EVIDENCE OF WATER RETENTION AND LOSS IN MG-SILICATE SMOKES

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Introduction: Water ice forms in the interstellar clouds along with preexisting silicate grains forming amorphous structures that sublimate and re-condense with temperature changes, developing the precursors to protoplanetary disks [1]. Throughout the formation process, planetesimals inside the snowline tend to outgas any H_2O that may have been trapped in the silicate grains. This leads to a depletion of H_2O in terrestrial planets.

However, the simplicity ends there because planets forming in regions where adsorbed H_2O has been lost, but absorbed water is still locked into the silicate grains, can still contain a significant amount of water. In fact, analysis of basaltic magma shows that H_2O content was at least 3 wt.% H_2O or higher [2]. Knowing the temperatures at which adsorbed, and absorbed, H_2O leaves silicate grains is crucial in understanding planetary formation, transfer of H_2O across the solar system, sequestration of gases, and habitability, amongst others. Laboratory experiments can better constrain the temperatures at which H_2O remains incorporated in planetary formation.

Methods: Amorphous Mg-silicate smokes, similarly synthesized in procedures by Nuth, et al. 2002 [3], was used for this study. These were chosen because the formation for the smokes are indicative of high-temperature processes in the circumstellar outflows. The amorphous Mg-silicate samples were powdered and placed in the sample holder of a AABSPEC #2000-A multimode system. The cell was pumped under vacuum to pressures of $9.3e^{-6}$ bar and initial spectral measurements were taken at 300 K. Subsequent measurements were taken in 50K increments up to 1000K. Each measurement consisted of 1000 scans with a resolution of 4 cm^{-1} to ensure high resolution data. **S**pectra was collected using a Mattson RS-10000 Fourier Transform InfraRed (FTIR) spectrometer operating in the near and mid-IR regimes (2µm – 17µm). The data for each sample was normalized and plotted to demonstrate the change in features with increasing temperature.

Results: The preliminary results of this investigation indicate that the solid state H_2O contained within the smokes is removed from the sample between 725 and 750K. Initial spectra of the Mg-silicate smoke sample before it was heated up clearly displayed the 3µm and 4.4µm water bands. The bands are broad and relatively smooth, indicating that they are solid-state absorption features. The characteristic 10µm silicate feature is also visible, although it is very weak compared to the intensity of the other bands. At 700K the spectra show the H_2O still in the solid-state at around 3µm and 4.4µm. In the 750K measurement, H_2O emission features replace the solid state features. Emission features that were present in the spectra taken at higher temperatures were diminished as the temperature increased, until they disappeared almost completely at 950K. After the sample was heated up to temperatures of 1000K and cooled back down to 300K, in 100K increments, the emission features returned, all while retaining the 10µm feature.

Post-ramp spectra of the silicate smoke was collected after it had been cooled down to 300K. The spectra shows the water bands in the same position, but after being subjected to heat, the bands are now emission features, indicating that the H_2O being measured is in the gas phase. The 10µm silicate feature remains and is more pronounced, suggesting that the chemical integrity of the sample remained intact over the course of the heating run. The solid-state H_2O features did not return, indicating that the H_2O in the samples had been removed completely.

Conclusions & Future Work: Preliminary results from this study suggest that the samples started losing their solid-state H_2O features between 725 and 750K. This suggests that planetesimals forming within the snow line could have a higher water content. The procedures outlined in this abstract will be repeated in order to clearly quantify the temperature at which water is released from the amorphous smokes. Further work will also involve kinetic studies to determine the activation energy of the H_2O in order to determine exactly how much water can be released, and how long it would take to release it.

References: [1] Lunine, J. I. (2006). *Meteorites and the early solar system II*, 309-319. [2] Ushioda, M., *et al.* (2014). *Earth, Planets and Space,* 66, 127. [3] Nuth III, J. A., et al. (2002). *Meteoritics & Planetary Science*, *37*(11), 1579-1590.