VOLATILE ACQUISITION DURING TERRESTRIAL ACCRETION: SOLAR WIND (SW)-IMPLANTED NEON IN COSMIC DUST.

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Introduction: Earth's present-day atmospheric noble gas inventory is assumed to have inherited its elemental and isotopic signatures from accreting planetesimals, mantle degassing, meteoritic additions and fractionation processes during Earth's early history [1-3]. The "planetary" composition of the atmosphere includes Ne isotopes with a $^{20}Ne/^{22}Ne$ ratio of 9.8, whereas the "solar" mantle composition rather resembles the solar wind implanted Ne-B in meteorites [4] ($^{20}Ne/^{22}Ne$ ~12.5-12.7).

Currently, micrometeorites (MMs) are dominating the extraterrestrial mass flux to Earth [5,6]. Furthermore, as He and Ne in MMs and interplanetary dust particles (IDPs) are dominated by solar wind isotopic ratios [7], implanted Ne-B in small particles has to be considered as a significant source of the terrestrial noble gases. Especially before the formation of Earth was terminated, cosmic dust with large surface/volume ratios may have been of essential importance as the protoplanetary disk was still dust rich [8]. Accretion of these objects to form proto-Earth might therefore supply sufficient solar gases to Earth's interior.

Model input data: For our model approach we compiled available Ne inventories of MMs and IDPs and complemented Ne data for other objects. Furthermore, we constrained the annual terrestrial influx for solid matter ranging from 10^{-16}g–10^{25}g. The particle flux as well as the size and mass dependent Ne concentrations allow for calculation of the respective Ne flux to Earth. After setting a framework for the terrestrial accretion and scaling for early particle fluxes these values are used as basic input data to model the terrestrial Ne acquisition.

Framework of terrestrial Ne accretion: We consider the earliest phase of terrestrial formation in a shielded disk environment allowing accretion of a significant portion of Earth's mass. After a protoplanetary disk lifetime of a few to tens of millions of years [9,10], part of terrestrial accretion occurs after dissipation of the solar nebula within a cleared disk [11]. This environment allows for implantation of solar wind gases into objects with high surface/volume ratios in regions that are cleared from gas. Impact degassing of accreted material and the formation of a steam atmosphere possibly triggers melting of the surface and dissolution of solar gases into a magma ocean. In a subsequent phase of terrestrial formation after atmospheric loss during the moon-forming impact, mantle degassing and the late veneer completes the atmospheric inventory.

Results and Conclusion: Our performed model calculations fit the current terrestrial atmospheric and mantle neon inventory and their isotopic compositions assuming a more moderately degassed plume-type mantle or a more strongly degassed MORB type mantle. The Ne isotopic composition of the late veneer has a strong influence on the mantle contribution to the atmosphere by mantle degassing, and hence, constrains also the terrestrial inventory of solar wind implanted neon during the early accretion of irradiated cosmic dust. This inventory is limited by the depth of the magma ocean and the fraction of irradiated material. We find that a fraction of less than 12% of the pre-moon-forming impact accreted Ne is dissolved into an early magma ocean with a maximum depth of less than 2500 km. A magma ocean of a few hundred km depth constrains the fraction of SW-irradiated material to less than 10% whereas a depth of more than 1000 km is consistent with less than ~5% irradiated material. In any case, a minimum of $\gtrsim$1% SW-irradiated material is needed to explain the terrestrial Ne inventories.

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