Stability of Orthopyroxene in Mg2Si2O6-CaMgSi2O6 at 1 atm and High Temperatures

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In the Mg-rich portion of the system Mg2Si2O6-CaMgSi2O6, there had been the controversy about the appearance and stability of the orthopyroxene phase at high temperatures other than protoenstatite since the discovery by Foster and Lin (1975). Longhi and Boudreau (1980) found the stability field of Ca-bearing orthorhombic pyroxene (OPx) was separated from orthoenstatite and this OPx was same as orthoenstatite. However, Carlson (1988) concluded that this OPx is a thermodynamically distinct phase from orthoenstatite but there was no obvious experimental evidence that stands by his conclusion. In recent years, Jackson et al. (2004) and Miyake et al. (2004) independently reported the transition to the high temperature orthoenstatite (HT-OEn) at high temperatures although both of them used Ca-free starting materials. However, an inconsistency is about the symmetry of the phase; Jackson et al. (2004) determined the space group as Cmca whereas Miyake et al. (2004) as Pbca. The purposes of the present study are (1) to elucidate the stability of HT-OPx near 1673 K using the Ca-bearing starting materials, (2) to characterize the transition into the HT-OPx, and (3) to determine the space group of the HT-OPx.

At first, synthesis experiments were carried out to confirm the stability field of OPx near 1673 K. 30 samples were synthesized from gels with 3 kinds of compositions in enstatite-diopside-forsterite system at different 10 temperatures between 1633 and 1723 K. They were analyzed with an optical microscope, X-ray powder diffractometer (XRD), a scanning electron microscope and energy dispersive X-ray spectrometer and an electron backsckattered diffraction. The composition of PEn is below 0.03 mol% of XDio, OPx between 0.05 and 0.08 mol% of XDio, and Pig above 0.09 mol% of XDio. The stability field of OPx phase is restricted between 1643 and 1715 K and confirmed to be almost same as Carlson (1988).

The sample in the phase of OPx (Ca0.06Mg1.94Si2O6) + forsterite + liquid was used as a starting material for the examination of high temperature in-situ XRD at the temperature between 1063 and 1637 K. It is first attempt to examine the sample of Ca-bearing OPx thought to be stable at high temperature by high temperature in-situ XRD. The variation of volume and the intensity of (121) peak show that the first order transition occurs from low-temperature orthopyroxene (LT-OPx) to high-temperature orthopyroxene (HT-OPx) at the temperature between 1443 and 1637 K.

The peaks of (210), (321) and (610) which are prohibited by the extinction rule of C lattice always appear and the transition to HT-OPx with the space group of Cmca isn't caused. All peaks except (121) don't show any change and the space group of HT-OPx is same as LT-OPx (Pbca).Therefore, the examination of high temperature in-situ XRD show that the isosymmetric phase transition between LT- and HT-OPx (Ca0.06Mg1.94Si2O6, space group, Pbca) is observed at the temperature between 1443 and 1637 K.