DAVINCI Mission to Venus: Connections to Habitability, Planetary Evolution, and Exoplanets. James B. Garvin[1], Giada Arney[1], Stephanie Getty[1], Natasha Johnson[1], *and* Erika Kohler[1] with the DAVINCI *Science Team*[2]; [1]NASA GSFC, Greenbelt MD 20771 USA (james.b.garvin@nasa.gov); [2]Science Team institutions including: NASA GSFC, NASA JPL, NASA JSC, NASA ARC, MSSS, JHU/APL, U. Michigan, Wesleyan, Univ. Calif./Riverside, Ariz. State Univ., PSI, Smithsonian (CEPS), ASI (Italy), and CNRS (France).

Introduction: The recently-selected Deep Atmosphere Venus Investigation of Noble gases, Chemistry, and Imaging (***DAVINCI***) mission is now planned for a June 2029 launch to Venus, with atmospheric entry for an hour-long transect of the atmosphere from ~ 70 km to the surface in June 2031 [1].

DAVINCI's emphasis is atmospheric evolution coupling the deep atmosphere to history of the surface with connections to tesserae, as well as setting boundary conditions on upper atmosphere chemistry and dynamics (**Figs. 1,2**). Measurements involving analytical chemistry of the atmosphere at altitude intervals to understand atmospheric profile via two primary instruments (VMS and VTLS), plus contextual observations of the physical parameters as often as every 14-50 m by an atmospheric structure investigation, are central to the mission as fundamental boundary conditions for the Venus community in a new era of Venus exploration. In addition, first-ever sub-cloud-deck Near Infrared imaging of composition and morphology (with derived topography) will be achieved for an area of pristine tesserae in *Alpha Regio* using a high sensitivity descent imaging system (VenDI). Two Venus flybys prior to the entry of the DAVINCI descent sphere (probe) will complement the in situ measurements with near UV movies of cloud motions together with nightside NIR emissivity of key tesserae (*Alpha, Ovda*) and volcanic centers (*Maat*) with hundreds to thousands of overlapping images at 0.93 to 1.02 μm. Collectively, these datasets will allow DAVINCI to contribute to the ensemble of new measurements forthcoming from VERTIAS, EnVision, as well as from *RocketLabs* (Venus Life Finder), ISRO, and others.

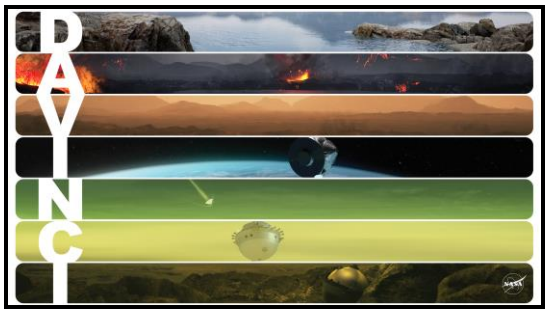

Fig. 1: *DAVINCI addresses interconnected themes in Venus exploration via the atmosphere and its evolution and relationship to surface materials.*

Approach: DAVINCI's focus is on filling the long-standing gaps in the altitude-resolved chemistry and dynamics of the Venus atmosphere, first outlined in 1983 in the SSEC report by Morrison and Hinners [2], and amplified via the work of VEXAG and in the latest Planetary-Astrobiology Sciences Decadal Survey "Origins, Worlds, and Life" [3].

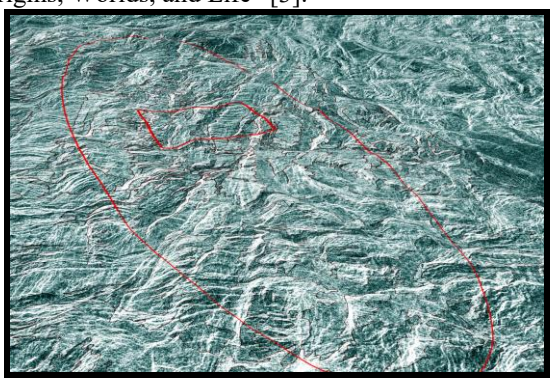

Fig. 2: *DAVINCI entry ellipse (red) atop a perspective view of Magellan SAR backscatter (FMIDR) draped atop a new Arecibo/Magellan Pseudo-Topography Model (PTM) developed by the DAVINCI team (see [1]).*

New discoveries about Venus including the role of phosphine (PH_3) and other species make the chemical context of the atmosphere and the key cycles involving C, H, N, O, P, and S (and D/H in water) all the more relevant as new models are advanced. Furthermore, the onset of the age of James Webb Space Telescope (JWST) and its planned observations of potential Venus-like exoplanets around cooperative parent stars will make detailed comparisons relative to Venus possible in the next decade [4]. Finally, new laboratory measurements relevant to Venus from DLR's PSL and from JPL-based high-temperature electrical properties investigations will contribute to interpretation of DAVINCI (and other mission) data moving forward, as well as activities coordinated by the newly-formed international VeSCoor group.

DAVINCI is prepared to address key themes identified by VEXAG and the PAS-Decadal Survey [3] as priorities, as follows:

Atmospheric Evolution: DAVINCI will study signatures of the origin and evolution of the Venus atmosphere through measurements of noble gases, stable isotope ratios, and compositional abundances.

Surface-Atmosphere Interactions: DAVINCI will measure composition of the atmosphere near the surface to constrain chemical interaction and exchange between the lowest regions of the atmosphere and descent imagery and mapping of the *Alpha Regio* tessera descent region (**Fig. 2**).

History of Water: Prior measurements of isotopic ratios in water indicate losses of vast amounts of water from Venus. DAVINCI will definitively confirm the D/H ratio in water and correlate with complementary insights into sources, processing, and losses of water on Venus to provide a new understanding of the history of water on the planet.

Formation/Evolution of Tesserae: DAVINCI will enable differentiation between rock types on the surface through remote sensing measurements from flyby and NIR descent imaging, connecting these observations to local maps and providing new compositional and topographic insights. These first views of the Alpha Regio tessera under the clouds will feature unprecedented spatial resolution as fine as one meter.

Connections Beyond: With JWST observations of exoplanetary systems such as TRAPPIST-1 already in hand and others planned for the near term, the opportunity for understanding how a candidate exo-Venus may present is at hand. DAVINCI measurements of our "exoplanet next door" will facilitate detailed examination of such JWST-discovered exo -Venuses in the context of how our Venus operates today [4]. Such exoplanetary connections are a new aspect of solar system exploration that DAVINCI aspires to support [1,3, 4]. DAVINCI is ready to support interdisciplinary, community-based investigations of Venus (**Fig. 3**) as part of the "decade of Venus" missions.

Fig. 3: *DAVINCI is ready for Venus, launching in June 2029, with planetary entry, descent, science, and touchdown in June 2031.*

References: [1] Garvin J. B. *et al.* (2022) *Planet. Sci. J. 3,* 117. [2] Morrison D & N. Hinners (1983) *Science 220, Issue 4597*, pp. 561-567. [3] PAS Decadal Survey (2022) "Origins Worlds Life", NASEM press. [4] Kane S. R.,. *et al.* (2014) *ApJ 785,* 93. [5]
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