Initiation, Interaction, and Suppression of Mantle Plumes on Venus-analog Planet using StagYY Numerical Model

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The volcanic dichotomy observed on the planet Venus is one of the most interesting questions in planetary science. Roughly the same composition, size, and distance from the Sun as the Earth, Venus has a unique topographic landscape of both Large Igneous Provinces (L.I.P.s) which are present on Earth (i.e. the Hawaiian volcanic chain) and **coronea,** fractured and circular regions of smaller volcanic upwellings, not present on Earth[1] . Additionally, Venus has a single tectonic plate, covering the entire planet's surface, whereas Earth has a system of over 20 moving plates that form at mid-ocean ridges and elsewhere **subduct** (i.e. sink back into the mantle), part of a heat-releasing convective process that drives planetary evolution[2]. Research in the past 20 years since the Magellan mission suggests that Venus may have processes analogous to Earth-type subduction of its outer layer[3], and investigation into subduction on Venus may hold the key to understanding the volcanic dichotomy of regionally-close L.I.P.s and coronae formation[4,6].

Numerical models solving for the conservation of mass, momentum, and energy of a viscous fluid are run using the parallelized, planetary-convection code StagYY[5] on the Expanse supercomputer at the San Diego Supercomputing Center. The domain of the model is a two-dimensional hemi-spherical annulus of a terrestrial planetary mantle. We initialize the mantle at potential temperatures of 1600 K, 1700 K, and 1800 K, and the model is heated from the bottom an additional 100, 200, 300, and 400 K above the background mantle temperature. This sharp temperature gradient simulates the effect of a hot core heating a thermal boundary layer of critical fluid at the core-mantle boundary, from which mantle plumes, buoyant upwellings of silicate rock, form and ascend.

Adding depth-dependent viscosity as well as disconnected, sinking slabs of cold, viscous lithosphere into the model's mantle creates various regimes of mantle plume initiation, interaction, and suppression, reflecting a volcanic dichotomy that could play out on the planet's surface[6]. Future work will investigate the role of thermochemical effects in the creation of regional, multi-scale volcanism on Venus[7].

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