American Mineralogist, Volume 100, pages 1554–1561, 2015

Dependence of R fluorescence lines of rubies on Cr^{3+} concentration at various temperatures, with implications for pressure calibrations in experimental apparatus

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ABSTRACT

The R fluorescence lines of rubies that contain 0.022, 0.068, 0.211, 0.279, 0.556, 1.221, and 1.676 wt% of Cr_2O_3 were measured at temperatures of 100–600 K and at atmospheric pressure. The R_1 line wavenumbers of all of the ruby samples shifted linearly as the temperature increased from 298 to 600 K at atmospheric pressure, and the temperature dependence increased from -0.157 ± 0.001 cm^{-1}/K to -0.149 ± 0.001 cm^{-1}/K as the Cr_2O_3 content in the rubies increased from 0.022 to 1.676 wt%, which suggests a significant dependence on Cr^{3+} concentration. At room temperature and atmospheric pressure, the full-width at half maximum (FWHM) of the peak height of the R lines also appears to be linearly related to the Cr^{3+} concentration. The relative intensity ratios of the R_2 to R_1 lines (I_2/I_1) of ruby samples with different Cr^{3+} concentrations show several non-linear variations with temperature from 100 to 600 K, and the maximum values, $(I_2/I_1)_{max}$, occur near room temperature. The effect of Cr^{3+} doping on the temperature dependence of the R line wavenumbers should be considered when rubies are used to calibrate the pressure or temperature in high-pressure and high-temperature experiments.

Keywords: R fluorescence lines, pressure calibration, temperature correction, ruby, Cr_2O_3 content