Sushil Atreya

Venus Chapman Conference
Key Largo, 16 February 2006

http://www.lpi.usra.edu/vexag/vexag.html

The Venus Exploration Analysis Group (VEXAG) was established by NASA in July 2005 to identify scientific priorities and strategy for exploration of Venus. VEXAG is currently composed of two co-chairs and three focus groups. The focus groups will actively solicit input from the scientific community. VEXAG will report its findings and provide input to NASA, but will not make recommendations.

July-October 2005: VEXAG publicised and membership in Focus Groups solicited, by LPI through AAS/DPS, AGU, ESA, ESTEC, JAXA, etc. email lists. Nearly 200 scientists filled out Indication of Interest Form.

November 4, 2005: First VEXAG Community Meeting, held in Pasadena, California. Nearly 100 scientists, including 10 from abroad, participated.

http://www.lpi.usra.edu/vexag/vexag.html

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, including a Venus surface sample return. 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.

http://www.lpi.usra.edu/vexag/vexag.html

VEXAG Steering Committee

Sushil Atreya,Janet Luhmann

Steve Mackwell, Kevin Baines

James Cutts, Thomas Thompson,
Adriana Ocampo, Steve Saunders

http://www.lpi.usra.edu/vexag/vexag.html

Co-Chairs:

Sushil Atreya
University of Michigan, Ann Arbor

Janet Luhmann
University of California, Berkeley

NASA Contacts:

Dr. Adriana Ocampo, NASA Headquarters
Dr. Steve Saunders, NASA Headquarters
Dr. Thomas W. Thompson, JPL (VEXAG Manager)

http://www.lpi.usra.edu/vexag/vexag.html

VEXAG

VENUS EXPLORATION ANALYSIS GROUP

Focus Groups:

1. Planetary Formation and Evolution: Surface and Interior, Volcanism, Geodynamics, etc.
   Focus Group Lead: Steve Mackwell, LPI

1. Atmospheric Evolution: Dynamics/Meteorology, Chemistry, Volcanism Solar Wind Interaction, Escape, etc.
   Focus Group Lead: Kevin Baines, JPL

3. Enabling Technology, including Venus *in situ* exploration.
   Focus Group Lead: Jim Cutts, JPL

Each Focus Group has more than a dozen members. The VEXAG co-chairs are members of each FG.

http://www.lpi.usra.edu/vexag/vexag.html

Chapman Conference

Larry Esposito and Dima Titov, Leads

http://www.lpi.usra.edu/vexag/vexag.html

VEXAG

VENUS EXPLORATION ANALYSIS GROUP

Findings of the first VEXAG Community Meeting, held in Pasadena, Nov. 4, 2005

• Decadal Survey (DS) recommendations are still valid

• DS recommendations need “fine-tuning” in view of Venus Express, Venus Climate Orbiter, and MESSENGER observations, and NASA’s Roadmap study

• Venus science goals will be best met by a combination of relatively low cost (Discovery class), medium (New Frontiers class), and Flagship (1billion +) missions

•VEXAG recognizes the value and importance of multinational partnerships in achieving the Venus science goals. Every attempt should be made by NASA to explore collaboration with our international partners including ESA, JAXA, ISRO, CNES, ASI, etc.

• VEXAG will provide scientific input and technology development plans for planning and prioritizing NASA’s exploration of Venus over the next several decades including a Venus surface sample return.

Enabling Technology identified by VEXAG

Short duration (hours-days)

Survival and Operation in “Extreme Environment” (720K, 90 bar, corrosive environ)

Passive cooling systems; Electronics; Communication of large data volume; Balloons with horizontal and vertical mobility; Precision landing; Hazard avoidance; Tools for mineralogical measurements, etc.

Long duration (months-years)

The enabling technology for the short duration applies to long-duration missions also, except that it needs to be robust enough for missions that could last up to a year. In addition, capability of seismometer, and heat flow measurements at and below the surface under the extreme temperatures of the Venusian surface.

