NUMERICAL SIMULATION FOR COOLING OF THE ITOKAWA PARENT ASTEROID.

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Introduction: According to mineralogy and isotopic signatures of Itokawa dust particles, it seems that they were thermally metamorphosed at a peak temperature of around 800 °C, and kept at 700 °C or higher at 7.6 Myr after CAI formation [1-2]. Based on these temperature conditions, Wakita et al. (2013) [3] performed a numerical simulation and the results show that the parent body of Itokawa would have been larger than 20 km in radius and accreted at a period between 1.9 and 2.2 Myr after CAI formation. This suggests that the Itokawa parent body was broken up by a catastrophic impact and current Itokawa (< 0.5km) is a remnant of the parent asteroid [1, 3]. Further mineralogical observation revealed that plagioclase exsolves K-feldspar lamella and application of plagioclase thermometry [4] to the plagioclase-K-feldspar pair fails to obtain equilibrium temperature [5]. This indicates that compositions of plagioclase and K-feldspar were modified during slow cooling of the parent asteroid of Itokawa. We further constrain thermal history of Itokawa parent asteroid to satisfy compositional change of feldspars during cooling.

Results and discussion: We simulated cooling process in several cases for size and formation timing of the Itokawa parent asteroid. In this paper, the result of simulation for one selected case is shown: the size is 25km in radius and formation timing is 2.2 Myr after CAIs. With these conditions, Itokawa parent asteroid reaches a peak temperature close to 800°C. We calculated diffusion length of Ca in plagioclase crystals during cooling at the center of the asteroid. We adopted two different CaAl-NaSi interdiffusion rates to our calculations: the diffusion rates are known to increase with increasing pressures and water contents [6]. The higher rate we used was experimentally determined under conditions of high pressure and hydrous conditions [7]. On the other hand, the lower rate we used is obtained in dry and low-pressure conditions [8]. The results of calculation indicate that it takes 4.4Myr for cooling from a peak temperature of 800 to 500°C of a 50-km size body and Ca diffusion lengths are 42 and 4μm for wet and high pressure condition and for dry and low-pressure condition, respectively. The diffusion almost completed at 700°C and 8Myr after CAIs. The size of plagioclase in Itokawa particles ranges from 20 to 50μm [1]. Therefore, if the Itokawa parent asteroid contain a low abundance of water, then An content of plagioclase cannot be equilibrated and thus retains high-temperature compositions, as is witnessed in plagioclase in Itokawa dust particles [5]. On the other hand, Na-K interdiffusion is at least several orders of magnitude faster than NaSi-CaAl interdiffusion [6]. Therefore, during cooling of a 50-km size body, Ab and Or contents are easily changed and re-equilibrated, while An content cannot be re-equilibrated, in 20 to 50μm-size plagioclase, which satisfies plagioclase compositions in Itokawa dust particles.

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