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Petrological modeling of sulfur cycling at active coronal boundaries on Venus

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The dynamics of geological volatile cycling on terrestrial planets have profound implications for the development and sustainment of habitable worlds. On Venus, sulfur-bearing gases, most notably SO_2, are abundant in the atmosphere[1] and inferred to be the main components in atmosphere-surface interactions (e.g., diopside/anorthite weathering) which serve as a sink for SO_2[2]. However, Venusian volcanism is episodic and may not occur frequently enough to sustain observed atmospheric SO_2 levels, creating an apparent imbalance within the Venusian sulfur cycle[1].

Active coronal boundaries are areas of potential exchange between the Venusian surface and deeper mantle: here, ongoing mantle plume activity drives pseudo-subduction of the lithosphere[3], potentially bringing weathered basalt enriched in sulfur to great depths, where S can either be devolatilized via metamorphism or assimilated into the mantle. We therefore evaluate sulfur evolution in these zones as follows: (1) Theoretically and experimentally determined bulk compositions of both weathered and unweathered basalts and andesites on Venus[4][5] are selected. (2) An estimated temperature profile[6] for the Venusian interior is utilized to generate P-T paths of pseudo-subducting lithosphere. (3) Thermodynamic modeling software[7] is used to calculate stable phases (including S_2 fluid after ref.[8]) along these P-T paths and calculate petrologic (pseudosection) models for each sample.

Initial calculations reveal that at a depth of ~125 km, reactions within the pseudo-subducting lithosphere begin to produce S_2 fluid from weathered basalt and andesite samples. It is unclear whether liberated S_2 fluid could ultimately be degassed at the surface or trapped in the overlying lithosphere; nevertheless, an additional flux of S_2 into the lower atmosphere (and subsequent oxidation into SO_2) could help balance the Venusian sulfur cycle. We therefore suggest that ephemeral pseudo-subduction at active coronal boundaries could constitute a key component of global sulfur cycling on Venus.

[1] Fegley (2014), *Treatise on Geochemistry* [2] Dyar et al. (2021), *Icarus* [3] Gülcher et al. (2020), *Nature Geoscience* [4] Treiman & Schwenzer (2009), *Venus Geochem.* [5] Klose & Zolotov (1992), *Lunar and Planetary Science Conference* [6] Smrekar et al. (2007), *Geophysical Monograph Series* [7] de Capitani & Petrakakis (2010), *American Mineralogist* [8] Evans et. al (2010), *Journal of Metamorphic Geology*