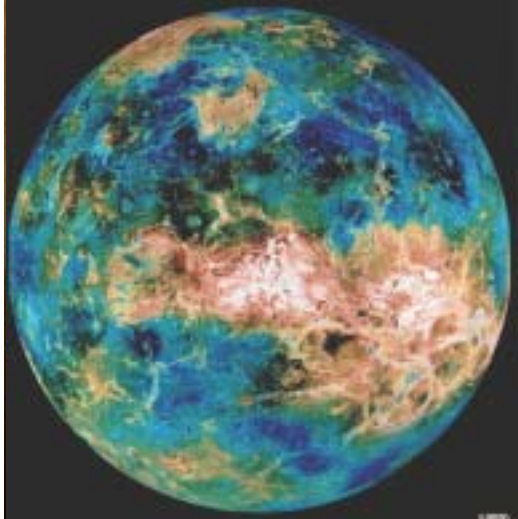
VEXAG Web-Site - **http://www.lpi.usra.edu/vexag**

Venus: The Forgotten Planet

A reinvigorated Venus exploration program could improve our understanding of the origin, evolution, and habitability of terrestrial planets.

- A comprehensive inventory of the noble gases and isotopes of C, H, O and N in the Venus atmosphere would help us to understand our *past* by clarifying the conditions in the primordial solar nebula.

- A investigation of the processes controlling the current surface and atmospheric environment on Venus will provide a deeper understanding of the *present*
  - greenhouse effects,
  - atmospheric photochemistry, thermal chemistry,
  - atmospheric dynamics,
  - chemical weathering, and intraplate geology.



- A more comprehensive understanding of Venus could yield important clues about our *future* by providing
  - atmospheric compositional stability and loss
  - geophysical evolution of the Earth
    - If plate tectonics evolves toward the stagnant-lid tectonics seen on Venus.

SRM 3: The Solar System Exploration Strategic Roadmap

NASA Goal relevant to Solar System Exploration

"Conduct robotic exploration across the solar system for scientific purposes and to support human exploration. In particular, explore the moons of Jupiter, asteroids, and other bodies to search for evidence of life, to understand the history of the solar system and to search for resources"

SRM 3: Scientific Objectives*

1. Learn how the Sun's family of planets and minor bodies originated
2. Determine how the solar system evolved to its current diverse state including the origin and evolution of the Earth's biosphere
3. Explore the space environment to discover potential hazards and search for resources that could enable permanent human presence
4. Understand the processes that determine the fate of the solar system and life within it
5. Determine if there is or ever has been life elsewhere in the solar system

* *Currently under revision*

NASA Science Mission Directorate
*Directions**

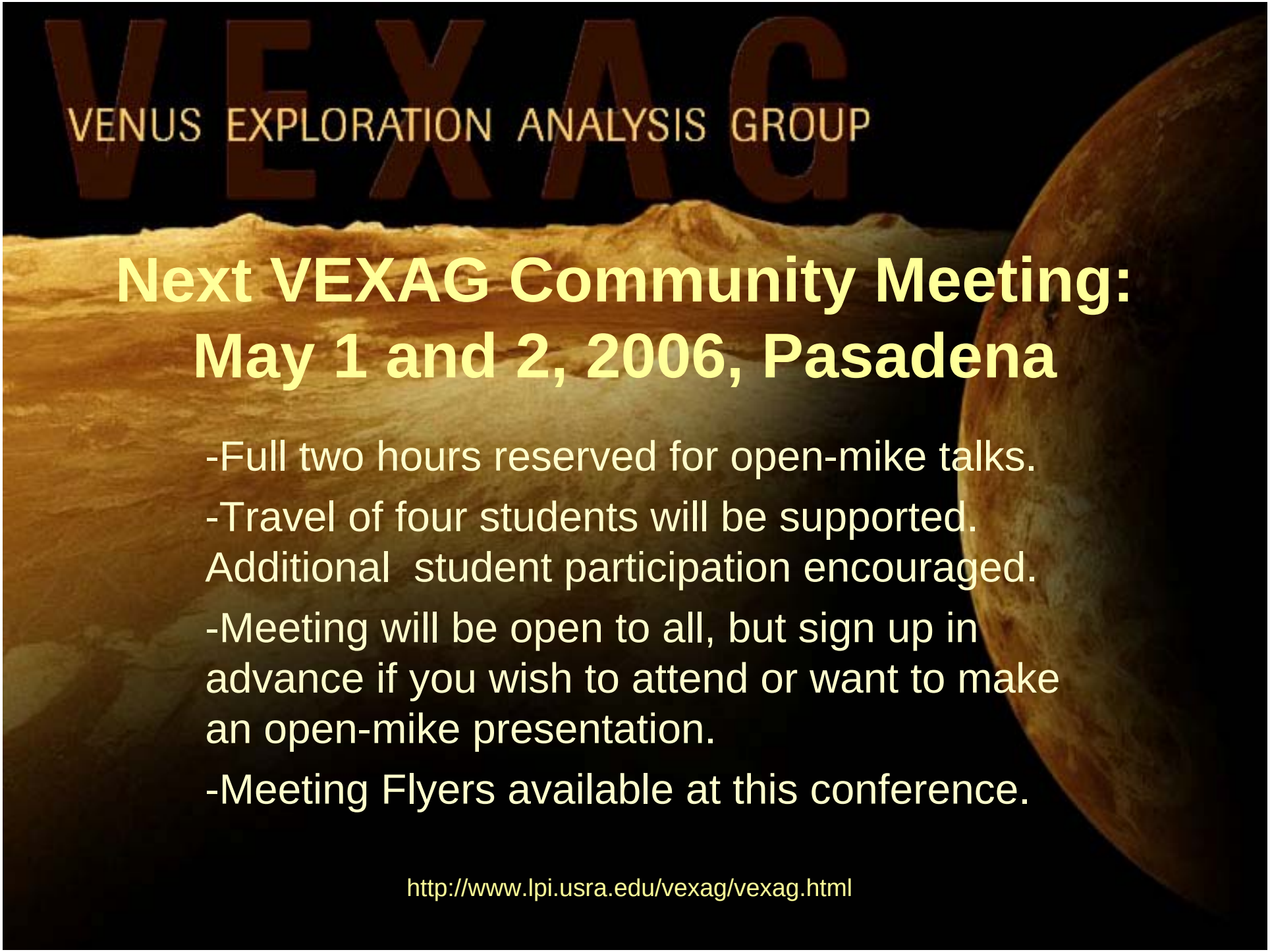
A. How the universe began, how it became the way it is today, and its final destiny
B. How the planets and their moons form, and how they evolved over the lifetime of the solar system
C. What conditions allowed life to arise on Earth, and whether there are similar conditions elsewhere
D. Whether life, and possibly intelligent life, exists elsewhere
E. How the Sun affects conditions and life on Earth
F. How to predict the Sun's behavior well enough to protect human space travelers
G. How to predict the changes in the Earth's system of land, oceans, atmosphere, and life
H. How human activity is affecting conditions and life on Earth

