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Title: Insights into hydrated sulfate minerals' elastic, electronic, and structural properties within planetary environments using spectroscopic and X-ray scattering techniques

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Hydrated sulfates are observed throughout the solar system: from larger terrestrial planets like Earth and Mars to the relatively smaller icy satellites and even asteroids. Whether as a dominant phase or minor component, understanding hydrated sulfates' role within the complex, multi-phase environments found within planetary interiors relies on the ability to characterize the physical and chemical properties of the endmembers that comprise these systems. To measure the electronic, vibrational, and elastic properties of the pure ferrous iron endmember of the kieserite group, szomolnokite, ($FeSO_4 \cdot H_2O$), we have performed high pressure synchrotron ^{57}Fe nuclear resonant inelastic X-ray scattering (NRIXS) and Mössbauer spectroscopy (SMS), X-ray diffraction, and synchrotron infrared spectroscopy measurements in the diamond-anvil cell. Utilizing synchrotron spectroscopic and X-ray scattering techniques we have constructed a comprehensive description of szomolnokite's micro- and macroscopic material properties at high pressures and low temperatures relevant to hydrous, sulfur-rich planetary environments [1,2]. Through this multi-technique investigation, we identify structural phase transitions, evidence of crystal lattice softening, changes in elastic properties, and changes in the electric field gradients of iron atoms associated with two structural transitions occurring within the experimental pressure range. In particular, we highlight the unique advantages of combining spectroscopy and scattering techniques to gain insight into the relationship between a material's changing physical state and its chemical properties at pressure. We apply these findings to icy, sulfur-rich interiors, including discussion of elastic properties and implications for tidal observations.

[1] Pardo et al. (2023) Am. Mineral. 108, 476-484
[2] Pardo et al. (2023, under revision) Phys. Chem. Min.