NE5C/2007G575

Pressure-induced structural change of jadeite composition melts

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Introduction

It is well known that viscosity of many silicate magma decreases with increasing pressure. This anomalous pressure dependence of viscosity is related to structural change of silicate magma with pressure. Structural study of silicate melt, therefore, is fundamental to understand physical properties of magma, such as viscosity and density. Here we report the results of X-ray diffraction analysis on jadeite ($NaAlSi_2O_6$) composition melts, which is a fully polymerized melt and has a decreasing trend of its viscosity with pressure.

Experiments

Static structure of jadeite composition melt under pressure has been studied by in situ x-ray diffraction experiments using synchrotron radiation. High-pressure and temperature x-ray diffraction experiments were conducted by energy-dispersive x-ray diffraction method using the cubic-press MAX 80 at AR-NE5C. Diffraction patterns of jadeite melt were acquired along the melting curve at the pressure range from 0.7 to 6.9 GPa.

Results and Discussion

Variation of interference function Qi(Q) of jadeite melts in terms of pressure is shown in Fig. 1. The first sharp diffraction peak (FSDP) of Qi(Q) shifts higher Q-side with increasing pressure, indicating the shrinkage of intermediate range structure composed of TO_4 tetrahedra. This shift is quite large from 0.7 GPa to 2.5 GPa, but it is small above 2.5GPa, so that the reorganization of network structure of TO_4 tetrahedra almost finishes up to 2.5 GPa.

Correlation function g(r) indicates the short range structure changing with increasing pressure (Fig. 2). T-O distance gradually increases with pressure, and shoulder of T-O around 2 Å appears at the higher pressure than 6GPa. Increase of T-O distance with pressure indicates a gradual increase of nearest neighbor coordination number up to 6.9 GPa, probably for aluminum. This is consistent with the results of Al K edge XANES study on jadeite glass quenched from melt at 4.4 GPa (Li et al.,1995).

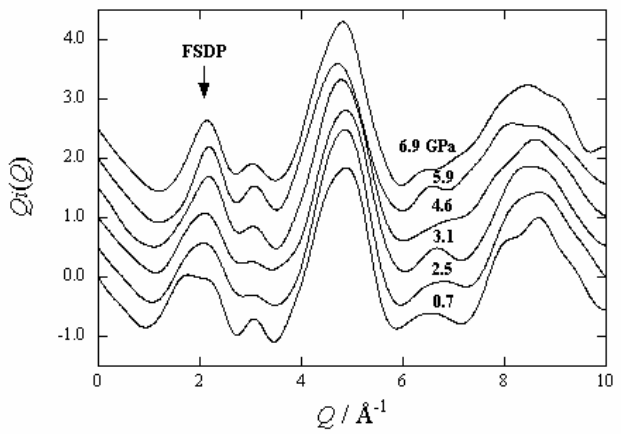

Fig. 1. Interference function of $NaAlSi_2O_6$ melts.

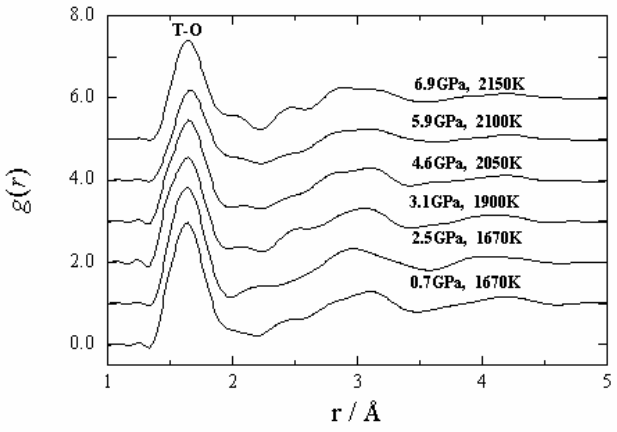

Fig. 2. Correlation function of jadeite melts.

Recently, Suzuki et al (2009) showed that viscosity of jadeite melt rapidly decreases to 2 GPa and then it becomes constant up to 5.5 GPa. Our study yields the structure based interpretation of viscosity of jadeite melt. The viscosity of jadeite melt must be controlled by network topology below 2 GPa. At the higher pressure than 2 GPa, competing effect between a weakening of T-O bond with increasing Al coordination and a decreasing of free volume in jadeite melt with compression may result nearly constant viscosity.

References

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