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Evidence for a primordial origin of Titan's atmospheric methane

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The origin of Titan's atmospheric methane is a key issue for understanding the formation conditions of the saturnian satellite system. It has been proposed that serpentinization reactions in Titan's interior could lead to the formation of the observed methane. Meanwhile, alternative scenarios suggest that methane was incorporated in Titan's planetesimals before its formation. Here, we point out that serpentinization reactions in Titan's interior are not able to reproduce the deuterium over hydrogen (D/H) ratio observed at present in methane in its atmosphere, and would require a maximum D/H ratio in Titan's water ice 30% lower than the value likely acquired by the satellite during its formation, based on Cassini observations at Enceladus. Alternatively, production of methane in Titan's interior via radiolytic reactions with water can be envisaged but the associated production rates remain uncertain. On the other hand, a mechanism that easily explains the presence of large amounts of methane trapped in Titan in a way consistent with its measured atmospheric D/H ratio is its direct capture in the satellite's planetesimals at the time of their formation in the solar nebula. In this case, the mass of methane trapped in Titan's interior can be up to about 1,300 times the current mass of atmospheric methane.