**Venus Geodynamics, Habitability, and Initiation of Subduction, S. Smrekar\(^1\) and A. Davaille\(^2\), \(^1\)Jet Propulsion Laboratory (USA), smrekar@ipl.nasa.gov, \(^2\)CNRS/FAST, Univ. Paris Sud (France), anne.davaille@u-psud.fr.**

**Introduction:** In addition to the push to find past or present life beyond our home planet, a key astrobiological objective is to understand what it takes to create a habitable world [1]. Currently we have one example of such a world: Earth. Understanding the divergent evolution of Venus from a geodynamic viewpoint is essential to understanding how Earth successfully developed and sustained life.

**Plate tectonics and habitability:** Plate tectonics may play a key role in supporting life on Earth. Since both life and plate tectonics began billions of years ago, their definitive origins are murky. However plate tectonics clearly drives the release of volatiles from the interior that forms the bulk of Earth’s atmosphere and hydrosphere and the recycling of volatiles into the interior via subduction, thus strongly regulating long term climate [1]. Plate tectonics is responsible for cooling the mantle and driving the core dynamo that shields Earth from radiation. Erosion of continents introduces nutrients into the oceans. Subduction of carbon may have lead to the great oxidation event that promoted the flourishing of life [2]. An increase in continental area, due to creation of continents via plate tectonic processes, increased nutrient concentrations in the oceans via enhanced weathering.

Just as plate tectonics is a key process for Earth’s habitability, Venus’ geodynamic evolution is essential to understanding how it arrived at its current uninhabitable state. Given its similarities to Earth, a fundamental question for Venus is why does it lack plate tectonics? For a long time, the prevailing hypothesis was that Venus is too dry. A dry interior can make the lithosphere very strong, and may prohibit a low viscosity zone, both of which inhibit plate tectonics. However, numerous lines of evidence point to the fact that planets start with the bulk of their volatiles, which are outgassed via volcanism. Venus’ Ar isotope data strongly suggests that Venus retains more interior volatiles than Earth, possibly due to the absence of plate tectonics. [3,4].

**Plate tectonics and the initiation of subduction:** A key question for plate tectonics on Earth is how did it transition from a single plate to multiple plates? The initiation of subduction appears to be the necessary (but insufficient) first step as it allows for the lithosphere to fully break and initiates slab pull forces. One hypothesis is that mantle plumes are responsible for initiating subduction on Earth [5].

Venus may be undergoing present-day initiation of subduction, and providing a blueprint for how Earth may have transitioned to plate tectonics. Both Artemis and Quetzelpetal Coronae appear to be locations of plume-induced subduction [5]. Artemis is by far the largest corona (2600 km diam.) and Quetzelpetalatl is the 3rd largest (800 km diam.). Several other smaller coronae, mostly located along major extensional belts, have also been proposed to be subduction zones. How common is plume-induced subduction on Venus and what are the conditions required for initiation?

Analytic [6] and numerical [7] models examine this question for Earth. The lithosphere must be weak enough to allow it break, yet strong enough to remain intact as it bends and sinks into the mantle. Lithospheric strength is dominated by temperature and composition. Venus’ lithosphere is hotter than Earth’s currently, but similar that of early Earth. For plume induced subduction, the lithosphere breaks due to extension driven by plume buoyancy. For a given mantle temperature, these requirements constrain the lithospheric thickness range favorable for plume-induced subduction (figure 1) [5].

![Figure 1](image.png)

New estimates of elastic thickness at numerous coronae with and without the characteristic surface features of plume induced subduction [8,9] support this prediction. Most coronae occur on lithosphere that is too weak to support initiation of subduction.

**Conclusion:** The quest to identify habitable exoplanets relies on habitability models. Venus’ similarities to and differences from Earth make it the ideal control case for understanding how interior dynamics, surface volcanism, tectonism, outgassing and weathering produce habitable planets -or not [e.g. 10, 11]. In particular, Venus may constrain the initiation of plate tectonics.


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