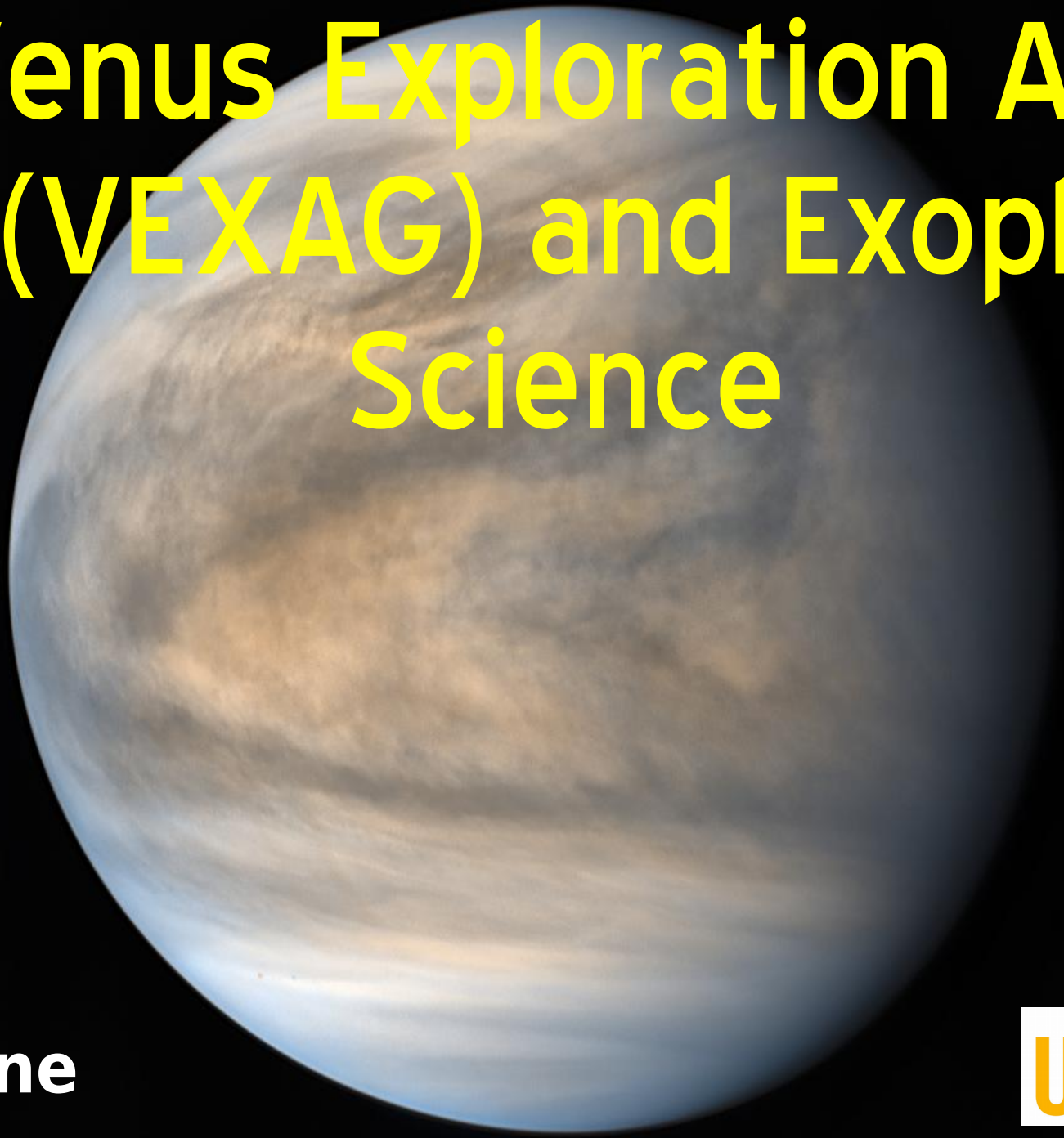
The Venus Exploration Analysis Group (VEXAG) and Exoplanetary Science



