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Mantle degassing of Mars

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The atmosphere of Mars like of the other terrestrial planets is formed by two main processes: input of volatiles from impacting material and degassing of the interior. In the present paper, we will focus on the input to the atmosphere due to degassing of the interior. The degassing history can be divided into two stages: an early degassing stage during or within a short period after the planetary formation (stage 1) and a continuous or episodic degassing stage throughout the planetary history (stage 2). Degassing during accretion is thought to be a plausible process for stage 1 and may contribute to a primordial atmosphere. Degassing through subsequent volcanic activity is a likely process for stage 2 and may have significantly formed the present atmosphere of the planet.

The degassing rate during the first stage is difficult to asses but can be very high. With a simple mass balance, maximal atmosphere pressures depending on the planet forming material will be estimated. For the second stage, a parameterized convection model is used to study the thermo-chemical evolution of Mars, which allows to calculate the degassing rates e.g. of CO_2 and H_2O that are proportional to the crust formation rate. The model considers the coupling of the atmosphere evolution with the interior evolution as both the viscosity and the melting temperature of the mantle strongly depend on the amount of volatiles. To constrain the model, observations of the crustal evolution are used: 1) the present total crustal thickness of 50 to 120 km (that includes a primordial crust of 20 to 45 km), 2) most of the crust was produced during the Noachian and 3) a continuous decline of global volcanism and crust growth since the Noachian. The degassing rates of the mantle have been calculated for various evolution scenarios of Mars: 1) one-plate convection throughout the entire evolution and 2) early phase of plate tectonics followed by one-plate convection. Further varied is the initial amount of water in the martin mantle for both scenarios.