

**TIME-RESOLVED REMOTE RAMAN SPECTROSCOPY FOR VENUS EXPLORATION.** S. K. Sharma<sup>1</sup>, A. K. Misra<sup>1</sup>, T. E. Acosta-Maeda<sup>1</sup>, M. D. Dyer<sup>2</sup>, S. M. Clegg<sup>3</sup> and R. C. Wiens<sup>3</sup>, <sup>1</sup>Hawaii Institute of Geophysics & Planetology, University of Hawaii, 1680 East-West Rd. POST #602 Honolulu, HI-96822 ([sksharma@soest.hawaii.edu](mailto:sksharma@soest.hawaii.edu)), <sup>2</sup>Dept. of Astronomy, Mt. Holyoke College, South Hadley, MA 01075, <sup>3</sup>Los Alamos National Laboratory, P. O. Box 1663 MS J565, Los Alamos, NM 87545

**Introduction:** Time-resolved remote Raman spectroscopy has been selected as a part of the Supercam instrument for the Mars 2020 Rover Mission, and as a mineralogical analysis system for Venus' Surface and Atmosphere Geochemical Explorer (SAGE) Mission [1,2]. Raman spectroscopy has several distinct advantages over other spectroscopic techniques that have been used in the past missions, specifically including the capability for rapid mineralogical analysis at stand-off distances [3,4]. We describe a compact gatable planetary Raman spectrograph (PRS) developed at the University of Hawaii (UH), characterize Raman spectra of several minerals species suggested to be present on the Venus' surface, and show detection limits in mixtures with a basalt glass analog using a 532-nm laser excitation.

**Experimental Set-up:** Figure 1 shows a photograph of the planetary Raman spectrograph used with a 532-nm laser source. The remote system uses a compact Raman spectrograph with dimensions of 10 cm (length) × 8.2 cm (width) × 5.2 cm (high). The spectrograph was constructed using a custom volume holographic HoloPlex grating. It is equipped with a custom gatable thermo-electrically cooled mini-intensified charge coupled device (mini-ICCD) camera. Spectral coverage is from 90 to 4520  $\text{cm}^{-1}$  Stokes-Raman shifted from 532 nm laser excitation. With its 50  $\mu\text{m}$  slit, resolution of the spectrograph is  $\sim 15 \text{ cm}^{-1}$  (0.43 nm) in the 100-2400  $\text{cm}^{-1}$  and  $\sim 13 \text{ cm}^{-1}$  (0.37 nm) in 2400-4500  $\text{cm}^{-1}$  region.

**Samples:** We selected a set of minerals for use in creating fine-grained mechanical mixtures of varying amount of minerals and glasses likely to be present on the Venus surface [4]. Fine-grained mixtures of glass and various minerals were pressed to form 12.5 mm disks for Raman measurements. We have also measured Raman spectra of natural hydrous and anhydrous minerals inside a high-T-P Venus cell under supercritical  $\text{CO}_2$ , simulating Venus atmospheric conditions [3].

**Results:** Figure 2 shows the Raman spectra of mixtures of Venus relevant minerals in basaltic glass matrix. Sample #5 has 3 wt% each of quartz (Qtz), pyroxene (Pyx), plagioclase (Plg), olivine (Ol), and anhydrite (Anh), and 85 wt% glass. Sample #11 has 10 wt% of each of Pyx, Plg, Ol, Anh, and sample #13 has 10% each of Qz, Pyx, Plg, Ol, and Anh. Olivine and Anh produce strong Raman emission at 824 and 855  $\text{cm}^{-1}$ ,

and at 1018  $\text{cm}^{-1}$ , respectively, in sample #5 containing 3 wt% each of Ol and Anh. Raman fingerprints of Qtz at 462  $\text{cm}^{-1}$  and of Plg consisting of a doublet at 482 and 508  $\text{cm}^{-1}$  were also detected. Pyroxene fingerprints at 666 and 1013  $\text{cm}^{-1}$  were only detected in the glass containing 10 wt% of Pyx.

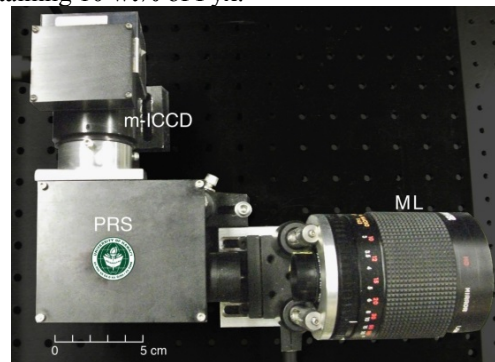


Fig. 1. UH Planetary Raman Spectrometer with custom mini-ICCD detector (m-ICCD) and 7.6-cm diameter mirror lens (ML).

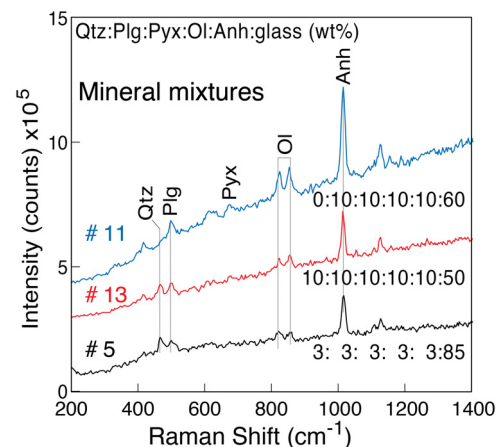


Fig. 2. Remote Raman spectra of minerals in basaltic glass matrices at 2 m distance (532 nm laser, 10 ns, 17 mJ/pulse, 15 Hz, integration time 30 s).

**Summary:** Raman data presented here show the ability of a gated standoff Raman system with pulsed laser excitation to detect low concentrations of mixed minerals, even in a strongly absorbing basalt glass matrix. A gated remote Raman system will be very useful for future Venus missions involving landers.

**References:** [1] Clegg, S. M. et al. (2014) *Appl. Spectrosc.* **68**, 925-936. [2] Wiens, R. W. (2014) *SCIX-2014*, abstract #472. [3] Sharma, S. K. et al. (2010) *Proc. Trans. Royal Soc. A* **368**, 3167-3191. [4] Sharma, S. K. et al. (2011) *LPSC*, **42**, abstract #1250.