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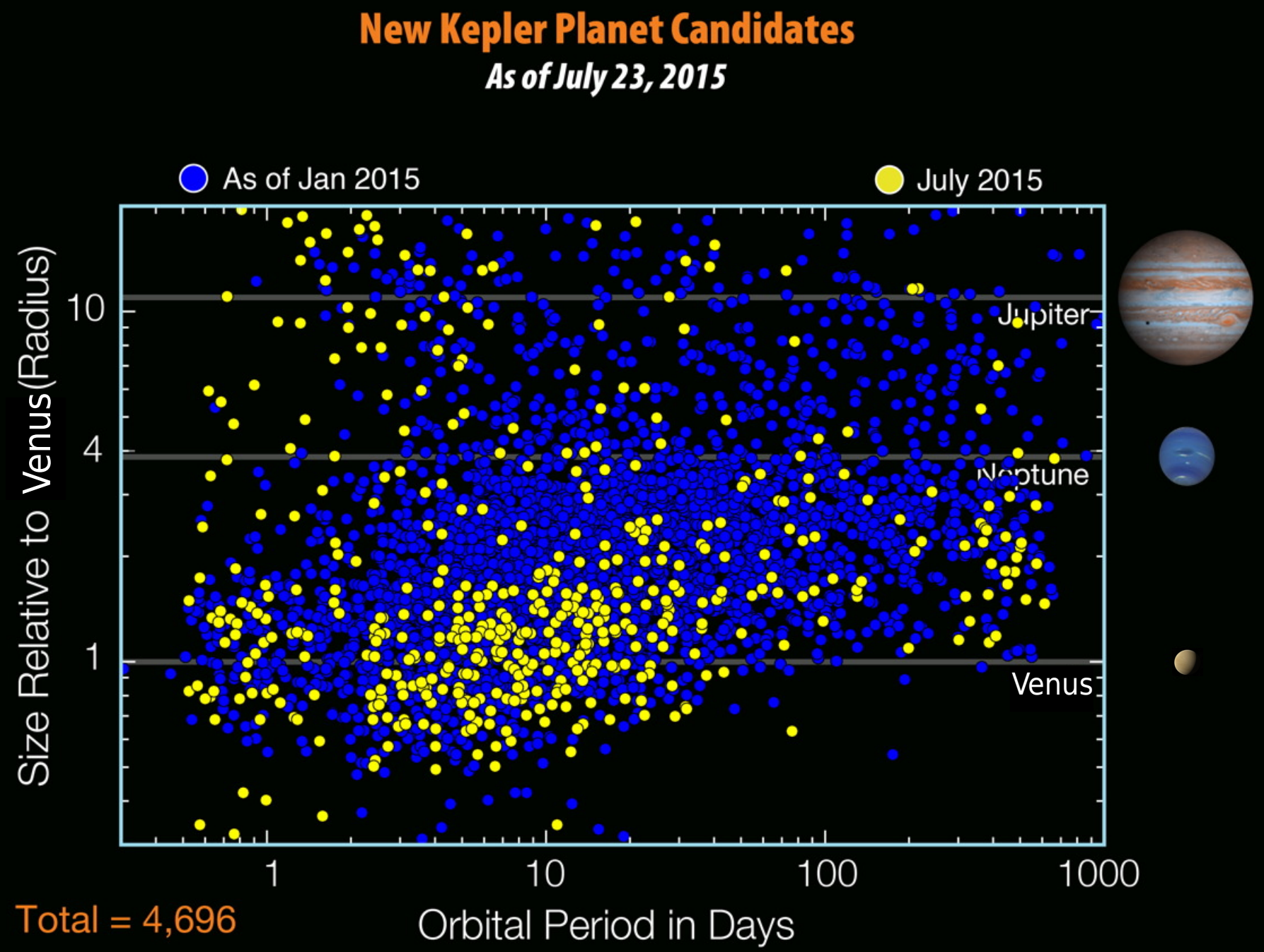
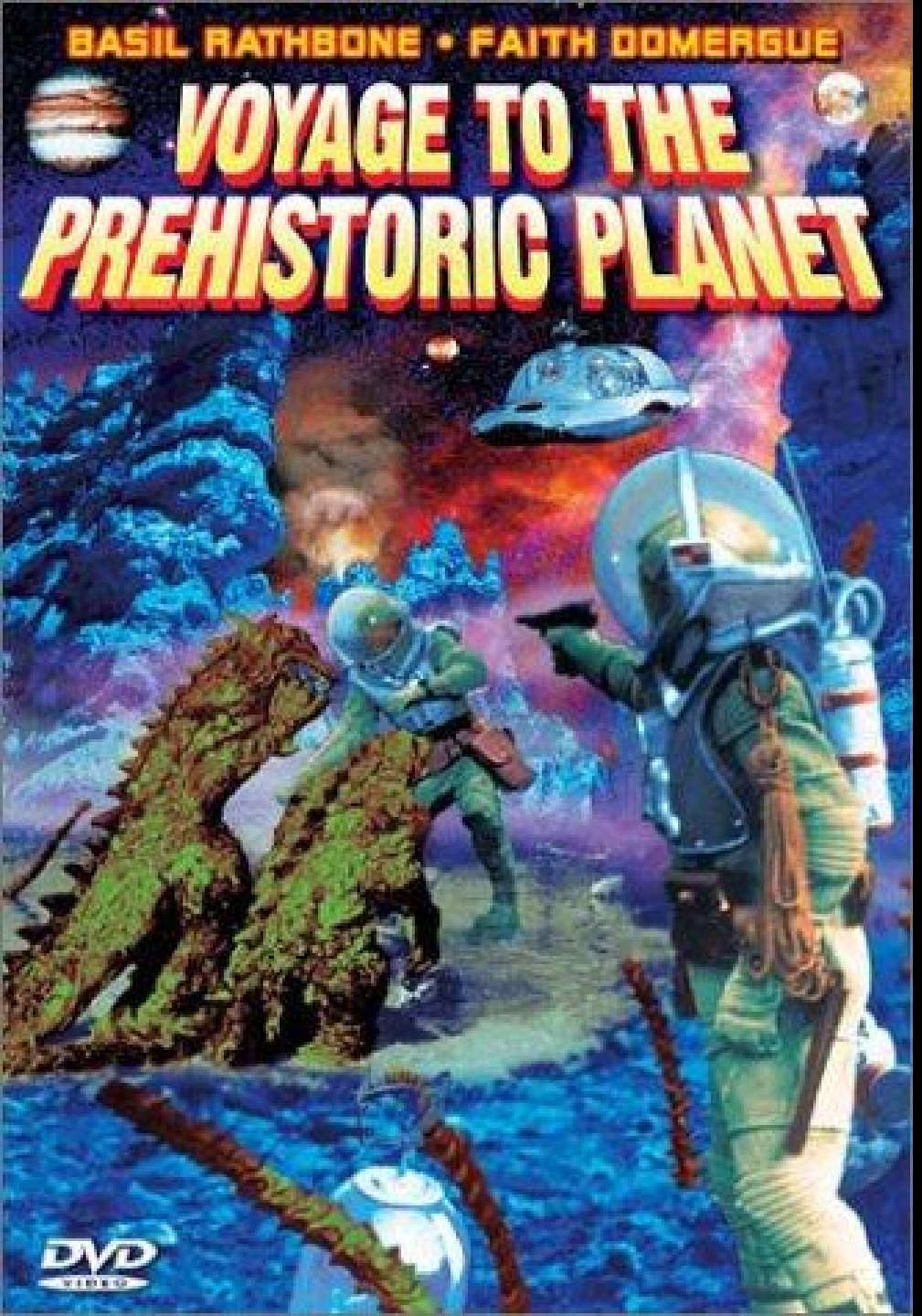


