

Analogue Studies for Mercury Exploration

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The surfaces of planetary bodies without atmospheres are shaped by impact processes, ancient volcanism, and space weathering. The planet Mercury and the Earth's Moon share many similarities in these regards. In anticipation of the ESA/JAXA BepiColombo mission's arrival at Mercury in November 2026, I will present a combined approach of using laboratory experiments on Mercury-analogue materials and observations from lunar Apollo samples to study and characterize these processes.

Mercury's surface exhibits an unusually high sulfur content, reaching up to 4 wt.%. Given the highly reducing conditions inferred for Mercury's mantle and crust, sulfides such as CaS (oldhamite) and MgS (niningerite) have been proposed to occur on the planet's surface. I will discuss possible sulfide enrichment processes on Mercury's surface and how we can characterize these experimentally and spectroscopically. Hollows are another unusual feature on Mercury's surface. These irregularly shaped depressions, surrounded by bright halos, suggest an ongoing formation process related to volatile depletion and possible fumarolic activity. I will present a new experimental approach to testing the stability of volatile-bearing phases, including sulfides, that may contribute to hollow formation, using in-situ measurements under high-vacuum, Mercury daytime conditions.

Apollo sample 14076 preserves the record of a high-energy impact event, containing highly refractory impact melt residues and volatile-rich condensates from the impact vapor plume. We study this sample as a Mercury analogue. Considering Mercury's larger size and higher gravity, we expect a significantly higher abundance of such impact plume-related materials in Mercury's regolith. In addition, the lunar sample provides insight into processes within the impact plume, including the ingassing of volatile species into the refractory melt at temperatures above 2000 °C.

Finally, I will present experimental results on the synthesis of both volcanic and impact glasses, and their analysis in preparation for the BepiColombo mission. Specifically, we use mid-infrared spectroscopy to relate Mercury surface observations by the Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS) to the analogue materials produced under controlled laboratory conditions. Together, experiments and BepiColombo observations will help constrain the evolution and volatile inventory of the Solar System's innermost planet.