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Escape from catastrophically outgassed volatiles and initial water inventories from early Mars and Mars-like planetary embryos

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Latest research in planet formation indicates that Mars formed within a few million years and remained a planetary embryo that never grew to a more massive planet. It can also be expected from dynamical models, that most of Mars building blocks consisted of material that formed in orbital locations just beyond the ice line which could have contained about 0.1–0.2 wt.% of water. By using these constraints, we estimate the nebula-captured and catastrophically outgassed volatile contents during the solidification of Mars' magma ocean and apply a hydrodynamic upper atmosphere model for the study of the soft X-ray and extreme ultraviolet driven thermal escape of the martian protoatmosphere during the early active epoch of the young Sun. After the solidification of early Mars' magma ocean, catastrophically outgassed volatiles with the amount of about 50–250 bar H_2O and about 10–55 bar CO_2 could have been lost during about 0.4–12 Myr, if the impact related energy flux of large planetesimals and small embryos to the planet's surface lasted long enough, that the steam atmosphere could have been prevented from condensing. Finally, we present results of volatile escape from Mars-like embryos that orbit in closer locations compared to Mars present orbit and discuss the consequences for accretion of planets such as Venus or Earth.