MEASURING THE PROPERTIES OF FORSTERITE FOR EXOPLANET CLOUD FORMATION AND IDENTIFICATION. E. Kohler[1], F. Ferguson[1], and S. Marcum[2], [1]NASA Goddard Space Flight Center, Astrochemistry Lab, Greenbelt, MD, 20771; [2]University of Missouri Physics Department, Columbia, MO, 65201.
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Introduction: The high number of extrasolar planets found in recent years has not only challenged our knowledge of solar system sciences, but also our fundamental understanding of some of the processes that operate on Earth. These recently discovered planets show a large diversity in their masses, temperatures, orbital periods, and other properties. With such a diverse mix of planetary parameters, it is safe to assume that the atmospheric properties are just as varied. evidence suggests the presence of silicate and metal condensates in their atmospheres. This has led to new insights into the physics of cloud formation, and new observational data will help test and validate theoretical models. However, these models are fundamentally limited by the insufficiencies of laboratory data on the properties of atmospheric constituents; new laboratory data is desperately needed to advance state-of-the-art of exoplanet atmospheric models [1].

A laboratory verification of the condensation and vaporization predictions of refractory materials is critically needed in order to inform and improve atmospheric and spectral models.

Methods: The stability of forsterite (Mg_2SiO_4), identified in the literature as a potential cloud candidate [2], was tested in a thermogravimetric balance at NASA Goddard Space Flight Center. The sample was pumped under vacuum (down to 10^{-6} torr) for twenty-four hours at room temperature and then heated to 1973K. Once mass loss is detected and stabilized, the temperature is lowered by 25 degrees at predetermined durations and mass measurements are taken in similar measured increments. The data is processed by a computer program in order to calculate the mass loss as a function of temperature resulting in the measured evaporation rate of forsterite.

Results: Several experiments on forsterite were completed and all were plotted to compare to previous studies. The evaporation rate was found to be similar to the comparison studies, but the mass loss was greater (Figure 1).

Discussion: The direct output of these experiments is the actual measured vapor pressures of minerals at high temperatures which are used to predict the temperature regimes for stable cloud formation. These temperature regimes are then used as inputs to atmospheric models that predict cloud condensates. Presently, inputs for models of exoplanet atmospheres depend heavily upon extrapolations from terrestrial pressures and atmospheres.

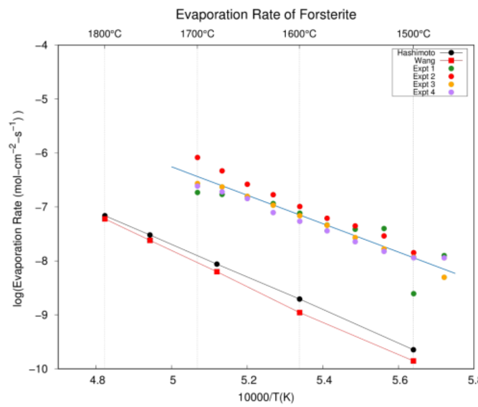

Figure 1. The resulting plot of several experiments comparing the evaporation rate of forsterite to previous studies. The results indicate a similar evaporation rate, but a higher mass loss.

Such extrapolations are clearly of dubious value for understanding the atmospheres of exoplanets and for these tests to be conclusive, the theoretical models need to improve through the inclusion of input data on core atmospheric properties.

Conclusion: The field of planetary science has significantly changed our perspective of planetary atmospheres from an Earth-centric point of view to exotic worlds in the Solar System where temperatures are far different, and chemical compositions are found to be significantly different than our own. Exoplanets are now opening our eyes to even more complex and exotic atmospheric regimes. Understanding the cloud formation process requires a knowledge of the local gas temperature and pressure, but also the thermodynamics of the cloud constituent in order to model the location at which that cloud may form. This work will lead to significant improvements in the accuracy of exoplanet atmospheric models by eliminating the need to extrapolate data from terrestrial conditions.

References: [1] Fortney, J.J., Robinson, T.D., Domagal-Goldman, S., Amundsen, D.S. alid, Brogi, M., Claire, M., Crisp, D., Hebrard, E., Imanaka, H., de Kok, R. (2016) *arXiv preprint arXiv:1602.06305*. [2] Wakeford, H.R., and Sing, D.K. (2014) *Astronomy & Astrophysics, v. 573*, A122.