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Temperature dependence of reflectance spectra and color values of hematite by in situ, high-temperature visible micro-spectroscopy

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Abstract

We measured visible reflectance spectra and colors of hematite (α-Fe_2O_3) reagent powders and a natural feldspar grain containing dispersed hematite microcrystals from room temperature up to 800 °C using an in situ, high-temperature visible micro-spectrometer with dark field optics. The spectrum of room-temperature hematite powder is characterized by a nearly constant reflectivity in the range 400–550 nm, a shoulder near 620 nm, and a reflectivity maximum near 750 nm. The reflectance spectrum is similar to the diffuse reflectance spectra measured by a spectrophotometer and a conventional spectrometer with an integrating sphere. This result indicates that the dark field objective is suitable for measuring visible reflectance spectra of hematite powders with the visible micro-spectrometer. The reflectance of hematite powders in the longer wavelength region (>550 nm) decreases gradually with increasing temperature. The shoulder centered around 620 nm and the reflectance maximum near 750 nm also become indistinct at high temperatures. The calculated L* (dark-light), a* (red-green), and b* (blue-yellow) color values decrease with increasing temperature. This means that the red color of hematite becomes black with temperature increase. The calculated absorption intensities (Kubelka-Munk functions) suggest that this temperature dependence of the hematite powder-reflectance spectra can be mainly explained by a change in band gap absorption edges for a semiconductor (Urbach rule). The visible spectra and colors of a natural feldspar grain containing dispersed hematite microcrystals show a similar change with temperature, indicating that the temperature dependence can be observed under natural conditions at high temperatures, such as in volcanic eruptions.

Keywords: Visible micro-spectroscopy, dark field optics, hematite, visible reflectance spectra, L*a*b* color values, temperature dependence, Kubelka-Munk function