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Perspectives

Characterizing basalt-atmosphere interactions on Venus: A review of thermodynamic and experimental results

Justin Filiberto[1,*] and Molly C. McCanta[2,†]

[1]Astromaterials Research and Exploration Science (ARES) Division, NASA Johnson Space Center, Houston, Texas 77058, U.S.A.
[2]Department of Earth and Planetary Sciences, University of Tennessee at Knoxville, Knoxville, Tennessee 37996, U.S.A.

Abstract

The surface of Venus is in contact with a hot (~470 °C), high pressure (92 bars), and caustic (CO_2 with S, but little H_2O) atmosphere, which should cause progressive alteration of the crust in the form of sulfate and iron-oxide coatings; however, the exact rate of alteration and mineral species are not well constrained. Different experimental approaches, each with its own limitations, are currently being used to constrain mineralogy and alteration rates. One note is that no experimental approach has been able to fully replicate the necessary conditions and sustain them for a significant length of time. Furthermore, geochemical modeling studies can also constrain surface alteration mineralogy, again with different assumptions and limitations. Here, we review recent geochemical modeling and experimental studies to constrain the state of the art for alteration mineralogy, rate of alteration, open questions about the surface mineralogy of Venus, and what can be constrained before the fleet of missions arrives later this decade.

Combining the new results confirms that basalt on the surface of Venus should react quickly and form coatings of sulfates and iron-oxides; however, the mineralogy and rate of alteration are dependent on physical properties of the protolith (including bulk composition, mineralogy, and crystallinity), as well as atmospheric composition, and surface temperature. Importantly, the geochemical modeling results show that the mineralogy is largely controlled by atmospheric oxygen fugacity, which is not well constrained for the near-surface environment on Venus. Therefore, alteration experiments run over a range of oxygen and sulfur fugacities are needed across a wide range of Venus analog materials with varying mineralogy and crystallinity.

Keywords: Venus, experimental petrology, sulfates, iron oxides, weathering, atmosphere, alteration rate, oxygen fugacity