Japan Geoscience Union Meeting 2014
(28 April - 02 May 2014 at Pacifico YOKOHAMA, Kanagawa, Japan)

PPS22-04 Room:415 Time:May 1 09:45-10:00

Estimation of the size of the angrite parent body

SUZUKI, Hiroko[1*] ; OZAWA, Kazuhito[1] ; NAGAHARA, Hiroko[1] ; MIKOUCHI, Takashi[1]

[1]Department of Earth and Planetary Science, University of Tokyo

Angrites has very old crystallization age yielding 4557 - 4564Ma (Brennecka and Wadhwa, 2012; Kleine et al., 2012) and are igneous rocks come from differentiated planetesimal or protoplanet (e.g. Prinz and Weisberg 1995; Baker et al., 2005; Weiss et al., 2008). Angrites preserve information on such differentiated planets, and are one of the best targets for studying processed operated in the early stages of planetary evolution of the solar system. However, the angrite parent body has not been found, and we have scarce knowledge on its planet size, which is one of the most important information in planetary science. The radius of angrite parent body is believed to be larger than 100 ? 200km because of the operation of dynamo, which requires prolonged high temperature of the planet interior due to heat production of ^{26}Al decay to achieve its core formation (Weiss et al., 2008; Elkins-Tanton et al., 2011). The upper limit of radius is not constrained at all, although 2440km is proposed based on ambiguous evidence for Mercury as the angrite parent body (Papike et al., 2003; Kuehner et al., 2006). The radius of the angrite parent body, particularly its upper limit, needs to be further constrained. In this study, we try to constrain the upper limit of the planet size from the presence of spherical voids as large as 25mm in D'Orbigny angrite.

D'Orbigny has many spherical voids suggesting that they formed in 100% molten magma before crystallization. The vesicles are deformed while ascending in the melt depending on several physical parameters such as, melt viscosity and the size of vesicles. There are two dimensionless numbers that determine the shape, Reynolds number and Eotvos (or Bond) number. Reynolds number is a ratio of inertia force and viscous force and Eotvos number is a ratio of buoyancy force and surface tension. These two numbers depends on gravity of the parental body, and the gravity depends on the radius of the parental body. Therefore, spherical shape of the largest void enables us to estimate the upper limit of the radius of the angrite parent body. The boundary conditions for spherical and nonspherical regimes have been determined by Bhaga and Weber (1981) based on fluid dynamic experiments and by Hua and Lou (2007) based on numerical simulations.

Spherical voids in D'Orbigny are armored by fine-grained olivine and plagioclase crystals, where are the first liquidus phases, suggesting that the spherical shape was frozen by heterogeneous nucleation and growth of these phases on the bubble wall. In order to know relationship between Reynolds and Eotvos numbers for D'Orbigny, accurate estimation of density and viscosity is very important, which are strongly dependent on temperature of shape freezing. The temperature was estimated by MELTS (Ghiorso and Sack, 1995) as metastable olivine liquidus for the D'Obigny bulk composition to be ~1100 ℃, from which the density and viscosity of D'Obigny magma are estimated to be ~3000 kg/m^3 and ~1.0 Pa s, respectively. Surface tension of the melt is 0.35N/m according to Walker and Mullins (1981), which is corrected by 50% occupation of olivine and plagioclase on the bubble-melt interface. We assume the average density of the parent body as 4000kg/m^3 for the planet having core, such as asteroid 4 Vesta (Zuber et al., 2011). By using these parameters, we estimated the upper limit of radius to be 700±100 km, which is clearly much smaller than that of Mercury.

Keywords: angite, planetesimal, parent body radius, parent body internal structure, D'Orbigny, protoplanet