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Large impacts and their contribution to the water budget of the Early Moon

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The Earth/Moon system likely results from a giant impact between a Mars-size objet and the proto-Earth 70 to 100 Myrs after the formation of the first solids of the Solar System. This high-energy context leads to extreme conditions under which volatile elements would not normally be preserved in the protolunar disk. However, recent measurements of lunar samples highlight the presence of a significant amount of water in the Moon's interior (1.2 to 74 ppm). The aim of the present work is to quantify the water contribution of the late accretion on the early Moon. Here, we use a 2D axisymmetric model with the hydrocode iSALE-Dellen to study the fate of a large impactor on a target body similar to the early Moon with a crust, a magma ocean, and a mantle. For this purpose, we compute different models to monitor the depth to which the impacted material is buried at the end of the impact event and the degree of devolatilisation of the impactor. Three parameters are explored: the crustal thickness (ranging from 12 to 100 km), the impactor radius (ranging from 25 to 400 km) and the impactor velocity (ranging from 0.5 to 10 km s^{-1}). Our models show that impactors with a radius greater than 50 km impacting a partially motlen lunar body with a crust thinner than 40 km could significantly contribute to the water content of the lunar mantle even for impact velocities of less than 5 km s^{-1}. For larger impact velocities (> 10 km s^{-1}) the impactor material is significantly molten and its water content is devolatilised within the lunar atmosphere. Depending on the water content of the impactor material and the ability of the lunar magma ocean to maintain chemical heterogeneities, the late lunar accretion following the Moon-forming giant impact could explain the differences in water content between the lunar samples.