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A theoretical investigation of the influence of clathrate hydrates on the atmosphere of Mars and Titan.

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Using a statistical model based on the theory of van der Waals and Platteeuw, we show that clathrate hydrates may influence the gas partionning in the atmosphere of Titan and Mars. Indeed, in January 2005, the atmospheric measurements carried out during the descent of the Huygens probe showed that, except for some tiny amounts of ^{36}Ar, no other primordial noble gases were detected in Titan's atmosphere (their mole fractions may be smaller than the GCMS instrument's sensibility). It has been recently proposed that the formation of clathrate hydrates on the surface of Titan may act as a sink for atmospheric gases and that the trapping of noble gases in such hydrates can deeply modify their atmospheric concentration. The results of our calculations show that there is actually a strong correlation between the evolution of Titan's climate and the efficiency of the noble gases trapping in hydrates. Moreover, we find that, when the Titan's atmospheric temperature and pressure conditions decrease, the capture of Kr and Xe in hydrates becomes more efficient, whereas that of Ar diminishes. Moreover, recent observations have evidenced traces of methane (CH_4) heterogeneously distributed in the Martian atmosphere. However, because the lifetime of CH_4 in the atmosphere of Mars is estimated to be around 250-430 years on the basis of gas-phase chemistry, its actual sources on Mars remain controversial. Among other assumptions, it has been proposed that clathrate hydrates located in the subsurface of Mars could be at the origin of the small quantities of CH_4 detected. Our results show that methane enriched clathrate hydrates could be stable in the subsurface of Mars only if a primitive CH_4-rich atmosphere has existed or if a subsurface source of CH_4 has been (or is still) present.