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Post-spinel transitions in pyrolite and Mg2SiO4:Effect of solid-solution components on the post-spinel transition

Takayuki Ishii[1*], Hiroshi Kojitani[1], Masaki Akaogi[1]

[1]Gakushuin Univ.

It is widely accepted that the 660-km discontinuity of the interior of the earth is due to post-spinel transition of spinel which is the major mantle mineral. This transition pressure in Mg_2SiO_4 and pyrolite which has a representative composition of the upper mantle have been examined with a quench method and in situ XRD observation by many investigations. But it is still discussed whether this transition really corresponds to the 660-km discontinuity or not, because there are problems of uncertainty of pressure in pressure scales, and so on. In high-pressure experiments on Mg_2SiO_4 and pyrolite, our results indicated that the post-soinel transition in pyrolite occurs at lower pressure by 0.1-0.5 GPa than that in Mg_2SiO_4, and the Clapeyron slope in pyrolite is more gentle than that in Mg_2SiO_4. Therefore, we have expected that the cause of decline of transition pressure and the Clapeyron slope is due to effect of solid-solution components (Fe^{2+}, Fe^{3+}, Al^{3+}) other than Mg^{2+}, and have compared the influence on post-spinel transition of these components using a multicell technique.

As starting materials, we prepared a mixture of Mg_2SiO_4 : Fe_2SiO_4 = 9 : 1 with mole ratio ($Fo_{90}Fa_{10}$), Mg_2SiO_4 and $MgSiO_3$: Fe_2O_3 : Al_2O_3 = 85 : 15 (mole ratio) with 6 : 4 (weight ratio) (Fo+En+$FeAlO_3$), Mg_2SiO_4 and $MgSiO_3$: Al_2O_3 = 85 : 15 (mole ratio) with 6 : 4 (weight ratio) (Fo+En+Al_2O_3). High-pressure experiments were made at 22.3-24.5 GPa and 1200-1600C with a Kawai-type 6-8 multianvil apparatus. Three sample combinations in one run were (Mg_2SiO_4, $Fo_{90}Fa_{10}$ and Fo+En+$FeAlO_3$) and (Mg_2SiO_4, Fo+En+$FeAlO_3$ and Fo+En+Al_2O_3). Three samples were packed in a Re capsule with three holes, kept simultaneously at desired pressure-temperature conditions for 3 hours, quenched and recovered after the run. Phase identification of each sample was made with a microfocus X-ray diffraction apparatus, and compositional analyses of them were made with a SEM-EDS.

The post-spinel transition pressure in $Fo_{90}Fa_{10}$ is slightly higher than that of Mg_2SiO_4, and those of Fo+En+$FeAlO_3$ and Fo+En+Al_2O_3 are lower than. Two transitions in Fo+En+$FeAlO_3$ and Fo+En+Al_2O_3 were a reaction from ringwoodite + garnet to perovskite + magnesiowustite (or periclase) + garnet. The results suggest that Fe^{2+} makes the transition pressure higher, and Fe^{3+} and Al^{3+} make it lower. $Fo_{90}Fa_{10}$ has a similar Clapeyron slope to Mg_2SiO_4. On the other hand, the Clapeyron slope of Fo+En+$FeAlO_3$ is more gentle than that of Mg_2SiO_4. This trend is consistent with the results of phase relations in pyrolite. Therefore, we conclude that the effect of Al^{3+} on the post-spinel transition pressure is more than Fe^{2+} and Fe^{3+}.

Keywords: postspinel transition, ringwoodite, perovskite, 660km discontinuity, high pressure experiment