IRON-MAGNESIUM DIFFUSION COEFFICIENTS IN ORTHOPYROXENE: IMPLICATIONS FOR METAMORPHISM OF THE PETERSBURG BRECCIA

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Introduction: The compositional zoning of minerals contained in igneous and metamorphic rocks provides us with clues about the thermal history of these rocks. Here, we report the results of modeling of the metamorphic redistribution caused by diffusion of iron at the edges of fragments of magnesian orthopyroxene in the polymict eucrite Petersburg. Previously [1], we suggested that this partial re-equilibration might have been caused by contact metamorphism. These calculations were made using two different sets of diffusion coefficients, which we initially suspected would provide different time periods for metamorphism. In fact, the results are quite similar.

Calculations: In the present study, we assumed that the compositional gradient of the mg# (=100 Mg/(Mg+Fe), molar) in these orthopyroxene fragments was controlled by atomic diffusion. In order to obtain cooling rates, diffusion profiles were numerically fit to the observed zoning profiles using calculation procedures similar to those in Miyamoto et al. [2]. Unfortunately, there are relatively few studies about Fe diffusion in pyroxene, and we were limited to the diffusion coefficients for orthopyroxene reported in [3] and [4].

Results and Discussion: One complicating factor of these calculations is that the diffusion coefficients for orthopyroxene suggested by these two studies [3, 4] vary with temperature. In the temperature range 1000 to 800 C, values are similar; however, at 500°C, the value suggested by [4] is nearly three orders of magnitude higher than that of [3]. We calculated the compositional profile resulting from Fe-Mg interdiffusion caused by cooling over the same temperature range (850 to 400 C) as [1] using the two sets of diffusion coefficients. The diffusion coefficients of [3] give the best fit profile at a cooling rate of 0.16 C/year (a period of ~3000 years), and the diffusion coefficients of [4] give the best fit profile at a cooling rate of 0.25 C/year (~2000 years).

Conclusions: Despite significant differences in the suggested diffusion coefficients at low temperatures [3, 4], the calculated cooling rates are very similar and are within the range expected for wall rock near a laccolith intruded into the crust of 4 Vesta [1]. This similarity in calculated zoning profiles suggests that diffusion at maximum temperatures during metamorphism is the most important factor in determining the character of the zoning profile in the orthopyroxene fragments in Petersburg.

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