A carbonaceous chondrite and cometary origin for icy moons of Jupiter and Saturn

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The inner structure of icy satellites depends on their evolution throughout time. Several components comprising ices, liquid water, a silicate rocky core and sometimes an inner metallic core are mixed in the less differentiated bodies, and separated in layers in the most differentiated models. Mineralogy and density models for the silicate part of the icy satellites cores are assessed assuming a carbonaceous chondritic (CI) bulk composition and using a free-energy minimization code and experiments. Densities of other components, solid and liquid sulfides, carbonaceous matter, were evaluated from available data. Silicates have higher mean densities than what is commonly used by 8 to 20%, due to the high CI iron bulk concentration. We find that CI density models of icy satellite cores taking into account only the silicate and metal/sulfide fraction cannot account for the observed densities and reduced moment of inertia of Titan and Ganymede without adding a lower density component. We propose that this low-density component is carbonaceous matter derived from insoluble organic matter, in a proportion compatible with contributions from CI and comets. The result on icy satellites suggests that comets and CI chondrites including carbonaceous matter could represent the building blocks of any object that accreted beyond the snow line.