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Vers un modèle de dégazage du magma océan définissant la composition de l'atmosphère à l'Hadéen

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Texte :

Nitrogen, carbon, hydrogen and sulfur are essential elements for life constituting less than ca. 1 % of terrestrial planet masses. While they are abundant in the atmosphere due to their volatile nature, the Earth's interior represents the major C-H-N-S reservoirs. Capturing the origin of such distribution between surficial and deep reservoirs require deciphering 4.5 Giga-years of planetary activities, with many unknowns.

Here, we show that the mass of carbon, nitrogen and presumably hydrogen outgassed by the last magma ocean episode, 4.5 Giga-years ago, is similar to the mass of these elements in Earth's present-day exosphere (atmosphere+ocean+crust). By modelling the equilibrium partitioning of C-H-O-N-S elements between the magma ocean and its atmosphere, we show that the oxidation state is critical, yielding H₂-CO dominated atmospheres under strongly reduced conditions and CO₂-N₂-SO₂-rich ones under oxidizing conditions. On Earth, magma ocean degassing at reducing conditions must have produced a C-N-H rich atmosphere. Venus's dry, SO₂-poor, CO₂-N₂ atmosphere perfectly corresponds to an equilibration under slightly more oxidized conditions, possibly linked to enhanced hydrogen loss to space due to a long-lasting magma ocean stage⁹. The C-H-N contents of the mantle and the atmosphere must have marginally changed since these reservoirs were born, pushing back the setting of habitability to the very first 100 millions of years of planetary systems.

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