Thermal history of the parent bodies of asteroid Itokawa

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Introduction: The Hayabusa spacecraft collected dust particles from asteroid 25143 Itokawa. The mineralogic studies of Itokawa dust particles revealed that those dust particles resemble LL5 and/or LL6 type ordinary chondrites [1-3]. Those particles were thermally metamorphosed at a peak temperature around 800 °C but did not experience temperatures over 1000 °C [1]. The ^{26}Al-^{26}Mg age study and oxygen thermometry indicated that the parent body of Itokawa kept at 700 °C or higher at 7.6 Myr after the Ca-Al rich inclusion (CAI) formation [2,3].

Methods: We investigated numerically the thermal modeling of the parent bodies of Itokawa which are in agreement with the mineralogic and isotopic evidence from the dust particles of Itokawa. We assumed that the parent body of Itokawa is an instantaneously-accreted spherically symmetric body and the initial temperature of the body is -73 °C (200K), which is the temperature at ~ 2 au in the solar nebula [4]. The physical properties (e.g., density, thermal conductivity) of the parent body are assumed to be the same with those of LL6 chondrites based on the analyses of the Itokawa sample [1, 2]. The main heat source is the decay energy of ^{26}Al, as used in most of the previous thermal modeling works [e.g., 5]. The one-dimensional heat conduction equations are numerically solved using a finite difference method and an explicit method of time integration (see [6] for details of the numerical methods). Numerical simulations are performed for parent bodies which have various sizes and accretion times (i.e. the initial ratio of ^{26}Al/^{27}Al).

Results: Our numerical results showed that the parent bodies that accreted within 2.2 Myr after CAI formation could reach 800 °C at the center of the body: those bodies could be the parent bodies of Itokawa. If the parent bodies accreted within 1.9 Myr after CAI formation, the peak temperature exceeds 1000 °C: those bodies could not be the parent body of Itokawa. The parent bodies which are less than 20 km in radius and accreted between 1.9 and 2.2 Myr after CAI formation could reach 800 °C; however, they could not maintain 700 °C or higher at 7.6 Myr after CAI formation: those bodies also could be eliminated from the list of parent body candidates of Itokawa. The parent bodies of Itokawa should be larger than 20 km in radius and accreted at a period between 1.9 and 2.2 Myr after CAI formation to satisfy the mineralogic and isotopic evidence from the Itokawa particles. We conclude that Itokawa ($\simeq 0.5$ km) originated in a larger parent body (> 20 km), which was once disrupted after reaching a high temperature (800 °C) and then reaccumulated.

References: [1] Nakamura et al. (2011) *Science* **333** 1113–1116 [2] Yurimoto et al. (2011) *Science* **333**, 1116–1119 [3] Yurimoto et al. (2011) *Meteoritics and Planetary Science* **46**, A260 (abstract) [4] Hayashi (1981) *Prog. Theor. Phys. Suppl.* **70**, 35–53. [5] Miyamoto et al. (1981) *Proc. Lunar Planet. Sci.* **12B**, 1145–1152. [6] Wakita et al. (2014) *Meteoritics and Planetary Science* **49**, 228–236.