The Challenges of High Temperature Spectroscopy of Planetary Analog Materials

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Hyperspectral remote sensing observations are a key technique for studying the composition of planetary surfaces in our solar system and soon even beyond it. Interpretation of these observations requires laboratory measurements of analog materials obtained under relevant surface conditions. For Mercury and Venus, as well as any rocky extrasolar planets close to their host star, this requires obtaining spectra at temperatures up to 500 °C. Over the last 10 years, the Planetary Spectroscopy Laboratory (PSL) at DLR in Berlin, German has been constructed to routinely measure emissivity of particulate and solid samples under vacuum conditions at temperatures well beyond 500 °C for the spectral range from 0.7 to 200 µm. Studies of a wide range of planetary analog materials have proven the importance of these measurements. The surface of the planet Mercury, for example, exhibits "chameleon-like behavior." Band shifts solely due to temperature effects can mimic the spectrum of an olivine enriched in iron by almost 20 % if room temperature spectra are used as reference. Other surprising new findings include the loss of spectral contrast and a darkening effect in the visible spectral range, observed after thermal processing at temperatures above 300 °C in vacuum. This "thermal space weathering" can mimic traditional space weathering effects, but acts on a much shorter timescale. A range of geochemical analysis methods as well as extensive modeling efforts complement the laboratory measurements at PSL. Crystal field theory as well as numerical modelling of lattice effects have been used in planetary science so far. We are exploring the use of *ab initio* calculations to complement spectroscopic results. Simulations of thermal IR spectra of crystals, performed at high and low temperatures using first principles, provide important support to data interpretations of the main mineral analogues studied. First tests of this approach have been very successful, but have also shown the challenges in reproducing sample characteristics such as grain size, particle scattering, and preferential orientations.