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Diffusivities of major divalent Cations in Gem quality and chemically heterogeneous Garnets: multi-couple Experiments

A. Perchuk (1,2) , H-P. Schertl (3), M. Burchard (4), W. V. Maresch (3), T.V. Gerya (5), H-J. Bernhardt (3)

(1) IGEM, Russian Academy of Sciences, Moscow 119017, Russia, (2) IEM, Russian Academy of Sciences, Chernogolovka 142432, Russia, (3) Institute of Mineralogy, Geology and Geophysics, Ruhr-University Bochum, D-44780, Germany, (4) Mineralogical Institute, University Heidelberg, D-69120, Germany, (5) ETH Zurich, Switzerland (alp@igem.ru /Fax: +7 495- 2302179)

Diffusivities of major divalent cations in garnet are commonly retrieved on the basis of experiments with homogeneous, gem quality crystals. However, natural garnets in metamorphic and magmatic rocks are often not chemically homogeneous and may contain various mineral inclusions. In this study we compare experimental results on diffusion rates in gem quality and highly heterogeneous garnets. Experiments on volume diffusion in different garnet diffusion couples were carried out in piston-cylinder apparatus under dry conditions at P=1.9-3.2 GPa and T=1070-1400^{o}C. Gem quality garnets of almandine, spessartine and grossular compositions together with heterogeneous eclogitic garnets were embedded in a powder of natural pyrope and annealed together under dry conditions at P=1.9-3.2 GPa and T=1070-1400^{o}C. Diffusion profiles were measured by electron microprobe and fitted numerically (*DXL* program of Perchuk and Gerya, 2005, Petrology 13: 253–266) on the basis of multi-component diffusion theory. Retrieved self-diffusion coefficients of Mg, Fe and Mn for the gem quality crystals are close to the dataset of Chakraborty and Ganguly (1992, Contributions to Mineralogy and Petrology 111: 74-86), which were obtained with the "sandwiched-crystal" approach. Diffusion rates of Mg and Fe in heterogeneous inclusion-rich eclogitic garnets are systematically lower than in the gem quality crystals. The dataset derived from natural eclogitic garnet yields the following parameters of the Arrhenius equation D =D^o exp [-(E+P dV)/RT]

Mg: D^o = 1.13($\pm$0.83)*10^{-6} m^2/sec; E = 322.8($\pm$33.8) kJ/mol; dV = 5.3$\pm$3.0 kJ/GPa,

Fe: D^o = 5.06($\pm$0.20)*$10^{-7}$$m^2$/sec; E = 313.4($\pm$35.9) kJ/mol; dV =5.6$\pm$2.9 kJ/GPa,

Ca: D^o = 3.42($\pm$0.30)*$10^{-9}$$m^2$/sec; E = 270.8($\pm$27.4) kJ/mol; dV = 6.0$\pm$2.9 kJ/GPa,

where the activation volumes (dV) are from Chakraborty and Ganguly (1992). Note that this dataset includes a self diffusion coefficient for Ca. Reliable data on this coefficient have been lacking so far, thus hindering geospeedometric approaches for the reconstruction of time scales of metamorphic and magmatic events.