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The role of ammonia in the primordial distribution of volatiles in the hydrosphere of Europa

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The presence of hydrospheres within the Galilean moons raises the question of whether or not they could provide habitable environments. The study of nowadays' volatiles inventory on those moons is indicative of their formation processes and their effects on this inventory. However, for the ability to disentangle between the possible scenarios, it is necessary to examine the post-accretion processes that could impact the volatile inventory of the hydrospheres. Especially, an "open-ocean" phase which took place shortly after accretion, before the icy crust formation, must be considered, in view of its influence on the volatile inventory. More specifically, the abundance of ammonia in Europa's building blocks is a key constrain, both on the habitability conditions of the ocean and the volatile distribution in the primordial thick atmosphere of the moon.

Our work focuses on modelling the ocean-atmosphere equilibrium which took place over this period, based on different formation scenarios of Europa. To do so, we compute the vapor-liquid equilibrium between water and volatiles, as well as the chemical equilibria happening within the ocean to investigate the primitive hydrosphere of Europa. Our model allows for an assessment of the impact of the initial distribution of volatiles resulting from the thermodynamic equilibrium between Europa's primordial atmosphere and ocean. In particular, we show the correlation between the ratio of dissolved CO_2 and NH_3 and the distribution of partial pressures in the primordial atmosphere of Europa.

Navigating between two endmembers for the composition of the building blocks (nitrogen delivered by hydrated rocks or cometary ices), and varying the proportion of ammonia incorporated into the ocean after accretion, we obtain a range of primordial volatile distributions, to be linked to nowadays inventory. We also find ammonia abundance thresholds above which CO_2 content is significantly depleted by NH_2COO^- formation.