VERITAS (VENUS EMISSIVITY, RADIO SCIENCE, INSAR, TOPOGRAPHY AND SPECTROSCOPY): A SELECTED DISCOVERY MISSION, S.E. Smrekar[1], S. Hensley[1], M.D. Dyar[2], J. Whitten[3], D. Nunes[1], J. Helbert[4], L. Iess[5], E. Mazerico[6], J. Andrews-Hanna[7], D. Breuer[4], D. Buczkowski[8], B. Campbell[9], A. Davaille[10], G. DiAchille[11], C. Fassett[12], M. Gilmore[13], R. Herrick[14], L. Jozwiak[8], T. Kataria[1], A. Konopliv[1], M. Mastrogiuseppe[5], N. Mueller[4], M. Raguso[1], J. Stock[15], E. Stofan[6], T. Widemann[16], H. Zebker[17]; [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA 91109, ssmrekar@jpl.nasa.gov; [2]Mt. Holyoke Coll., MA, USA; [3]Tulane U., USA, [4]Inst. Planetary Research, DLR, Berlin, Germany; [5]U. Roma La Sapienza, Italy, [6]NASA Goddard, USA, [7]U. AZ, Tucson, USA; [8]John Hopkins U./APL, USA; [9]Smithsonian Inst,. DC, USA; [10]CNRS/FAST, Paris, France; [11]Inst. Natl. Astrophys., Italy; [12]NASA Marshall, USA, [13]Wesleyan U., USA, [14]U. AK Fairbanks, USA; [15]Caltech, USA, [16]Observ. De Paris/LESIA, France. [17]Stanford U., USA.

Introduction: VERITAS was selected as a Discovery class mission on June 2, 2021. It is designed to understand Venus' evolution through acquiring foundational, high resolution global datasets. A deep understanding of planetary habitability requires identifying key factors that govern the environment over time. Venus is the ultimate control case for studying how Earth developed and maintained conditions suited to life. Venus is very likely to have had elements essential to habitability [1,2] such as (past) surface water and even a dynamo. Tectonism and volcanism, with associated outgassing and driven by a robust internal energy budget, very likely persist today. Current interactions among the interior, surface, and atmosphere may include exchange of volatiles.

Mission Overview: VERITAS was selected to kick off the Decade of Venus, with a launch in 12/2027. Other Venus missions, DAVINCI (NASA) and ENVISION (ESA), are scheduled for launch in 2029 and 2031, respectively. In Nov. 2022, NASA directed that VERITAS be delayed in response to the findings of the Psyche Independent Review Board (https://www.nasa.gov/sites/default/files/atoms/files/psyche_irb_report_and_response_nov_2022.pdf). Due to these and other financial issues outside of VERITAS, VERITAS may be delayed for ~3 years.

Payload: VERITAS carries two instruments, the Venus Interferometric Synthetic Aperture Radar (VISAR) and the Venus Emissivity Mapper (VEM), plus a gravity science investigation. The VISAR X-band [6] datasets include: 1) a global digital elevation model (DEM) with 250 m postings and 6 m height accuracy, 2) Synthetic aperture radar (SAR) imaging at 30 m horizontal resolution globally, 3) SAR imaging at 15 m resolution for targeted areas, and 4) surface deformation from repeat pass interferometry (RPI) at 2 cm precision for targeted areas.

VEM [7] covers >80% of the surface in six NIR bands located within five atmospheric windows sensitive to iron mineralogy, plus eight atmospheric bands for calibration and water vapor measurements. This configuration offers significant advantages over systems like Visible and Infrared Thermal Imaging Spectrometer (VIRTIS) instrument on the European Space Agency Venus Express mission. Specifically VEM has significantly enhanced SNR and higher wavelength stability, providing the ability to ratio band intensities and use slopes between bands. The instrument will be calibrated by the German Space Agency in Berlin using the Planetary Spectroscopy Laboratory [9,10,11]

VERITAS's low circular orbit (< 250 km, mean 217 km) and Ka-band uplink and downlink to create a global gravity field with 3 mGal accuracy at 155 km resolution – a significantly higher and more uniform resolution than available from Magellan [11].

