Accretion disk origin of Earth's water

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Abstract

Earth's water is conventionally believed to be delivered by comets or wet asteroids after the Earth formed. However, their elemental and isotopic properties are inconsistent with those of the Earth. It was thus proposed that water was introduced by adsorption onto grains in the accretion disc prior to planetary growth, with bonding energies so high as to be stable under high-temperature conditions. Here, we show both by laboratory experiments and numerical simulations that water adsorbs dissociatively on the olivine {100} surface at the temperature (approx. 500-1500 K) and water pressure (approx. 10(-8) bar) expected for the accretion disc, leaving an OH adlayer that is stable at least up to 900 K. This may result in the formation of many Earth oceans, provided that a viable mechanism to produce water from hydroxyl exists. This adsorption process must occur in all disc environments around young stars. The inevitable conclusion is that water should be prevalent on terrestrial planets in the habitable zone around other stars.