

PLANETARY RAMAN SPECTROSCOPIC STUDY FOR UNDERSTANDING VENUS EVOLUTION HISTORY. Alian Wang, Dept. Earth and Planetary Sciences and McDonnell Center for Space Sciences, Washington University, St. Louis, MO, 63130 (alianw@levee.wustl.edu).

Introduction: Venus is an extremely interesting place to study the evolution history of a planet. It has a dense and highly corrosive atmosphere, which would react with the minerals at the surface of planet under very high temperature and high pressure conditions. S-cycling is the major and crucial process that needs to be well understood for the purpose of study the evolution history of Venus. Planetary Raman Spectroscopy is well suited for this task.

Planetary Raman Spectroscopy: By sending a condensed laser beam onto a target (gas, liquid, or solid) and by collecting the induced back-scattering Raman radiation, one can extract information on the chemical bonding in molecules, crystal structures, and chemical compositions. Planetary Raman spectroscopy is well suited for Venus exploration for the following reasons: (1) It is definitive; i.e., minerals are unambiguously identified through their fingerprint spectra. Raman peaks are sharp and non-overlapping; straightforward identification of phases in a mixture can be achieved from raw spectra. Spectral deconvolution in general is not required. (2) Analyses are rapid, requiring only a few seconds to half a minute to obtain a spectrum. (3) No sample positioning or sample preparation are required: original rough surfaces of rocks and soils give informative Raman spectra; the gaseous components in the atmosphere can be detected by sending the excitation laser beam through a short distance in the air (a few cm on Earth and even shorter distance on Venus). (4) Photons from excitation laser and Raman scatters can penetrate through optically transparent material (i.e. window) that would facilitate a variety of instrument deployments during a mission.

Investigation of S-cycle on Venus: S-bearing species, H₂S & SO₂ as gases, SO₃, (SO₄)²⁻, and (HSO₄)⁻ in aqueous solutions, S₈, Fe₂S, sulfides, and sulfates as minerals, are all very strong Raman scatters. Because the Raman cross sections of many gaseous species are known, the partial pressure of a gaseous S-species in a mixture (Venus atmosphere) can be calculated from the relative intensity of its characteristic Raman peak. The concentration of H₂SO₄ in a

water droplet (aerosol) can vary in a range, which will affect the types and the concentrations of various S-species dissolved in the water, such as SO₃, (HSO₄)⁻, (SO₄)²⁻, and H₂SO₄.nH₂O complexes. They all have distinct Raman peaks that would enable their direct identifications (Figure).

We have been conducting a systematic Raman (combined with XRD, mid-IR, and Vis-NIR) investigation [1, 2] on Mg-, Ca-, and Fe-sulfates (hydrous and anhydrous, crystalline and amorphous), to set constraints on the phase stability and phase transition pathway under variable environmental conditions, such as temperature, pressure, relative humidity, acidity, and oxygen fugacity. In addition, a Raman study on Fe-oxides, hydroxides, and sulfides was published [3]. These investigations have built a knowledge basis for developing an understanding about the surface-atmosphere interaction on Venus.

The applications of Planetary Raman Spectroscopy for igneous mineralogy and petrology on planetary bodies (Moon and Mars, as well as for Venus) are characterized by providing “definitive mineralogy,” that includes mineral identification, determination of key mineral chemical compositions, the relative proportions of different minerals in a rock or soil as well as textural relationships of mineral assemblages [4, 5, 6]. This type of investigation will shine light on the planet’s early igneous chemical differentiation, as well as the later stages of weathering caused by recent volcanic activities.

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