Pressure induced structural change of jadeite composition melt and implications for viscosity

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It is well known that viscosity of many silicate magma decreases with increasing pressure. This anomalous pressure dependence of viscosity is connected with 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 composition melts, which is a fully polymerized melt and has a decreasing trend of its viscosity with pressure.

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 Photon Factory, KEK, Japan. Diffraction patterns of jadeite melt were acquired along the melting curve at the pressure range from 0.7 to 5.9 GPa.

Radial distribution function of molten jadeite shows a gradual increase of nearest neighbor coordination number up to 5.9 GPa, probably for aluminum. This is consistent with the results of Al K edge XANES study on jadeite glass quenched from 4.4 GPa (Li et al.,1995). The first sharp diffraction peak (FSDP) of interference function 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. Recently, Suzuki et al (2008) 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.