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Formation of the Ganymede/Callisto Dichotomy by Impacts during the Late Heavy Bombardment

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Despite their similar sizes and compositions, Jupiter's large ice/rock satellites Ganymede and Callisto have followed different evolutionary pathways. Ganymede is fully differentiated, and shows signs of global endogenic resurfacing [1]. Callisto's surface is ancient. Core formation in Callisto has apparently been incomplete; its interior has layers of mixed ice and rock [1].

I will discuss our recent hypothesis that the Ganymede/Callisto dichotomy could have likely arisen during an outer solar system late heavy bombardment [2]. It has been proposed that the lunar Late Heavy Bombardment (LHB) was triggered by dynamical events in the outer solar system [3,4]. For every gram of material that hits Earth's moon, 40 grams hits Callisto and 80 grams hits Ganymede [5]. These hypervelocity cometary impacts onto the satellites melt their ice/rock surfaces, allowing denser rock to sink to the their centers. Once core formation in Ganymede or Callisto is 50% complete, it becomes an energetically self-sustaining process ("runaway differentiation").

Using a 3 dimensional model of impact-induced core formation [2], we find that during an outer solar system LHB, Ganymede undergoes runaway differentiation, but Callisto does not, consistent with their present interior states. The dichotomy is created if the disk supplying LHB cometary impactors contains between about 5 to 21 Earth-masses, consistent with simulations of a disk-scattering event that creates the present day solar system architecture and the lunar LHB [3,4]. Our results imply that the Ganymede/Callisto dichotomy would arise naturally as a consequence of proposed dynamical sculpting processes in the outer solar system.

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