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The early Martian magnetic field: implication for the loss of the atmosphere and water inventory of the planet

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We studied the possible protection of the early Martian atmosphere and its water inventory by an intrinsic magnetic field against ion pick up by the solar wind plasma of the young active Sun. We apply a diffusive-gravitational equilibrium and thermal balance model for high X-ray and EUV flux values which can be expected after the Sun arrived at the Zero-Age-Main-Sequence for the study of the radiation impact on the CO_2-rich Martian thermosphere due to photodissociation and ionization processes, exothermic chemical reactions and cooling by CO_2 IR emission in the 15 μm band. Our results show, that during the Noachian epoch high XUV fluxes between 10 to 100 times that of the present Sun were responsible for much higher temperatures of the early Martian thermosphere-exosphere environment. We found that the exobase level could expand from the present altitude of about 200 km up to about 2000 km (4.5 Gyr ago). Our preliminary results indicate that an early strong planetary dynamo which was active over a period of more than 250 Myr after the formation of the planet, may have protected the early upper atmosphere against solar wind erosion. If one assumes that impact erosion was nearly in balance with impact atmospheric delivery, our results would favour a weak early dynamo with a magnetic moment of less than 0.1 that of the present Earth combined with a higher heating efficiency in the thermosphere, or a late onset of the Martian dynamo not before 200 to 250 Myr after the origin of the planet. In such cases the X-ray and EUV heated and expanded Martian atmosphere could have lost, depending on the solar wind mass flux of the young Sun, between several bar up to some tens of bar of the surface pressure.