spectral range $120 - 20$ cm^{-1} ($83.333 - 500.000$ μm); 50 μm Mylar beamsplitter, with spectral range $60 - 10$ cm^{-1} ($166.666 - 1000.000$ μm) and a Multilayer beamsplitter, with spectral range $680 - 30$ cm^{-1},($14.705 - 333.333$ μm). The instrument also allows 12 different aperture settings to achieve better SNR. The standard spectral resolution is better than 0.2 cm^{-1}, with a resolving power greater than $300,000 : 1$ in the visible range. The instrument is equipped with an automatic beamsplitter exchange unit so that measurements in different ranges are possible without breaking vacuum.

In addition, the A513/QA reflectance accessory enables specular and diffuse reflectance measurements at different illumination geometries i.e. different incidence and emission angles. The reflectance accessory is equipped with motorized arms which allow the incidence and emission angles to be independently and continuously varied over a wide range i.e. between ($13^o - 83^o$). The A513/QA reflectance accessory is shown in Figure. (1).The accessory is placed in the sample FTIR compartment, which enables room temperature vacuum bidirectional reflectance measurements. The sample holder was modified to include a translation stage that allows the measurement of multiple samples

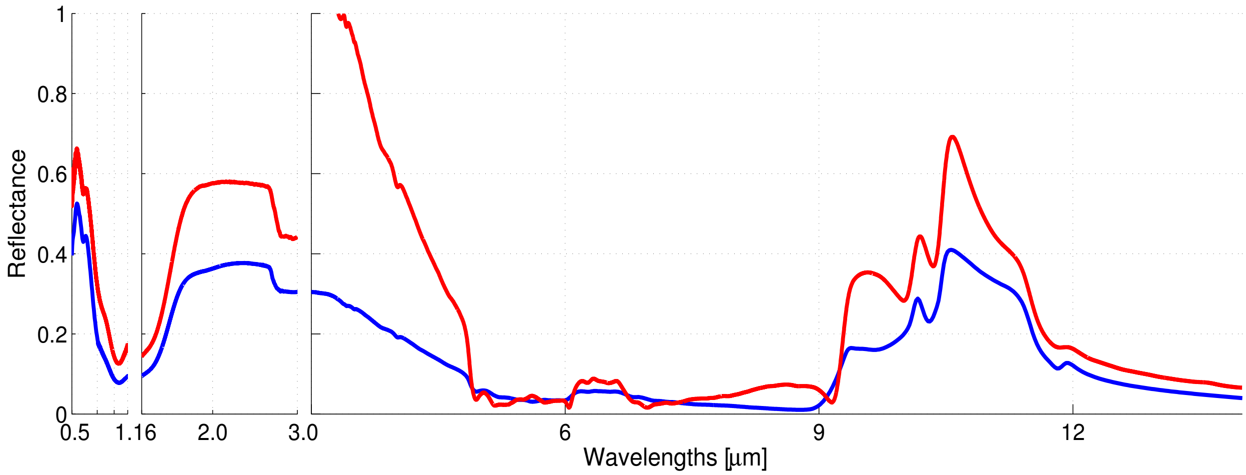

Figure 4: Comparison of spectra of San Carlos Olivine(300-500μm) incidence angle=15^o and emission angle=40^o with other Olivine sample measured at RELAB (250-500μm) incidence angle=30^o and emission angle=0^o

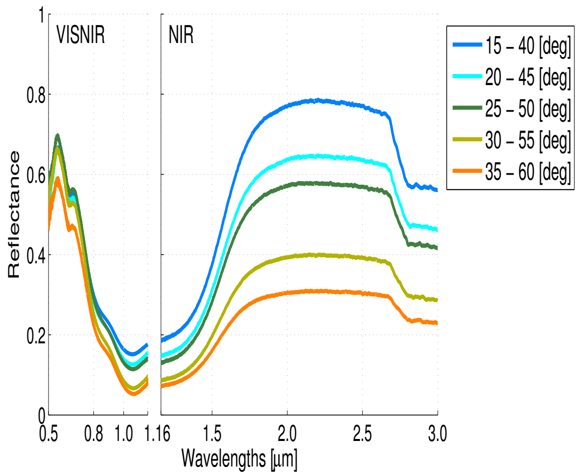

Figure 2: VNIR spectra for olivine (300-500μm) at different geometries

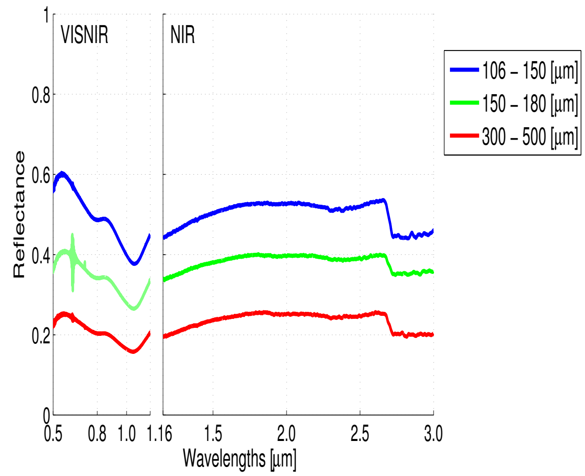

Figure 3: VISNIR spectra for diopside incidence angle=15^o and emission angle=40^o))

without opening the sample compartment and breaking vacuum.

Diffuse Reflectance Measurements for Olivine and Diopside: In order to showcase some of the capabilities of the set up we performed diffuse reflectance measurements on samples of San-Carlos Olivine and Diopside. The sample preparation is described in an accompanying abstract (reference). In the visible region Labsphere Spectralon was used as analogue of a Lambertian scatterer whereas in the NIR and MIR regions a Labsphere Infragold target was used.

Figure (2) shows the effect of change in incidence and emission angles on the spectrum of a single Olivine sample (grain size 300-500μm) showing an expected trend (e.g. [1]) while Figure (3 shows the effect of grain size variation on a a Diopside sample.

Finally, the spectrum for an Olivine sample (grain size 300-500μm, incidence angle=15^o and emission angle=40^o) is shown in Figure 4 (red) compared to a spectrum (blue) of a different sample of San Carlos Olivine from the RELAB database measured under similar (but not equal) conditions (grain size 250-500μm, incidence angle=0^o and emission angle=30^o).

Future Work: The immediate next step would be to find the optical constants for these endmembers by assuming that the grain sizes composition remains constant by using the technique described here [**?**]. Following we plan to use a non-linear least squares based solver and the measurements of the same sample at different angle to calculate both grain size distribution and the optical constants at the same time.

References: [1] B. Hapke (2012) *Theory of Reflectance and Emittance Spectroscopy* Cambridge University Press.