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The role of Fe content on the Fe-Mg exchange reaction in augite

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Abstract

The study of the intracrystalline Fe-Mg exchange between *M*1 and *M*2 crystallographic sites in clinopyroxene on samples a variety of geological settings has provided a framework to understand the thermal history of pyroxene-bearing rocks. The Fe-Mg exchange reaction has successfully been exploited as a geothermometric tool in the study of orthopyroxene and pigeonite-bearing rocks, but relatively few data are available for clinopyroxene. A strong correlation between total iron content and the slope of the Fe^{2+}-Mg equilibrium distribution coefficient (k_D) as a function of temperature has been found for orthopyroxene and pigeonite, and we investigate this relationship in augite.

We carried out new equilibrium annealing experiments at 800, 900, and 1000 °C followed by single-crystal X-ray diffraction and structural refinement to obtain a new geothermometric calibration for augite from a 120 m thick lava flow from Ontario, Canada [Theo's Flow, $En_{49}Fs_9Wo_{42}$ hereafter also referred as Fs_9 where Fs = 100·ΣFe/(ΣFe+Mg+Ca) with ΣFe = Fe^{2+}+Fe^{3+}+Mn]. This new calibration enabled us to evaluate the compositional effects (mainly Fe content) by comparison with the data previously obtained on augite from MIL 03346 martian sample ($En_{36}Fs_{24}Wo_{40}$ hereafter referred to as Fs_{24}).

The extremely good agreement observed between the data obtained on Theo's Flow and Miller Range (MIL 03346) augite demonstrate that for the range of compositions between Fs_9 and Fs_{24}, total iron content has a negligible or null influence on equilibrium behavior. Furthermore, linear regression of data from Theo's Flow and MIL 03346 gave a single calibration equation:

$$\ln k_D = -4040(\pm 180)/T(\mathrm{K}) + 1.12(\pm 0.17) \quad (R^2 = 0.988).$$

This new calibration describes the equilibrium behavior of augite and can be reliably used to determine the closure temperature (T_c) of augite with composition ranging between Fs_9 and Fs_{24}.

Keywords: Augite, geothermometer, single-crystal X-ray diffraction, Fe-Mg exchange reaction