



## The role of clathrate hydrates in cleaning the noble gases of Titan's atmosphere

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### Abstract

A striking feature of the atmosphere of Titan is that no heavy noble gases other than argon were detected by the Gas Chromatograph Mass Spectrometer (GCMS) aboard the Huygens probe during its descent to Titan's surface in January 2005. Here we provide an explanation of the mysterious absence or rarity of these noble gases in Titan's atmosphere: the thermodynamic conditions prevailing at the surface-atmosphere interface of the satellite allow the formation of multiple guest clathrates that preferentially store some species, including all heavy noble gases, over others. The clean water ice needed for formation of these clathrates could be delivered by successive episodes of cryo-volcanic lavas that have been hypothesized to regularly cover the surface of Titan. The formation of clathrates in the porous lavas and their propensity for trapping Ar, Kr and Xe would progressively remove these species from the atmosphere of Titan over its history. In some circumstances, a global clathrate crust with an average thickness not exceeding a few meters could be sufficient on Titan for a complete removal of the heavy noble gases from the atmosphere.