PHOTOCHEMICAL EFFECTS OF IMPACT MELT POOL OUTGASSING ON MARS. Alejandro Soto[1], Simone Marchi[1], and Benjamin A. Black[2], [1]Southwest Research Institute, Boulder, CO, USA; aso-to@boulder.swri.edu, [2]The City College of New York, New York, NY, USA.

Introduction:

To understand the early Martian climate, we must understand the various mechanisms that created volatiles in the Martian atmosphere. During early Mars, asteroid bombardments, or impacts, may have been an important mechanism for the generation of these volatiles. We still lack, however, a comprehensive understanding of the extent to which impacts may have created transient or long-lived climates capable of sustaining surface liquid water and possible habitable conditions.

Previous research into the effects of impacts on the Martian climate have focused on the delivery of volatiles initially contained in the impactor body or vaporized from the target material. These studies have demonstrated that both water and various greenhouse gases, including carbon dioxide and sulfur species, would have been injected into the atmosphere. These one-time, impulsive injections of volatiles into the Martian atmosphere may have created transient climate conditions conducive to surface liquid water. However, the lifetime of these impact-induced climates have been shown to be geologically short.

Along with the vaporatization of the impactor, large impacts also induce shock melting in the martian crust (and mantle for larger impacts) and will also lead to mantle decompression melting driven by the initial crater excavation and any subsequent convection [1], [2]. Volatile concentrations in the resulting magmas will thus reflect contributions from melting of the crust, the mantle, and possibly also the projectile. The volatiles from the resulting magmas will be delivered into the Martian atmosphere, potentially over an extended, geologically long period of time. Thus, impact melt pools could be a significant source of atmospheric volatiles early in Mars' history.

We have begun to investigate the importance of impact melt pools on the early atmosphere of Mars. We estimate the outgassing of impact melt pools using a recently developed model of impact melt production and outgassing [3]. We then use a photochemical model of the atmosphere to investigate the chemical response of the atmosphere to the impact melt generated outgassing. The goal is to simulate the Martian climate response to the outgassing from impact melt pools generated by large impacts.

Outgassing from impact melt pools: Large impacts create impact melt pools in the following manner. The impact initially vaporizes crustal and mantle material (Figure 1(a)). Crater excavation by the impactor, along with convection due to perturbed isotherms, creates decompression melting deep in the earth (Figure 1(b)). The melt generated by decompression then erupts onto the surface, creating an impact melt pool (Figure 1(c)).

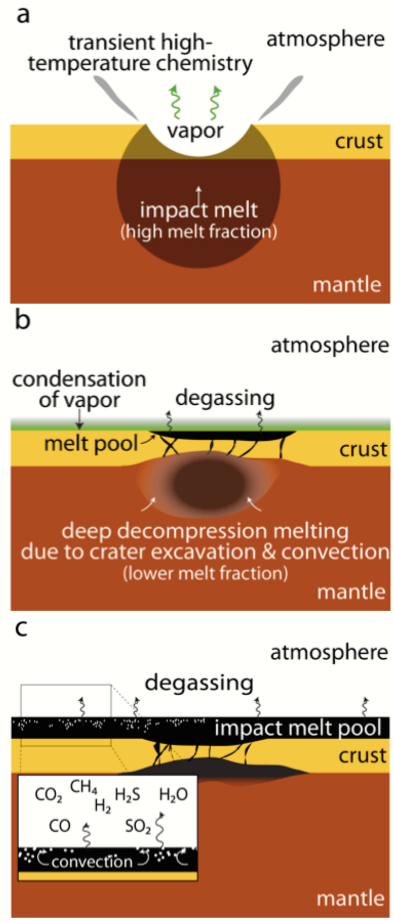

Figure 1. Schematic cross section through an impact-generated melt pool. (a) Vaporization of target material. (b) Deep decompression melting due to crater excavation and convection due to upwarped isotherms. In large collisions, the ejecta and vapor depicted in panel (a) may be responsible for a transient, hot atmosphere dominated by silicate vapor that condenses within several thousand years. (c) Eruption of large volumes of impact-induced melt and degassing.

We estimate the magnitude of carbon, water, and sulfur outgassing from these impact-generated melt pools. Our initial modeling assumes outgassing based on volatile solubilities and outgassing efficiencies derived from terrestrial large igneous provinces [3], for a range of hypothetical impact melt volumes from 10^5-

10^7 km^3. We use constraints from martian meteorites to infer prevailing redox conditions. Future modeling will include thermodynamic calculations of volatile speciation as well as outgassing magnitude.

Photochemical response to impact melt outgassing: We use the total inventory of outgassed volatiles provided by the melt pool modeling as initial conditions for photochemical modeling of the Martian atmosphere. We use a 1D photochemical atmospheric model that is based on Kasting et al. (1979) [4]. This photochemical model is part of Atmos, a coupled photochemical-climate model that has been used to study the Earth, Mars, and exoplanets (for example, see [5], [6], and [7]). We consider the effects of varying starting atmospheric conditions, orbital conditions, and gas compositions.

We will present our initial modeling of the effects of impact melt pool outgassing, comparing pre-impact conditions to post-impact conditions for a variety of melt pool sizes and durations. This 1D model is a first step that will be followed by 3D modeling of the climate effects of these impact melt pools.

References:

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