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Viscosity of $NaAlSi_2O_6$ melt at high pressure

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Introduction

The viscosity of silicate melts is one of the important properties controlling the migration of magma in the Earth's interior. Although viscosities of various silicate melts are fairly well known at 1 atm, knowledge of the effect of pressure on viscosity is limited.

Kushiro [1] measured the viscosity of $NaAlSi_2O_6$ melt by falling sphere "quenching" method up to 2.4 GPa at 1350ºC. He showed that the viscosity decreased with increasing pressure. However, the viscosity measurement by quenching experiments is limited to 2.5 GPa in the piston cylinder device. The *in situ* falling sphere technique is the most promising approach to extend the pressure range. Suzuki et al. [2] measured viscosities of $CaMgSi_2O_6$ (diopside) – $NaAlSi_2O_6$ (jadeite) melts and found that the viscosity of Di50Jd50 melt had a minimum at 3.5 GPa. Whereas the viscosity of Di25Jd75 melt gradually decreased to 5.0 GPa. The main goal of the present study is to determine the pressure and temperature dependence of the viscosity of $NaAlSi_2O_6$ (jadeite) melt.

Experimental

High-pressure experiments were performed using a KAWAI-type apparatus driven by uniaxial presses, MAX-III at the BL14C2 beamline at the Photon Factory and SPEED1500 at the BL04B1 beamline at Spring-8. Viscosity was measured with the falling sphere method using X-ray radiograph. The X-ray absorption contrasts between Pt sphere and silicate melt were converted into visible-light images by YAG:Ce fluorescent screen and recorded by a digital video camera. The videos of the descending sphere can then be used to accurately determine the falling velocity of the sphere. The melt viscosity was calculated by using the Stokes' equation combined with the Faxén correction for the wall effects.

Results and Discussion

The results extended the pressure range of the measurement of viscosity of $NaAlSi_2O_6$ melt up to 5.5 GPa and are consistent with those previously measured by Kushiro [1]. Fig. 1 shows that the viscosity of $NaAlSi_2O_6$ melt decreased up to 3.6 GPa at 1580±10°C. The temperature dependence of viscosity can be described by the Arrhenius relationship (Fig. 2). The calculated activation energy was 330 ± 80 kJ/mol from linear regressions of $\log\eta$ on $1/T$ for experiments at 2.2 ± 0.2 GPa. This activation energy is slightly smaller than that at 1 atm [3, 4]. The negative pressure dependence of the activation energy suggests that the structure of $NaAlSi_2O_6$ melt is gradually depolymerized by compression.

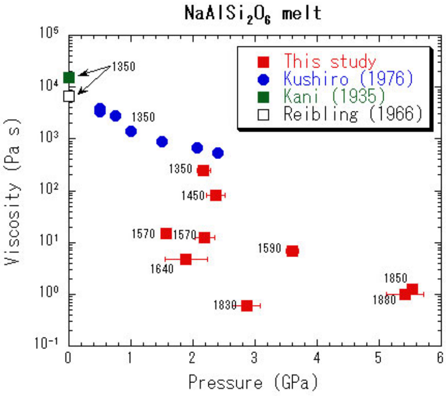

Fig. 1. Viscosity of $NaAlSi_2O_6$ melt as a function of pressure. The numbers in the figure indicate temperature in degrees Celsius.

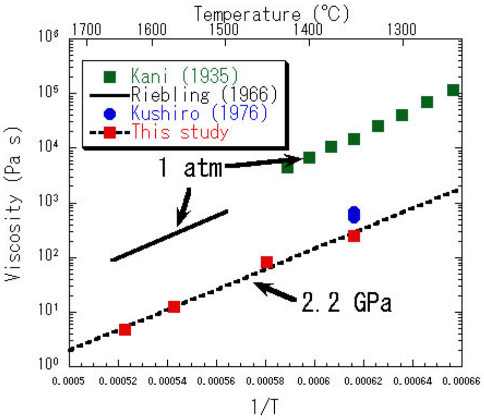

Fig. 2. Arrhenius plot for viscosity of $NaAlSi_2O_6$ melt.

References

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