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# Dehydration of primordial hydrous rock in Ganymede: formation of the conductive core and the grooved terrain

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From gravity data, it has been found that Ganymede has a small value of the moment of inertia (MoI) factor (0.3115), which suggests a highly differentiated interior. Combined with its mean density (1,942 kg $m^{-3}$), a three-layered structure (an outermost $H_2O$ layer, a rocky mantle, and a metallic core) is most consistent with the gravity data. Also, existence of the intrinsic magnetic field strongly supports the existence of a (at least partially) liquid, iron core. However, process of the internal differentiation including the core formation is highly unclear, and the size of Ganymede implies that only accretional heat is insufficient to segregate the water, rock, and metallic materials completely. On the other hand, Callisto has similar size to Ganymede but show larger value of the MoI (0.355) implying incomplete differentiation. Although many hypotheses to explain this contrasting characteristic between two moons have proposed, but none of these theories has been sufficiently convinced. Here we suggest another hypothesis for the internal evolution in early stage and focus on a dehydration process of primordial rock-metal-mixed core.

Dehydration of hydrous rock and associated rheological change might be a key to create the dichotomy but its possible influence to the thermal histories of these satellites has never been explored. During the stage of accretion, rocky component is possibly hydrated because of the chemical reaction with liquid water generated by accretional heating. The similarity in reflectance spectra among hydrated carbonaceous chondrites and asteroids near Jovian orbit also implies that the constituent material of the icy moons has already been hydrated prior to their incorporation into circum-Jovian nebula in which the regular satellites accreted. After the end of accretion (and after initial upwelling segregation of excess water due to the accretional heating), hydrous rock-metal-mixed core starts to warm due to the decay of long-lived radioactive elements. The thermal convection occurs efficiently in such mixed core because of low viscosity of hydrated minerals. However, once the temperature within the mixed core reaches the dehydration point then the viscosity would significantly increase and the efficiency of heat transport would decrease. As a result, thermal run-away would occur, that is, the core temperature would increase higher and the dehydration of rock would further proceed. Consequently, the temperature would exceed the melting point of the metallic component, and thereby metal segregation from rocky material could occur, although in mainly depends on the amount of the heat sources. If the trigger of thermal runaway needs sufficient rocky mass near that of Ganymede, it could explain the dichotomy in differentiation state between the two satellites and the metallic core formation of Ganymede.

To test above idea, we performed numerical simulations for the internal thermal evolution taking into account the reaction heat due to dehydration. In a reasonable range of viscosity is assumed for hydrated rocky core, models for Ganymede experience the dehydration of the pristine mixed-core and possibly the metallic component could segregates from the rocky materials in case of the high silicate content and/or higher viscosity of hydrous rock. On the other hand, Callisto does not undergo dehydration because of the smaller amount of radiogenic heat. The difference of radiogenic heat and the dehydration process have potential to create the dichotomy between two moons. Moreover, this may also explain the geological records on Ganymede showing the occurrence of global extension after the period of heavy bombardment. Global mapping with high spatial resolution in future mission on giant icy moons and improvement of accuracy in cratering chronology (e.g., current estimate on Ganymede's bright grooved terrain has uncertainty of an order of Gyr) are needed to examine our hypothesis.