National Aeronautics and Space Administration

Venus Science Into the Next Decade

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Strategic Focus Area: Venus Science and Technology Initiative - Strategic Initiative Leader: Jeffery L Hall

Background: This proposal provides the quantitative scientific motivation for future missions from 2 objectives: I) the first ever comprehensive estimation of Venus' seismicity from both shallow and deep sources, along with modeling of seismic wave propagation into the atmosphere validated using earth data, and II) estimate rates of weathering, including of rock indicative of past water (Venus' putative granitic continents). This proposal address the essential elements needed to enable the selection of such a mission: 1) provide a comprehensive estimate of likely active seismicity on Venus, based on a range of possible seismic sources (volcanos, shallow faulting, and deep, phase-change driven quakes), 2) provide seismic detectability estimates via comprehensive modeling of seismic wave propagation in Venus' atmosphere, and 3) assesses mineralogy as a way to identify and provide an age estimate for recent volcanism. This work could also be used to justify other types of measurements of seismicity from orbit and surface landed missions to investigate mineralogy and weathering. The science community's growing interest in Venus should be accompanied by a strong research initiative to ensure JPL is the leader for Venus exploration.

Objectives:

- **Objective 1A: Shallow Seismicity.** In this Objective we will identify seismic 'type locales' based on geologic setting identifying the fault dimension, type, and likely magnitude; and determine likely active sources. These Tasks will be integrated to produce a defensible estimate of seismicity on Venus.
- **Objective 1B: Deep Seismicity.** In this Objective we will identify likely regions of subduction, lithospheric dripping, and crustal thickening, to estimate potential sources of deep seismicity. We will also conduct laboratory measurements to explore the characteristics of hydrous and anhydrous (metastable) phase transitions at depth.
- **Objective 1C: Surface-atmosphere coupling.** Seismic events and propagation of related pressure waves in Venus' atmosphere will be investigated through seismo-acoustic modeling in order to understand detectability (a crucial aspect of future mission designs).
- **Objective 2: Mineral Weathering.** We will perform weathering studies on minerals under Venus surface conditions using the newly operational Planetary Geochemistry Simulation Facility.

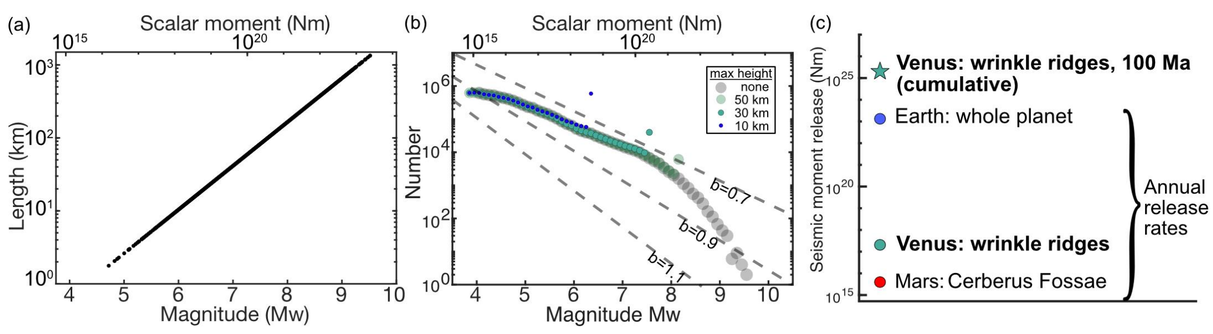

Figure 1: (A) Venusquake magnitudes calculated from wrinkle ridges mapped by Bilotti & Suppe 1999. (B) Size-frequency diagram for three maximum faulting heights of 10, 30, and 50 km, and with no maximum height. (C) Comparison of annual seismic moment release measured on Mars (red circle, Stahler et al. in press) and on Earth (blue circle) to our estimates for Venus. Our cumulative moment release estimate for Venusian wrinkle ridges (green star) is used to calculate a likely annual moment release from Venusian wrinkle ridges (green dot) based on 100 Myr activity. Wrinkle ridges are only one of several possible seismic sources on Venus.

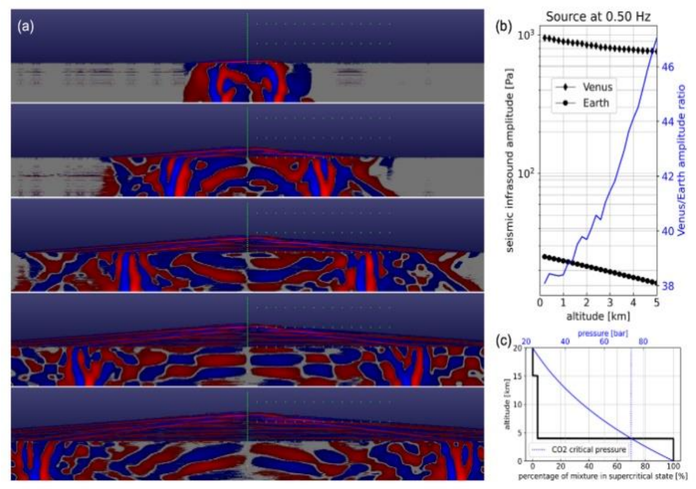

Figure 2: (a) Snapshots for a Venusquake simulation. The atmosphere background model is extracted from the Venus Climate Database (VCD). (b) Ratio of seismic infrasound between Earth and Venus. This demonstrates that for a similar quake, seismic infrasound will be at least 40 times stronger on Venus than on Earth. (c) Venusian atmosphere supercriticality, based on parameters extracted from the VCD.

Significance/Benefits to JPL and NASA: Revealing Venus' geological history is key to our understanding of how Earth-like planets have evolved. Venus is the only terrestrial planet for which we can't answer such basic questions as 1) What are the youngest geological processes? 2) What processes are active? 3) What is the composition of the surface? 4) Is there chemical evidence for past surface water? NASA has not visited Earth's twin planet in 30 years; now, there are two NASA missions selected to return to Venus, including VERITAS. JPL has also recently invested in balloon studies for long term atmospheric and surface investigations on Venus. Both VERITAS and an atmosphere balloon mission would map surface composition at different resolutions, and would look for geologic activity using different approaches. Weathering on Venus is also not well understood; our new Venus lab facility will be used to provide some of this valuable information.

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