Constraining the deep oxygen abundance of Uranus and Neptune from mass spectrometry and thermochemical modeling

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Abstract

The determination of the deep oxygen abundance in the giant planets is an outstanding question as it bears implications on their formation processes. Oxygen was mainly carried by water beyond the snowline in the Solar System at the time of Giant Planet formation. As ices are responsible for the trapping of the other heavy elements, it is important not only to measure the heavy element abundances themselves, but also to understand in which form water condensed, either amorphous or crystalline, to constrain the deep oxygen abundance. The trapping of heavy elements in clathrates indeed requires a significantly larger initial water abundance than amorphous ice for similar heavy element enrichments. In Uranus and Neptune, the deep tropospheric water will probably remain out of reach for remote sensing and in situ measurements as it condenses already at several hundred bars. In this paper, we investigate the means to determine the deep oxygen abundance of Uranus and Neptune by combining mass spectrometry measurements that would be carried out in situ by an entry probe with thermochemical modeling to link upper tropospheric measurements with deep tropospheric elemental abundances.

Keywords: Atmosphere, formation, thermochemistry

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