American Mineralogist, Volume 88, pages 1138–1144, 2003

^{57}Fe Mössbauer-effect studies of Ca-rich, Fe-bearing clinopyroxenes: Part II. Magnetic spectra of magnesian hedenbergite

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ABSTRACT

The magnetic properties of two natural magnesian hedenbergite samples with slightly different Fe contents (hereafter denoted HED1 and HED2) were studied by transmission ^{57}Fe Mössbauer spectroscopy within the temperature range 4.2–35 K and in a longitudinal, external field of 60 kOe at 4.2 K. The magnetic zero-field Mössbauer spectra (MS) were adequately refined using a superposition of two model-independent hyperfine-field distributions, one for the dominant Fe^{2+} component and one for the weak Fe^{3+} contribution, the positions of the eight absorptions and their intensities for each composing elemental subspectrum being determined by diagonalization of the hyperfine-interaction Hamiltonian. The maximum-probability saturation hyperfine fields for Fe^{2+} were found to be 180 kOe and 185 kOe for HED1 and HED2, respectively, while a value of ~545 kOe was obtained for Fe^{3+}. For both hedenbergite samples, the Fe^{2+} asymmetry parameter η of the electric field gradient (EFG) is quite high, namely 0.7–0.8 regardless of temperature. The orientation of the ferrous magnetic hyperfine field in the EFG principal-axes frame is ~(85°, 38°) and is not affected by the temperature of the absorber. The applied-field Mössbauer spectra show that the applied field does not disrupt the magnetic structure, and consequently that magnetic anisotropy is quite strong. The spectra were satisfactorily described by a two-parameter distribution model, taking into account distributions for the magnitude and the orientation of the hyperfine field with respect to the external field. The obtained hyperfine parameters are in excellent agreement with the results from the zero-field spectra. The temperature dependence of the hyperfine field seems to indicate that the magnetic structure in hedenbergite can be approximated by a two-dimensional rectangular Ising model and that the inter-chain and intra-chain magnetic exchange interactions are of similar magnitude.