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Building Rocky Planets and Their Atmospheres: Meteorite Outgassing Experiments and the Lamat Summer Research Program

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As exoplanet science enters a new technological era with the recent launch of NASA's James Webb Space Telescope, we will begin characterizing the physics and chemistry of low-mass, rocky exoplanets. In preparation for the upcoming observational data, we need a strong theoretical basis for the formation history, bulk composition and atmospheric properties of rocky planets. Outgassing is a central process during the formation and evolution of terrestrial planets and their atmospheres. Although rocky planets' initial atmospheres likely form via outgassing during and after their accretion, the connection between a planet's bulk composition and its initial atmospheric properties is not well understood. An important step towards establishing this connection is to analyze the outgassing compositions of meteorites. For the foreseeable future, meteorites are the only direct analog building-blocks of rocky planets that can be rigorously studied in the laboratory.

To inform the connection between rocky planets, the loss of their volatiles and their early outgassed atmospheres, we present a novel experimental technique to measure the outgassing compositions from various meteorite samples. The experimental set-up consists of a thermogravimetric analyzer (TGA) with a high-temperature furnace coupled to a gas chromatograph (MicroGC). The TGA-MicroGC heats samples to 1600 ^{o}C under atmospheric pressure while simultaneously measuring changes in the mass of the sample and the abundances of different outgassed species (e.g., H_2, H_2O, CO, CO_2, CH_4, SO_2). Various background gases can flow through the system, including argon, O_2, CO and CO_2, allowing us to explore outgassing under a range of redox conditions. We discuss our current experimental results from heating and analyzing the outgassing compositions of a set of chondritic meteorites and their implications for rocky planets' early atmospheres.

We are conducting these laboratory measurements and data analysis together with an undergraduate student as part of the UCSC Lamat Institute's summer research program. This initiative seeks to increase retention, graduation rates and preparation for STEM careers for undergraduate students, particularly those from community colleges. In collaboration with the Lamat Institute, our goal to is introduce this student to laboratory cosmochemistry research and to help them prepare a lead-author scientific publication.