* *From the President's 2007 NASA budget*

VEXAG GOALS*

- Investigate how Venus originated and evolved, including the potential for an early biosphere
  - SSE Roadmap 1,2,5
- Characterize the processes that shape Venus
  - SSE Roadmap 1,2,4
- What can Venus tell us about the fate of Earth's environment
  - SSE Roadmap 4

**based largely on Crisp et al. (2002) in The Future of Solar System Exploration 2003-2013*



Next VEXAG Community Meeting: May 1 and 2, 2006, Pasadena

-Full two hours reserved for open-mike talks.

-Travel of four students will be supported. Additional student participation encouraged.

-Meeting will be open to all, but sign up in advance if you wish to attend or want to make an open-mike presentation.

-Meeting Flyers available at this conference.

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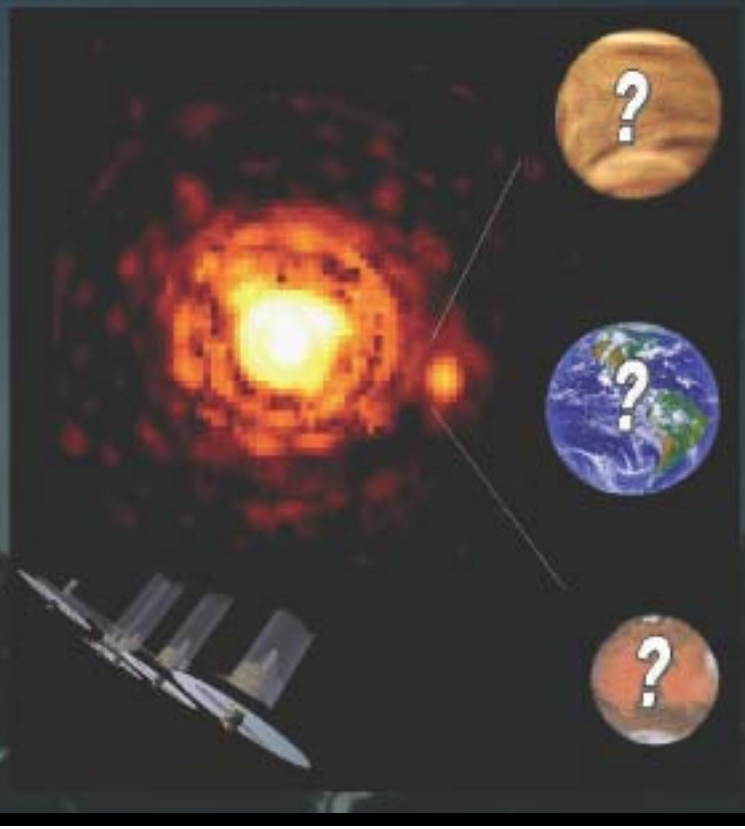
Why study Venus NOW?