1. The occurrence rate of planets increases to smaller sizes.

2. Transit and radial velocity techniques are more sensitive to high insolation flux regimes.

3. The Venus analogs are being discovered first and will dominate JWST high S/N terrestrial targets.

4. We have more than one habitability data point.



5. We will never have in-situ data for an exoplanet. Surface conditions will always be inferred from models based on solar system data.

6. We did not fully understand Venusian surface conditions until probes penetrated the atmosphere (mid-late 60s).

7. Atmospheric data of terrestrial planets from the top to the middle and deep atmosphere are critically important.

Venus Exploration Analysis Group

NASA's future exploration of Venus should strive to achieve three non-prioritized Goals:
I. Understand Venus' early evolution and potential habitability to constrain the evolution of Venus-sized (exo)planets,
II. Understand atmospheric composition and dynamics on Venus, and
III. Understand the geologic history preserved on the surface of Venus and the present-day couplings between the surface and atmosphere.

Chair: Darby Dyar

Deputy Chair: Noam Izenberg

Scientific Goals, Objectives, and Investigations for Venus Exploration (2019)

Draft for Community Feedback (May 2019)

Venus Exploration VEXAG Analysis Group

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At the VEXAG meeting in November 2017, it was resolved to update the scientific priorities and strategies for Venus exploration. Here we present the 2019 VEXAG Goals, Objectives and Investigations for Venus Exploration.

Prepared by the VEXAG GOI Focus Group: Joseph O'Rourke and Allan Treiman (Co-Chairs), Giada Arney, Paul Byrne, Lynn Carter, Darby Dyar, James Head III, Candace Gray, Stephen Kane, Walter Kiefer, Kevin McGouldrick, Laurent Montesi, Chris Russell, and Suzanne Smrekar.

3.1. Goal I: Understand Venus' early evolution and potential habitability to constrain the evolution of Venus-size (exo)planets.

