Internal Structure of Callisto: Evidence for subsurface Ocean

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Models of the internal structure of partially differentiated Callisto have been constructed on the basis of *Galileo* gravity measurements, geochemical constraints on composition of chondrites, and thermodynamic data on the equations of state of water, high-pressure ices, and meteoritic material. We show that Callisto must only be partially differentiated into an outer ice-I layer, a water ocean, a rock-ice mantle, and a rock-iron core (mixture of anhydrous silicates and/or hydrous silicates + Fe-FeS alloy). Assuming conductive heat transfer through the ice-I crust, heat flows were estimated and the possibility of the existence of a water ocean in Callisto was evaluated. The liquid phase is stable (not freezing) beneath the ice crust, if the heat flow is between 3.3 and 3.7 mW m^{-2}, which corresponds to the heat flow form radiogenic sources. The thickness of the ice-I crust is 135-150 km, and that of the underlying water layer, 120-180 km. The maximum thickness of the outer water-ice shell is up to 270-315 km. The surface temperature of Callisto is expected to be 100-112 K. The presence of a thick and rigid ice crust prevents flooding of the surface with water and is consistent with the absence of tectonic activity on Callisto. Rock-iron core radii, depending on the presence or absence of hydrous silicates, do not exceed 500-700 km, the thickness of an intermediate ice-rock mantle is not less than 1400 km and the ice content in the ice-rock mantle is between 35 and 42 wt%. Taking into account the H_2O content in hydrous silicates, the total amount of H_2O in Callisto is found to be 48-55 wt%. The correspondence between the density and moment of inertia values for bulk ice-free Io, rock-iron core of ice-poor Europa, and rock-iron cores of Ganymede and Callisto shows that their bulk compositions may be, in general, similar and may be described by the composition close to a material of the L/LL type chondrites with the Fe_{tot}/Si weight ratios ranging from 0.9 to 1.3. Planetesimals composed of these types of ordinary chondrites could be considered as analogues of building material for the rock-iron cores of the Galilean satellites. Similarity of bulk composition of the rock-iron cores of the inner and outer satellites implies the absence of iron-silicon fractionation in the protojovian nebula.