Coordinated Venus and Mars programs are essential to the development of a comprehensive understanding of the origin and evolution of Earth-like terrestrial planets.

The present NASA Inner planets strategy, which focuses exclusively on Mars, will provide an incomplete, and possibly misleading description of processes that resulted in the current environments of Venus, Earth, and Mars.

Our lack of understanding of these processes could also cripple efforts to interpret observations of extrasolar terrestrial planets, which are expected to become available by the end of the decade.




VEXAG
VENUS EXPLORATION ANALYSIS GROUP
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OVERVIEW OF PAST VENUS MISSIONS

Mariner 2
-1962 American flyby spacecraft
-found out Venus has no magnetic field
-slow retrograde rotation rate
-measured planet's thermal microwave emissions

Venera 4
-1967 entered atmosphere
-measured temperature, pressure, density
-performed 11 automatic experiments to analyze atmosphere
-returned atmospheric composition of 95% CO2 --
-returned surface pressures of approximately 75-100 atm
-battery life ran out while floating in atmosphere

Mariner 5 (1967 Flyby)
-measured magnetic fields, charged particles, and plasmas, and radio refractivity and UV emissions of the atmosphere

Veneras 5 & 6 (1969)
-verified results from Venera 4
-crushed by high pressure above surface

Venera 7
-1970, first successful landing
-relayed surface temps of 455 -475 degrees Celsius

Mariner 10
-1973 gravity assist flyby en route to Mercury
-produced first clear pictures of Venusian clouds using near-ultraviolet filter
- Performed atmospheric studies

Veneras 9 & 10
- 1975; entered orbit, first artificial satellites of Venus
-battery of camera and spectrometers returned info on clouds, ionosphere and magnetosphere
-performed bistatic radar measurements of surface
-descent vehicle landed and took pictures of surface
-analyzed crust with gamma ray spectrometer and densitometer
-pressure, temperature and photometric measurements made during descent
-also backscattering and multi-angle scattering measurements of cloud density
-discovered the 3 distinct layers of Venus's clouds

Pioneer Venus (1978)
-Orbiter and Multiprobe; (one large, three small)
-carried over 25 experiments consisting atmospheric composition, dyamnics, radiation, gravity, solar wind, solar flux, and surface topography
-fuel exhausted, destroyed by atmospheric entry in 1992

Veneras 11 & 12 (1978)
-discovered unexpected large portion of chlorine and sulfur in clouds
-strong lightning activity detected?

Veneras 13 & 14 (1982; Essentially same missions as Veneras 11 and 12)
- color camera and soil-drilling/analysis experiments successful
- X-ray fluorescence analysis of soil samples showed results similar to potassium-rich basalt rock

Veneras 15 & 16 (1983 entered polar orbits)
- mapped and analyzed upper atmosphere with an infrared Fourier spectrometer
- both satellites mapped northern third of planet with synthetic aperture radar
-results provided detailed understanding of surface geology of Venus,
-including discovery of unusual massive shield volcanoes

Vegas 1 & 2 (1985 probes / landers)
- upper two layers of atmosphere were found to be sulfuric acid droplets
- lower layer assumed to be composed of phosphoric acid solution
-crust of Venus analyzed with soil drill experiment / gamma ray spectrometer
- deployed ballon-borne aerostat probes that floated 1/3 of way around planet
-measured wind speed, temp, pressure, and cloud density; more turbulence/convection activity than expected

Magellan (1990-1994)
-detailed radar mapping 98% of surface with constructed 3d views
-high-res gravity field map; 95%
-Windmill Experiment

Galileo (1990 flyby en route to Jupiter)
-revealed indications of lightning though at relatively far distance

Cassini-Huygens (1998/1999 flyby en route to Saturn)
- measured radiofrequency emissions of Venus using radio and plasma wave instruments; saw no frequency radio waves (0.125 to 16 Mhz, commonly associated with lightning) in contradiction with the results of Venera missions