THE EFFECT OF ATMOSPHERIC PRESSURE ON THE DISPERSAL OF PYROCLASTS FROM MARTIAN VOLCANOES. L. Kerber[1], F. Forget[1], J. B. Madeleine[2], R. Wordsworth[1], J. W. Head[2] and L. Wilson[3]. [1] Laboratoire de Météorologie Dynamique du CNRS, Université Paris 6, Paris, France (Kerber@lmd.jussieu.fr), [2]Department of Geological Sciences, Brown University, Box 1846 Providence RI 02912, [3]Lancaster Environment Centre, Lancaster University, Lancaster LA1 4YQ, UK.

Introduction: Explosive eruptions into the atmosphere of Mars throughout its history are important because of their ability to deposit large quantities of fine particles across large areas, to release significant quantities of water vapor and other volcanic volatiles, and to affect short-term climate. Several authors have explored explosive eruptions into the martian atmosphere, modeling the interactions between the plume and the atmosphere and estimating the height to which the plume can rise convectively [1-3]. Recent work has been done to apply what has been learned from convective plume modeling to the large-scale deposition of far-field ash by releasing ash into a Mars global circulation model developed by the Laboratoire de Météorologie Dynamique (LMD-GCM) [4-6]. These simulations were performed under current martian atmospheric conditions, using Apollinaris Mons, a 5.5-km volcano located near the equator, as a test case [5-6]. However, many of the explosive volcanic centers on Mars (including Apollinaris Mons) can be dated to the Hesperian period of martian history [7-8], when it is possible that the atmospheric pressure was higher than it is at present [9]. Higher atmospheric pressure would affect both the height to which the plume could convect and the subsequent dispersal of the pyroclasts. Higher pressure will mute the initial inertial volcanic blast from the vent (due to drag) [1-2], but may ultimately allow a plume in the convective regime to rise higher (due to the availability of atmosphere to entrain) [3]. After their release from the plume, the pyroclasts should fall faster in a low pressure atmosphere compared with a high pressure atmosphere. In addition to these direct effects on the rise of the ash plume and the fall of the pyroclasts, there will be changes in atmospheric circulation which will affect the strengths and directions of the winds that the pyroclasts encounter as they fall. It is therefore important to compare the results obtained using the modern martian atmosphere with higher pressure simulations in order to test the sensitivity of the model results to different pressure regimes.

Approach: The “ancient” martian atmosphere was modeled using a generalized planetary model developed by the LMD to model the early martian atmosphere and the atmospheres of exoplanets [10]. This model uses a fully-developed radiative-transfer scheme to more accurately model energy exchange in higher pressure atmospheres. For this investigation, the pressure in the model was varied between 7 millibars and 2 bars. In this way it is possible to investigate the effects of increased pressure on the dispersal of volcanic clasts. In the modern martian atmosphere, the convection height of volcanic plumes is limited by the atmospheric pressure: above ~20 km, there is too little atmosphere to entrain, and the plume cannot buoyantly rise any higher [3]. The combination of high subsurface driving pressures and low ambient atmospheric pressures could create strong inertial plumes that would carry pyroclasts to heights in excess of 20 km; however, their horizontal motion while in the higher parts of the atmosphere would be small compared with their horizontal motion at heights less than 20 km [2]. Convecting plumes would reach a neutral buoyancy height at 20 km or lower. In a thicker atmosphere, the basal inertial parts of plumes would extend for a smaller vertical distance (due to drag) but would entrain more atmosphere, so that the upper, convecting parts of the plumes could extend to a greater height ([3] calculated a limit of 65 km for plumes in the ancient atmosphere). For these simulations, we chose a common ash release height of 20 km in order to facilitate comparison between different pressure simulations; however, we also simulated ash dispersal from up to 65 km height in order to incorporate the effects of plume-rise height into the ash-dispersal simulations. The simulations were run for one year as a way of averaging out the effects of seasonal winds (see [6]). The one-year eruption is therefore a proxy for dozens of shorter eruptions that might have taken place over hundreds to millions of years during random seasons. As a point of reference, the total volume of the eruption was taken to be the volume of the nearby Medusae Fossae Formation (1.4 million cubic kilometers [11]). The pyroclasts dispersed in these simulations are 35-µm in radius, representative of small, far-field ash. Pyroclasts larger than about 200 µm would fall on the roughly 40,000 km^2 area representing Apollinaris Mons itself.

Results: The simulations produced ash dispersal patterns different from those produced under a modern martian atmosphere. In particular, whether the majority of the pyroclasts are emplaced east or west of Apollinaris Patera varies as a function of atmospheric pressure (Fig. 1). For example, the direction of dispersal seen at two bars is almost opposite that seen at 0.5 bars. The dispersal seen at 50 mbar is wider and the pyroclasts sample a seasonal wind which transports them to the south of where they are seen in other regimes, such as the two bar regime. Despite these differences, however, the pyroclasts are still dominantly emplaced along a latitudinal line east or west of Apollinaris Mons. In this way the sensitivity of the result to pressure is similar to the sensitivity of the result to season of eruption or obliquity [6]. Pyroclasts erupting from Apollinaris Mons would be expected to travel either east or west, depending on individual parameters, but they would never be expected to travel north or south. Increasing the pressure increases the distance to which each class-size of particles may travel, allowing coarser grain sizes to settle further from the edifice. Allowing plumes to convect to a greater height has the strongest effect on dispersal, resulting in a much wider coverage by the smallest grain sizes.

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