Goldschmidt 2024 Abstract
https://doi.org/10.46247/gold2024.24102

Meteorite outgassing experiments as a tool for linking the atmospheric and bulk compositions of rocky planets.

NATHAN MCGREGOR[1], MAGGIE THOMPSON[2], MATRACA ELLING[3], MIA TRODDEN[4] AND **MYRIAM TELUS**[5]

[1]1156 High Street
[2]ETH-Zürich
[3]Stony Brook University
[4]University of California Santa Cruz
[5]University of California, Santa Cruz

Presenting Author: mtelus@ucsc.edu

The atmospheric compositions of terrestrial exoplanets offer insights into their internal structures. Volatiles enter a planet through accretion of planetesimals, yet we have a limited understanding of how volatiles in planetesimals outgas during planetary accretion, hindering our ability to accurately interpret the atmospheric compositions of terrestrial exoplanets. Meteorite outgassing experiments provide unique insight into how planetary building blocks influence the compositions of rocky planet atmospheres.

We simulate planetesimal outgassing during accretion by conducting heating experiments on chondritic meteorites using our novel technique, which utilizes a thermogravimetric analyzer coupled with a micro-gas chromatograph at the University of California Santa Cruz. This system heats a sample at temperatures up to 1600°C while measuring changes in mass and outgassed species. We conducted heating experiments on enstatite (Abee, EH4), ordinary (Krymka, LL3.2), and carbonaceous (Murchison, CM2) chondrites. Samples were powdered, sieved and stored in a vacuum furnace prior to analyses. Then samples were heated from 200°C to 1450°C at 3°C min-1 under argon at 1 bar.

Murchison lost more mass (~13%) than Abee and Krymka (~2%), reflecting its volatile-rich components. Below 1000°C, primary species included CO_2 for enstatite chondrites, CO_2 and H_2O for ordinary chondrites, and H_2O, CO_2, and H_2 for carbonaceous chondrites. Above 1000°C, primary species included H_2 and CO (enstatite), H_2 and SO_2 (ordinary), and H_2, H_2O, CO_2, and SO_2 (carbonaceous). Above 1200°C, all chondrites outgassing compositions converge towards predominately H_2. Estimates for N_2 and O_2 are uncertain due to terrestrial atmospheric contamination; nevertheless, Abee shows hints of N_2 at temperatures above 600°C. We use these results to estimate the outgassing composition of rocky terrestrial planets.

The mineralogy and textures of the residues indicate that the samples experienced complete melting prior to recrystallization. We observe vesicles, glass, olivine, pyroxene and FeS-metal nodules in all sample residues. Chemical analyses of these phases were carried out using the electron microprobe at Stanford University (20kV, 20nA). These results provide constraints on the bulk composition of the residue, redistribution of elements, equilibrium conditions, and outgassing of moderately volatile elements. Our results provide a framework for interpretation of spectral analyses of terrestrial exoplanet atmospheres.