Solving the Sulfur Problem: Box Modelling Sulfur Transfer on Mars Using Earth as a Geochemical Analogue

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Mars' current surface preserves a geological record for its mineralogical processes, with volcanism once being the primary source of sulfur transport. However, there is a mismatch between the location of volcanic provinces and satellite instrument detections of high sulfur concentrations, which exceed Earth's basalts by almost an order of magnitude. Here I test the hypothesis that including both eruptive and quiescent degassing rates and flux values (volume over time) in a box model of Mars' sulfur cycle can better justify the observed sulfur content. Applying the principles of comparative planetology, the degassing rates for Earth volcanoes with similar eruption conditions to Mars were found using multidecadal SO_2 measurements. These were equated to Martian volcanoes through the surface area of volcanoes, calculated through map analysis. Box model calculations found that, for quiescent and explosive degassing fluxes of 5x10^5 kgyr^{-1}km^{-2} and 5x10^8—5x10^9 kgyr^{-1}km^{-2} respectively over a eruption duration of 2 myr, 5.8x10^{21}—5.8x10^{22} kg of sulfur was released into the atmosphere. These results agree with current literature and are the first attempt in providing holistic values that account for the net planetary movement of sulfur, serving as the foundation for future calculations in consolidating the sulfur cycle. Knowing the magnitude of the sulfur cycle contributes to understanding how climate change could remove sulfur — the source of energy to fuel sulfur-metabolizing microbes — from the environment. The novel method of using comparative planetology principles to estimate a flux rate can also be applied to other rocky planets in our solar system or beyond.

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