Venus and Earth possibly both hosted liquid water oceans for billions of years—or alternatively these celestial cousins may have trod distinct evolutionary paths from the birth of the Solar System. Precisely because it may have begun so like Earth, yet evolved to be so different, Venus is the planet most likely to yield new insights into the conditions that determine whether a Venus-sized exoplanet can sustain long-lived habitability

Objective I.A. | Did Venus have temperate surface conditions and liquid water at early times?

The amount of water that Venus received during and after its accretion remains unknown. Standard models imply that Venus and Earth received similar amounts of water from comets and bodies that formed in the vicinity of Jupiter. Liquid water may have never condensed on Venus if its atmosphere was always hot and dense. Temperate surface conditions represent only one possible evolutionary path for Venus. However, this scenario is uniquely compelling given the implications for the habitability of ancient Venus and Venus-sized exoplanets at present day.

Investigation I.A.HO. Hydrous Origins (1)

This Investigation is considered Essential because of the importance of water to the geologic evolution and potential habitability of Venus. Although liquid water is not now present, water is required to form large amounts of some types of rock. A prime example would be abundant granitic rock, as has been suggested for some tesserae. On Earth, large continents only formed because water was relatively abundant in the crust and mantle where magmas were being generated. Similarly, some sedimentary rocks cannot form without liquid water, such as those rich in minerals such as sulfate and halide (evaporite), silica (hot springs or hardpans), or carbonates. Even deposits of clastic sediments can preserve physical signatures of transport by liquid water (e.g., delta deposits observed from orbit on Mars).

Remote sensing and in situ analyses may reveal signatures of hydrous origins. Many granitic rock types have much lower VNIR emissivity than basaltic rocks, and these different signatures can be accessed through several spectral 'windows' (near 1 μm) in Venus' thick atmosphere even if substantial weathering has occurred. Similarly, low emissivity may reveal sediments rich in evaporites, silica, or carbonates. Emissivity could be measured from orbit, from aerial platform, or from the surface. The physical characteristics of clastic sedimentary systems may be discernable from orbital or aerial radar, given high-enough spatial resolution. Landers are required to provide the most detailed determinations of rock type and physical inter-relationships using high-resolution imagers and chemical analysis instruments (such as x-ray fluorescence, gamma ray spectrometry, or LIBS). Lander instruments may remove any surface rind from chemical weathering to measure the detailed mineralogic composition of the rock.

Investigation I.A.RE. Recycling (1)

Crustal recycling occurs when surface and near-surface material is introduced by subduction and/or delamination to the planetary interior, where it can participate in melt production and the chemical evolution of the lower crust and mantle. This Investigation is Essential because identifying widespread ongoing or ancient crustal recycling on Venus would have profound implications for our understanding of the thermal, chemical, geological, and atmospheric evolution of the planet, and of terrestrial planets in general. Localized plume-

The Venus Exploration Analysis Group

Unveil Venus: Why is Earth's sister planet so different?

VEXAG was established by NASA in 2005 to identify scientific priorities and opportunities for the exploration of Venus, Earth's sister planet. The group has an open membership and an 7-person Executive Committee, 3 Focus Groups, and 2 Topical Analysis Groups. Input from the scientific community is actively sought. The VEXAG provides findings to NASA Headquarters, but does not make recommendations. Stay in touch by visiting our Twitter and Facebook pages! If you have interest in becoming a member of VEXAG, please fill out the VEXAG Indication of Interest form.

VEXAG Charter

The Venus Exploration Analysis Group is NASA's community-based forum designed to provide scientific input and technology development plans for planning and prioritizing the exploration of Venus over the next several decades. VEXAG is chartered by NASA's Solar System Exploration Division and reports its findings to NASA. Open to all interested scientists, VEXAG regularly evaluates Venus exploration goals, scientific objectives, investigations, and critical measurement requirements, including especially recommendations in the NRC Decadal Survey and the Solar System Exploration Strategic Roadmap.

Related Documents

- VEXAG website https://www.lpi.usra.edu/vexag/

- Kane et al. “Venus: The Making of an Uninhabitable World”, 2018, white paper submitted to the NAS Astriobiology solicitation.

- Kane et al. “Venus: The Nearby Exoplanet Laboratory”, 2018, white paper submitted to the NAS Exoplanet solicitation.

- Kane et al. “Venus as a Nearby Exoplanet Laboratory”, 2019, white paper submitted to the 2020 Decadal Survey.

- Arney & Kane. “Venus an an Analog for Hot Earths”, 2019, to appear in the textbook “Planet Astrobiology”, Space Science Series, editor: Victoria Meadows.

- Kane et al. “Venus as a Laboratory for Exoplanetary Science”, 2019, invited review for JGR Planets.

Next VEXAG meeting: Nov 6-8, 2019, LASP, Boulder, CO