Theoretical and experimental evidence for wet accretion of Earth

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† In memory of Prof. Michael J. Drake

There has been an ongoing debate on the origin of water on Earth and other inner-solar system planets. So far, there is no consensus regarding the water-delivery mechanism(s) to the terrestrial planets. While water delivery via comets and asteroids is widely accepted, an upper limit for water delivery to Earth of about 15% is necessary, to ensure consistency with the measurements of D/H and Ar/H_2O ratio in water-bearing comets. On similar lines, although asteroids are considered as a plausible source of water, the Os isotope ratio in Earth's mantle rules out of asteroids as being the dominant source of Earth's water. In this context, given that water and solid particulates coexisted in the accretion disk prior to planet formation, it was recently hypothesized that some of Earth's water could be endogenous, with the delivery occurring via direct adsorption of water onto mineral surfaces. To confirm this hypothesis, we have carried out experimental and computational investigations examining water adsorption on olivine grains. The strong binding energy characterizing the adsorption process as seen by both theory and experiments unequivocally indicate that significant amounts of water can be adsorbed on to grains in the accretion disk prior to planetary accretion. This mechanism involving direct adsorption of water on to planetary grains joins late addition of water from comets and wet asteroids as a possible source of Earth's water, and should account for some Earth oceans of water at 1 AU. This process must occur in all disk environments around young stars. The inevitable conclusion is that water should be prevalent on terrestrial planets in the habitable zone around other stars.