EXPERIMENTAL INVESTIGATION OF MINERAL REACTION RATES IN VENUS-RELEVANT GASES.

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Introduction: The weathering reactions of rocks and minerals on Venus have been predicted through thermodynamic modeling and experiments for decades, but in recent years, the style and rate of weathering reactions has gained new importance. With the advent of near 1 µm emissivity spectroscopy from orbit, weathering rates are critical to know in order to use this data to constrain ages of lava flows (e.g., [1-2]) and the mineralogical evidence of past environments that may be preserved into the present day due to slow reactions, despite mineral instability in modern atmospheric conditions (e.g., [3]). In order to address weathering rates of a variety of minerals, we established an experimental setup to include the temperature of the Venus surface (460 °C), as well as combinations of the most abundant gases of the atmosphere (CO_2, SO_2, N_2). This simplified set of conditions allow the investigation of the effect of specific variables in a way that complex experiments cannot address. The combination of both simplified and complex experiments is necessary to understand weathering reactions and rates on Venus. The functionality of our setup is demonstrated here by a preliminary experiment using calcite.

Methods: The calcite experiment was conducted in a Thermo Fisher Scientific Lindberg/Blue M Mini-Mite horizontal tube furnace at Wesleyan University. This experiment used a natural calcite chip and synthetic calcite powder, and was conducted at 1 atmosphere and 460 °C under a pre-mixed SO_2/N_2 gas (1800 ppm SO_2) provided by AirGas. The furnace is set up in a flow through configuration so that solid samples are exposed to a fixed gas composition. This experiment was run with a ¾" diameter alumina ceramic process tube, with the samples loaded into ceramic crucibles. These conditions were maintained for 17 days, at which point the furnace was turned off with gas flowing until the sample was cool enough to extract and be placed in a desiccator for storage. Both types of run product were carbon coated and examined using a Hitachi SU5000 Field Emission Gun Scanning Electron Microscope (SEM) equipped with an EDAX Octane Pro EDS detector located at Wesleyan University.

Results: Upon examination under the SEM, the chip and an aliquot of powder were both found to have reacted to produce secondary calcium sulfate (Fig. 1). This is the thermodynamically predicted reaction between SO_2-bearing gas and calcite at these temperatures (summarized in [4]), and is similar to the secondary minerals produced by calcite reaction in experiments run in the Glenn Extreme Environments Rig, which contains a full compliment of Venus gas species [5-6]. The chip surface formed a semi-continuous coating of secondary minerals, where the coverage density appears to be influenced by cracks and other surface heterogeneities. The surfaces of grains of powder formed a continuous coating of secondary minerals.

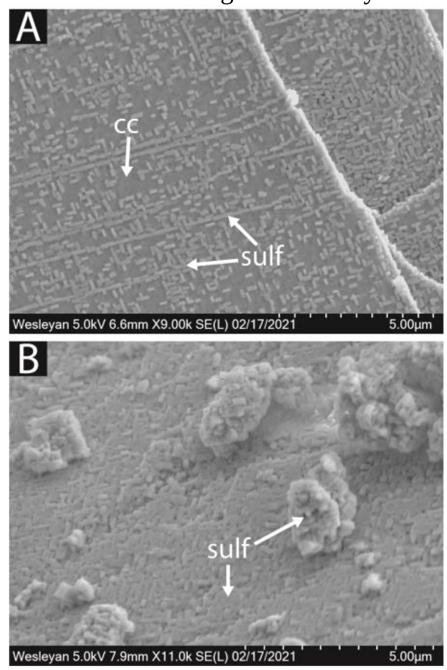

Figure 1: Secondary electron images of calcite chip surface (A) and powder grain surface (B) after 17 day experiment. cc-calcite, sulf-calcium sulfate.

Discussion: New fittings and procedures have been developed since this initial experiment to allow for multiple samples to be run simultaneously through the use of multiple smaller diameter quartz glass tubes and split gas flow. This setup also allows for flow rates through individual tubes to be monitored. Extraction procedures have also been developed to begin examining dehydration rates and breakdown rates of hydrous minerals. Work to continue developing experimental procedures and understand rates of specific mineral-gas reactions is ongoing.

References: [1] Smrekar S.E. et al. (2010) *Science*, 328: 5978, 605-608. [2] Filiberto J. et al. (2020) *Sci. Adv.*, 6: 1 eaax7445. [3] Johnson N.M. and Fegley, B. (2000) *Icarus*, 146: 1, 301-306. [4] Zolotov M.Y. (2018) *RIMG 84*, 351-392. [5] Radoman-Shaw B.G. (2019) Ph.D. dissertation, Case Western Reserve University. [6] Lopez X.R. (2021) *LPSC 52*, Abstract 1383.