Atmospheric evolution on Mars during the heavy bombardment period

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We conducted laser shock experiments using silicate mineral to investigate the atmospheric survivability of early martian atmosphere during the heavy bombardment period. The shock temperature and shock pressure up to 1.2 TPa were obtained simultaneously using time-resolved pyrometry and velocimetory. We found that the shock temperature under warm dense condition at a given shock pressure is systematically lower than the predicted values by M-ANEOS, which is widely-used equations of state in planetary science field. This discrepancy is expected to result from the endothermic heat term due to shock-induced melting, dissociation and ionization. Based on the experimental results, we can calculate the available energy to accelerate the ambient atmosphere via the expansion of a silicate plume after an impact. Then, we constructed a stochastic atmospheric evolution model using a Monte Carlo approach. The probability of a complete atmospheric lost as a function of the initial atmospheric pressure was derived based on our blow-off model, the size and velocity distributions of impactors during the terminal stage of planetary accretion. We found that the cumulative kinetic energy injected into a proto Mars at this time can completely remove a pre-existing atmosphere on Mars.