

Spectroscopic characteristics of synthetic olivine: An integrated multi-wavelength and multi-technique approach

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ABSTRACT

Spectroscopic measurements have been made of two suites of olivine minerals synthesized under slightly different conditions in 5–10 mol% increments across the solid solution from forsterite to fayalite. Here, we present Mössbauer results for the entire Fe-Mg olivine suite, as well as the results for only the fayalite end-member as an introduction to our team's other diverse spectral-analysis techniques and data that will be presented in forthcoming papers. Experimental methods used to synthesize both suites of samples are discussed here in detail, along with specifics of the analytical techniques used to study them. Electron microprobe data and Mössbauer spectra acquired at 293 K across the solid solution are presented first to characterize and address the presence of impurities in the broad suite of samples that may affect other spectroscopic methods. We then focus specifically on the fayalite end-member to illustrate its properties using multiple techniques. Fayalite is an especially important phase for different types of spectroscopy because, by definition, it contains an equal distribution of Fe²⁺ cations between the M1 and M2 octahedral sites. Thus, features associated with each of the two sites must represent equal numbers of Fe²⁺ cations, removing uncertainties associated with assumptions about order/disorder of Fe²⁺ and other cations. Mössbauer, Raman, thermal emission, attenuated total reflectance (ATR), specular reflectance, and visible to mid-infrared total reflectance studies are presented for fayalite. These include calculation of mid-infrared optical constants (n and k) and fundamental Mössbauer parameters: intrinsic isomer shift (δ_I), Mössbauer temperature (θ_M), and recoil-free fraction (f). Data from the different techniques are described and related, demonstrating the importance of multi-wavelength data to provide a complete characterization and understanding of the spectroscopic features in fayalite.

Keywords: Fayalite, olivine, Mössbauer, Raman, thermal emission, reflectance, visible region, infrared, optical constant, attenuated total reflectance