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Properties of basaltic magmas and volatiles: application to origin of the asthenosphere-lithosphere boundary

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MOR basaltic volcanism is the most voluminous magmatic activity and produces oceanic floors and drives plate motion on the surface of the Earth. Thus the physical properties of magmas including the effect of CO2 and water on the properties are essential for account for the magmatic activity of the Earth.

We have conducted the density and viscosity measurements of basaltic magma under the upper mantle conditions. We observed a rapid increase in basaltic magma density at pressures around 3-5 GPa, and the compression curve cannot be expressed by the Birch-Murnaghan equation of state. This result implies that density contrast between the magma and the surrounding mantle disappears at the depths >100 km in the upper mantle. The viscosity of the magma shows a minimum in the same pressure range. The change in these physical properties of magma will be caused by the structural change of the melts such as coordination increase of Al at high pressure, which is consistent with the previous NMR measurements of the glass (Allwardt et al., 2007). The effect of volatiles on the density of magmas has also been studied under the upper mantle conditions, and it revealed that the effect of CO2 is small compared to that of water. If volatile associated with the melts in the asthenosphere is mainly CO2, we can expect disappearance of the density difference between the magma and surrounding rocks under the volatile bearing conditions.

We will discuss the relation between the change of the physical properties of basaltic magma and the processes in the oceanic lithosphere and asthenosphere including a Petit spot activity (Hirano et al., 2006), small-scale sublithospheric convection (SSC) (Ballmer et al., 2010), melt retention observed in seismology (Kawakatsu et al., 2009).

Keywords: basaltic magma, density, viscosity, volatiles, lithosphere, asthenosphere