Science Overview: *Past and Present Water:* VERITAS looks for the chemical fingerprint of past water in the tessera plateaus and larger inliers. Tessera plateaus may be analogous to Earth's continents, which form when basalt melts in the presence of water. VEM determines if tesserae are globally felsic or mafic, and thus analogous to continental crust or not [12,13,14]. The near-global VEM dataset provides the first ever map of surface rock-type on Venus.

Specific VEM bands are dedicated to detect near-surface water vapor [7] above background levels that indicate outgassing. Observations would be correlated with other indicators of surface change (see below) to provide convincing evidence of present day outgassing. Due to the high surface pressure on Venus, outgassing, if observed, would require several % water in the magma and would thus be an extremely valuable constraint on Venus' interior volatile content.

Current Activity: Multiple datasets yield evidence for current or recent volcanism. Both Venus Express VIRTIS [15] and Magellan emissivity data [16] provide evidence of incomplete chemical weathering and thus recent volcanism. Venus Express also observed SO_2 variations likely due to volcanic outgassing [17].

VERITAS' multiple methods to search for activity include 1) cm-scale geologic deformation, 2) recent, chemically unweathered flows, 3) volcanic thermal emission, 4) topographic or surface roughness changes, 5) near-surface water vapor, and 6) comparisons to past mission data sets including Magellan radar images and Venus Express NIR spectra at 1.02 µm. We compare the VISAR X-band to Magellan S-band imaging after accounting for look and wavelength differences.

This approach requires that new features, such as lava flows, have different radar backscatter than the pre-existing flows. This suite of analyses is key to investigating global activity because ~40% of the surface consists of 'featureless' plains, with limited radar backscatter variation. Flows with the same backscatter as prior flows are invisible in SAR images. Significant flows can be mapped using the VISAR DEM. VERITAS plans a field campaign, in conjuction with the German Space Agency airborne F-SAR to both validate change detection algorythms between x- and s-band radar and investigate earth-anaology signatures in X-band SAR [18,19]

Geologic Evolution: VERITAS answers key science questions via: 1) examining the origin of tesserae plateaus – possible continent-like features, 2) assessing the history of volcanism and how it has shaped Venus' young surface, 3) looking at craters and modifications subsequent to their formation, 4) characterizing possible subduction zones and the processes governing their formation, 5) looking for evidence of prior features buried by volcanism, and 6) determining the links between interior convection and surface geology. VERITAS would create a global inventory of geodynamic processes to understand the alternate evolutionary path of Earth's twin.

Gravity Science: The average Magellan spherical harmonic gravity field resolution is only degree and order 70. Spherical harmonic degrees less than degree and order 70 contain little or no information on elastic thickness [20]. VERITAS data, with a global resolution of 160 km (degree and order >100), enables estimation of elastic thickness (a proxy for thermal gradient) and density differences due to subsurface processes (e.g., rifts, small plumes [e.g., 21]). VERITAS also constrains interior structure, including mantle viscosity, core size and state [22-24].

Targeting approach: *SAR Imaging.* VERITAS obtains imaging at 30 m and 15 m, global and targeted (>25%) respectively. This level of coverage is enabled by onboard processing of the radar data. Throughout the mission, community input will be requested via both workshops and online. An extended mission would increase this 15 m coverage.

RPI Targeting. This resource is primarily limited by a) data volume because it requires full resolution raw data be downlinked, and by b) fuel to maneuver into position for the 2nd observation. The minimum RPI requirement is for twelve 200 × 200 km targets. Initial RPI targets focus on regions proposed to be active, again assessed with community input.

Conclusions: VERITAS would create foundational data sets of high-resolution topography, imaging, spectroscopy, and gravity. These co-registered data are on par with those available for Mercury, Mars, and the Moon, which have revolutionized our understanding of these bodies. VERITAS answers outstanding fundamental questions such as whether catastrophic resurfacing occurred, what types of geologic processes are active, whether tessera record the chemical history of water, and core size and state. VERITAS discoveries would lay the groundwork for future Venus missions, providing complementary data to optimize the science return of probe, arial, or lander missions. The motivation for this mission in the context of planetary habitability is described in a Decadal Survey white paper [25]. [26] provides a detailed overview of the mission. Further, VERITAS offer synergies with DAVINCI and ENVISION in terms of complimentary dataset resolution and converage, and, as originally planned for a 2027 launch, an extended observational baseline with modern instrumentation. As such, these synergies represent the potential for enhanced science return and a benefit to all of the community.

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