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Effects of pressure and temperature on the silicon diffusivity of pyrope-rich garnet

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We determine the pressure and temperature dependencies of Si volume diffusion rates in single crystal of Pyp75Alm15Gr10 garnet at 6-25 GPa and 1673-2073 K by the ^{29}Si tracer diffusion method. High-pressure experiments are conducted by using the Kawai-type multi-anvil high-pressure apparatus. The diffusion profiles are obtained by using the secondary ion mass spectrometry in the depth-profiling mode. The Si diffusion coefficient in garnet (D_{gt}) is expressed by the Arrhenius equation: $D_{gt} = D_0 \exp(-(E + PV)/RT)$, with $\log_{10}D_0$ = -7.9 m^2s^{-1}, E = 330 $kJmol^{-1}$, and V = 4.6 cm^3mol^{-1}. Si diffusion seems to be the slowest in the major constituent elements and controls rates of plastic deformation under the upper mantle to the mantle transition zone conditions. The comparisons of Si diffusion rates between garnet and wadsleyite/ringwoodite suggest that garnet has almost similar or slightly higher strength (at most 4 times) compared with wadsleyite and ringwoodite at the temperature ranging from 1173 to 1573 K. Thus, the subducted oceanic crust may have plastically similar or slightly higher strength compared with the underlying peridotite layer at the mantle transition zone conditions. This result suggests that the separation of the subducted oceanic crust from the underlying peridotite layer may not occur.

Keywords: garnet, diffusion, rheology, subducted oceanic crust