

Accretional growth and thermal evolution of Ryugu's parent body consisting of hydrous minerals.

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Analysis of Ryugu samples collected by Hayabusa2 has shown that the chemical composition and isotopic ratios are similar to those of CI chondrites, and are more primitive than CI chondrites collected previously [1][2]. Elemental composition of CI chondrites is close to those of the entire solar system, which is crucial for understanding the solar system, and more primitive Ryugu samples are important for the evolution of the solar system. Moreover, CI chondrites might to share a single parent body, and a parent body of C-type asteroids such as Ryugu is thought to be close to CI chondrites' [1]. In addition, the presence of organic materials and aqueously altered minerals have been found in Ryugu samples, which suggests that the parent body of C-type asteroids is thought to have contained a large amount of hydrous minerals. Therefore, C-type asteroids and their parent body was enriched in water and organic materials, and they might have an important contribution to the emergence of life on Earth. However, since parent bodies possibly do not exist today, model calculations of their thermal evolution are effective for understanding their thermal /chemical conditions and temporal changes.

Constraints of these calculations include the temperature conditions and the formation age of the parent body based on the analysis of Ryugu samples. Samples near craters formed by Hayabusa2 impactor have generally stronger peak of C-H bond by NEXAFS than samples from other surface area of Ryugu [2] and a previous kinetic study of aliphatic organic matter degradation in the Murchison meteorite [3], the parent body likely experienced up to 30 degC. Based on the oxygen isotope thermometry for dolomite and magnetite, aqueous alteration have occurred at 37 ± 10 degC [1]. Thus, Ryugu should have formed in the low-temperature region of the parent body. Previous works for thermal evolution simulations assumed that the radius of Ryugu's parent body is on the order of 10 km [4]. However, Ryugu is known to have experienced dehydration. If the dehydration was caused not only by space weathering but also by temperature increase, the parent body would have experienced at least 300-400 degC and the interior would have been differentiated into several layers [5]. In addition, since Mn-Cr isotopic measurements suggest that aqueous alteration occurred around 5.2 million years from the birth of the solar system, and the parent body may have grown to a radius of several hundred km during that time. It is necessary to investigate the conditions under which the various temperature environments described above can be achieved in the interior of such a large body.

In this study, we investigated the time evolution of the interior thermal structures of parent bodies by solving a one-dimensional spherically symmetric heat transport equation that takes into account conduction and convection as heat transport processes and decay heat of short-lived radioactive isotope (²⁶Al) and impact heating during accretion as heat sources. The parent bodies were assumed to be planetesimals composed of hydrous minerals with an initial radius of 1 km, the accretional growth and the dehydration and the metal separation due to internal heating are taken into account. The simulation was carried out for tens Myrs using the initial concentration of ²⁶Al and the accretion rate as main parameters. As a result, for the accretion time of 1 million years, large impact heating leads temperature over 30 degC even near the surface layer where aliphatic organic matter is not decomposed. Therefore, it is suggested that the accretion time of the Ryugu's parent body is likely to be longer than 1 million years. On the other hand, a metallic core with radius of several to several tens of kilometers could be formed at

the center. It means that the parent body assumed here could be the origin of iron meteorites and metal-rich asteroids, and may suggest the possibility that carbonaceous chondrites and iron meteorites share the same parent body [6].

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[2] Ito et al., 2022, *Nature Astronomy* 6, 1163-1171.

[3] Kebukawa et al., 2010, *Meteoritics & Planetary Science* 45, 99-113.

[4] Nakamura et al., 2023, *Science* 379, 787.

[5] Tatsumi et al., 2021, *Nature Communications* 12: 5837.

[6] Kleine et al., 2020, *Space Sci Rev* 216: 55.

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