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Aqueous fountaining as a mechanism of deposition at outflow channel sources

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Volcanic activity on Mars can interact with the crust, providing CO2 to the hydrosphere and fracturing the cryosphere. We examine both heat transfer between magma and cryosphere ice, and CO2 transfer between magma and aquifer water. Over the short time-scales required to fracture the cryosphere, plausible amounts of CO2 transferred from magma are readily dissolved at the base of an aquifer under typical pressure and temperature conditions. We examine the physical mechanism by which, in some circumstances, subsurface water containing dissolved CO2 is released through fractures to the surface and emerges as a liquid fountain. All of the bulk densities of mixtures of water and released CO2, for the range of surface pressures found on Mars, are significantly greater than the atmosphere density. Using a series of models we find a relationship between the dissolved CO2 fraction in an aquifer and the height of a fountain that would form at the surface above a crustal fracture connecting the aquifer to the surface. Water eruption velocities range from $\sim$54 to $\sim$163 m s-1, leading to water fountain heights of at least a few hundred meters, up to a few thousand meters with large CO2 content. Such fountains could be responsible for both the erosion observed at the source of Athabasca Vallis, and the series of arcuate ridges surrounding the eastern end of the source graben of Mangala Vallis. Any mixtures of water and carbon dioxide that supplied the outflow channels in the Hesperian or Amazonian may have erupted as such fountains.