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巨大氷衛星の内部分化と熱史

Internal differentiation and thermal history of giant icy moons

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Ganymede, the largest moon in our Solar System, has the lowest value of the moment of inertia among the solid solar system bodies indicating strongly differentiated interior. Also, the intrinsic magnetic field detected by Galileo spacecraft provides the existence of a liquid, iron-rich core. Thus Ganymede appears to be clearly layered structure consisting of an iron sulfide-iron core, silicate mantle and an outer water layer. However, process of the internal differentiation including the core formation is highly unclear. The size of Ganymede (2634 km in radius) implies that only accretional heat might be not sufficient to segregate the water, rock, and metallic materials completely. Perhaps another subsequent heating process, for example, tidal heating and/or long-lived radiogenic heating, drives to differentiate these materials. On the other hand, Callisto, another of Jovian moon, has a similar in size to Ganymede but large value of the moment of inertia implying not differentiated very much at all. This contradictory characteristic between two moons has been also still unsolved.

We performed numerical simulations for the internal thermal evolution and differentiation. As an initial setting, we assume that Ganymede and Callisto-sized moons, which were formed by homogeneous accretion, have been composed of a mixture of ice, rock, and metal. According to the accretional temperature profile, initial moons have an outermost water layer (probably a liquid ocean) underlaid by the mixed core composed of rock, metal, and residual water. Assuming long-lived radioactive elements as a unique heat source, the residual water in the mixed core should has segregate from the rocky and metallic component within a few hundred Myr depending on the thermal evolution. Afterward the temperature in the rock and metal mixed core would approach the melting point of the metallic component, and it would settle down and the metallic core was formed at the moon's center. We consider the accretional temperature profile and the volume fraction of ice, rock, and metal in moons as a parameter, the variation in timing of the water segregation and subsequent formation of the metallic core will be investigated. And we try to express the formation process of distinct layered structure of Ganymede and the difference from Callisto.