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Late mixing of a stably stratified hybrid-source atmosphere on newly accreted Mars

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Mars has recently emerged as a natural laboratory for studying the acquisition and physical processing of volatiles on the terrestrial planets. Whereas laboratory analyses of Martian meteorites probe the silicate reservoir(s) that became the Martian mantle and crust, in-situ isotopic measurements of the Martian atmosphere reveal compositions that, in some cases, record processes occurring in the first 500 Myr of planetary history [1,2]. The Martian isotopic record has revealed a dichotomy in volatile compositions: whereas interior volatiles from the mantle (e.g., H, N, Kr, Xe) appear to have a chondritic heritage [e.g., 3-5], the atmospheric reservoir of Kr and Xe have compositions indicating a solar-like source [6].

The compositional dichotomy between the chondrite-like mantle and solar-like atmosphere has been interpreted to mean that the Martian atmosphere could not be the result of magma ocean outgassing and must instead be the result of gravitational nebular capture [5]. However, it is known that the Martian interior systematically lost volatile iodine relative to refractory plutonium during the first tens of millions of years of its history [7], likely due to magma ocean outgassing [8], suggesting a chondritic atmospheric source. Here, we show that disparate inferences on the source of Martian atmospheric volatiles (outgassed versus nebula-captured) can be reconciled with a stably stratified atmosphere [e.g., 9]. In such an atmosphere, a high density (H2-CO-CO2-H2O-rich) outgassed layer is stably stratified beneath a low density (H2/He-rich) upper layer captured from the nebula. We will present a new model of a stably stratified atmosphere in which "late" (post-magma-ocean) mixing (e.g., due to eddy turbulence) reproduces the dichotomy of volatile source compositions observed in the Martian interior-atmosphere system.

References: [1] Musselwhite et al. (1991), *Nature* 352, 697-699 [2] Cassata et al. (2022), *EPSL* 580, 117349 [3] Dudley et al. (2022), *GCA* 317, 201–217 [4] Deligny et al. (2023), *GCA* 344, 134–145 [5] Péron et al. (2022), *Science* 377, 320–324 [6] Conrad et al. (2016), *EPSL* 454, 1-9 [7] Marty and Marti (2002), *EPSL* 196 251-263 [8] Elkins-Tanton (2008), *EPSL*, 271 181-191 [9] Saito and Kuramoto (2018), *MNRAS* 475, 1274–1287.