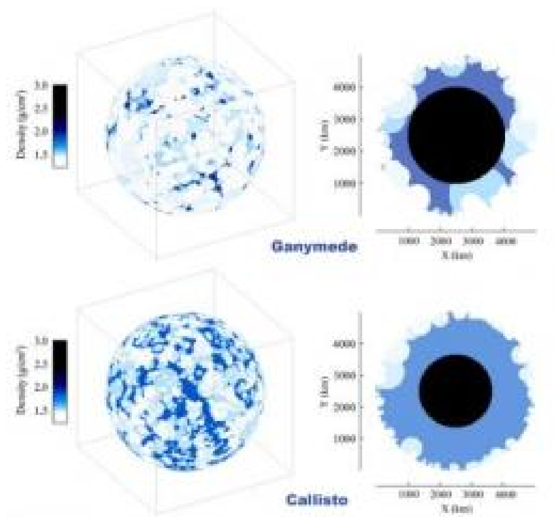
Researchers offer explanation for the differences between Ganymede and Callisto moons

January 24 2010



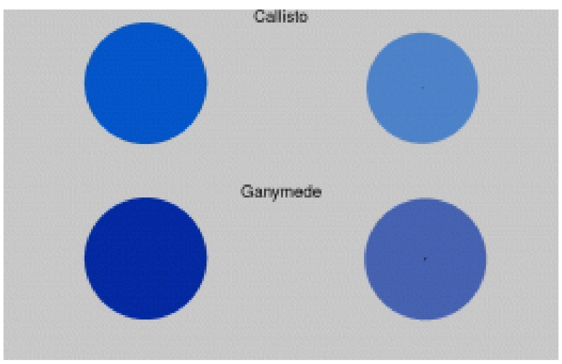
Interior density structures created by an outer solar system late heavy bombardment onto Ganymede (top row) and Callisto (bottom row). The left column shows the density at the surface as a function of latitude and longitude, and the right column shows a slice through the center of the globe. Colors show the density, with black representing pure rock, blue representing mixed ice and rock, and white showing pure ice. Credit: Southwest Research Institute

(PhysOrg.com) -- Differences in the number and speed of cometary impacts onto Jupiter's large moons Ganymede and Callisto some 3.8 billion years ago can explain their vastly different surfaces and interior states, according to research by scientists at the Southwest Research

Institute appearing online in *Nature Geoscience* Jan. 24, 2010.

Ganymede and Callisto are similar in size and are made of a similar mixture of ice and rock, but data from the Galileo and Voyager spacecraft show that they look different at the surface and on the inside. A conclusive explanation for the differences between Ganymede and Callisto has eluded scientists since the Voyager Jupiter encounters 30 years ago.

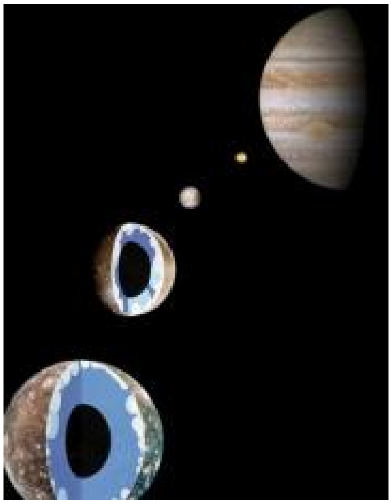
Dr. Amy C. Barr and Dr. Robin M. Canup of the SwRI Planetary Science Directorate created a model of melting by cometary impacts and rock core formation to show that Ganymede and Callisto's evolutionary paths diverged about 3.8 billion years ago during the Late Heavy Bombardment, the phase in lunar history dominated by large impact events.



Click 'Enlarge': The movies show the effect of an outer solar system late heavy bombardment on the interior structure of Callisto (top) and Ganymede (bottom). The left hand side shows the surface of each moon as it suffers repeated impacts that melt its outer layers and clean out rock suspended in its ice. Colors indicate density, with black showing rock, blue showing mixed ice and rock, and lighter shades of blue indicating a decreasing rock fraction. The surfaces are initially blue, indicating a uniform ice/rock mixture. Over time, repeated overlapping impacts remove all of the rock from the moons' outer layers. The right hand side shows a vertical slice through the spinning globe, allowing us to see the growth of the core (black). Each frame of the movie records 50 new impacts onto each moon. Callisto receives 2,600 impacts, but Ganymede receives 5,200. When the late heavy bombardment on Callisto is complete, the movie of Callisto stops, but Ganymede continues to experience an additional 2,600 impacts (so the movie of its evolution has more frames). The final frame of the movie shows the structure of the moons at the end of the late heavy bombardment. Note that Ganymede's rock core is significantly larger than the core created in Callisto.

"Impacts during this period melted Ganymede so thoroughly and deeply that the heat could not be quickly removed. All of Ganymede's rock sank to its center the same way that all the chocolate chips sink to the bottom of a melted carton of ice cream," says Barr. "Callisto received fewer impacts at lower velocities and avoided complete melting."

In the Barr and Canup model, Jupiter's strong gravity focuses cometary impactors onto Ganymede and Callisto. Each impact onto Ganymede or Callisto's mixed ice and rock surface creates a pool of liquid water, allowing rock in the melt pool to sink to the moon's center. Ganymede is closer to Jupiter and therefore is hit by twice as many icy impactors as Callisto, and the impactors hitting Ganymede have a higher average velocity. Modeling by Barr and Canup shows that core formation begun during the late heavy bombardment becomes energetically self-sustaining in Ganymede but not Callisto.



Jupiter (right) and the Galilean satellites (right to left) Io, Europa, Ganymede, and Callisto. Cutaways show the interior states of Ganymede and Callisto after many impacts by icy planetesimals during the late heavy bombardment. Colors represent density, with black showing the rocky core (with a density 3 g/cm^3), blue showing mixed ice and rock (densities 1.8 to 1.9 g/cm^3) and white showing rock-free ice. Credit: Southwest Research Institute

The study sheds new light on the "Ganymede-Callisto dichotomy," a classical problem in comparative planetology, a field of study that seeks to explain why some solar system objects with similar bulk characteristics have radically different appearances. In particular, the study links the evolution of Jupiter's moons to the orbital migration of the outer planets and the bombardment history of Earth's moon.

"Similar to Earth and Venus, Ganymede and Callisto are twins, and understanding how they were born the same and grew up to be so different is of tremendous interest to planetary scientists," explains Barr. "Our study shows that Ganymede and Callisto record the fingerprints of the early evolution of the solar system, which is very exciting and not at all expected."

More information: The article, "Origin of the Ganymede-Callisto dichotomy by impacts during the late heavy bombardment," by Barr and Canup, appears online in *Nature Geoscience* on Jan. 24, 2010.

Provided by Southwest Research Institute