

Venus Exploration and Analysis Group (VEXAG)

“Jump Start” Report

Atmospheric Evolution Focus Group

11-04-2005



Kevin Baines, Chair



Atmospheric Evolution Focus Group Steering Committee

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Takeshi Imamura	Japan
Andy Ingersoll	Cal Tech
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Janet Luhmann	UC Berkeley
Chris Russell	UCLA
Fred Taylor	Oxford University
Rich Young	NASA/Ames



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Group Goals

“Identify Scientific Priorities and Strategy”

- Determine Major Science Objectives pertaining to Atmospheric Evolution
 - Includes atmospheres, ionosphere, exospheres, etc
 - Also includes some surface observations: Volcanism, Surface weathering, etc.
- Implementation: Suggest Possible Mission Architectures
 - New Technologies (Goal: develop “Technology Development Priorities”)
 - New Instruments?



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Determine Major Science Objectives Process

- Start with Decadal Study Recommendations
- Fold in New, High-Priority Objectives
 - New Ground-Based and Analysis Results
 - If Time Available: Venus Express



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Implementation/Possible Mission Architectures Process

- Determine possible instrument techniques
- Determine required coverage (spatial/temporal)

⇒ Possible architectures

- probes, landers, balloons, orbiters, etc

⇒ Technology developments



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Table I

Summary of Priority Science Investigations of the NRC Decadal Study, Inner Planets Panel

<u>Theme</u>	<u>Questions</u>	<u>Priority Science Investigations</u> (BOLD = Venus Atmospheric Evolution Objectives)
<p><u>Past:</u> What led to the unique character of our home planet?</p>	<p>a. What are the bulk compositions of the inner planets and how do they vary with distance from the Sun?</p> <p>b. What is the internal structure and how did the core, crust, and mantle of each planet evolve?</p> <p>c. What were the history and role of early impacts?</p> <p>d. What is the history of water and other volatiles and how did the atmospheres of inner planets evolve?</p>	<p>1. Determine elemental and mineralogic surface compositions</p> <p>2. Measure noble gas compositions of atmospheres</p> <p>3. Measure oxygen isotopic ratios of the unaltered surface and atmosphere.</p> <p>4. Determine interior (mantle) compositions.</p> <p>1. Determine horizontal and vertical variations in internal structures.</p> <p>2. Determine the compositional variations and evolution of crusts and mantles</p> <p>3. Determine major heat-loss mechanisms and resulting changes in tectonic and volcanic styles.</p> <p>4. Determine characteristics of Fe-rich metallic cores (size, liquid and solid components)</p> <p>1. Determine large-impactor flux in the early solar system and calibrate the lunar impact record</p> <p>2. Determine the global geology of the inner planets</p> <p>3. Investigate how major impacts early in a planet's history can alter its evolution and orbital dynamics</p> <p>1. Make high-precision measurements of noble gases and light stable isotopes</p> <p>2. Determine the composition of magmatic volatiles</p> <p>3. Determine the composition and source of the polar deposits on Mercury and the Moon.</p>



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Table II

**Summary of VENUS ATMOSPHERIC EVOLUTION Priority Science Investigations of Decadal Study
And Mapping into Strawman Mission Architectures**

Theme	Questions	Priority Science Investigations	Desired Coverage Vert/Spat/Temp (Single, Multiple regimes, Expansive coverage: S,M,E)	Strawman Simplest Mission Architectures	Strawman Measurement Technique	New Mission or VeX, VCO Adequate?	
Past: What led to the unique character of our home planet?	a. What are the bulk compositions of the inner planets and how do they vary with distance from the Sun?	2. Measure noble gas compositions of atmospheres	S/S/S	Single Probe	GCMS	New Mission	
		3. Measure oxygen isotopic ratios of the unaltered surface and atmosphere.	S/S/S	Single Probe	GCMS	New Mission	
	d. What is the history of water and other volatiles and how did the atmospheres of inner planets evolve?	1. Make high-precision measurements of noble gases/light stable isotopes	S/S/S	Single Probe	GCMS	New Mission	
		2. Determine the composition of magmatic volatiles	S/M/E	Aerostat	GCMS	New Mission	
Present: What common dynamic processes shape Earth-like planets?	a. What processes stabilize climate?	1. Determine the general circulation dynamics of atmospheres.	E/E/E	Orbiters + Multi-Level Aerostats, Multi Probes	Cloud tracking, Radio tracking, Temps, Vertical motions, 0-400 km alt GCMS	New Mission(s)	
		2. Determine atmospheric composition, especially trace gases and isotopes.	M/E/M				
		3. Determine how sunlight, thermal radiation and clouds drive greenhouse effects	M/M/S	Orbiter, Multi Probes, High-altitude Aerostat	Temps, Nephelometers, GCMS, Net-Flux, UV-IR Global Spec. Imaging	New Mission(s)	
		4. Determine processes and rates of surface/atmosphere interaction.	M/M/M	Low-Altitude Aerostat	GCMS, temps, Near-IR spectral Imaging	New Mission	
	b. How do active internal processes shape the atmosphere and surface environments?	1. Characterize current volcanic and/or tectonic activity and outgassing.		M/E/S	Orbiter, Aerostat	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	VeX/VCO
			3. Characterize magnetic fields and relationships to surface, atmosphere, and the interplanetary medium.	S/E/M	Orbiter	INMS, Plasma waves. Magnetic field (VeX: ASPERA + Magnetometer)	VeX
		2. Quantify processes in the uppermost atmospheres of the terrestrial planets.	S/M/M	Orbiter	UV/NIR occultations, radio occultations, INMS (VeX: SPICAV + VeRA + ASPERA)	VeX	
	c. How do active external processes shape the atmosphere and surface environments?						
	Future: What fate awaits Earth's environment and those of the other terrestrial planets?	a. What do the diverse climates of the inner planets reveal about the vulnerability of Earth's environment?	1. Characterize the greenhouse effect through meteorological observations.	M/M/S	Orbiter, Multi-Probes, Aerostat	Temps, Nephelometers, GCMS, Net-Flux, UV-IR Global Spec. Imaging	
b. How do varied geologic histories enable predictions of volcanic and tectonic activity?		1. Assess the distribution and age of volcanism on the terrestrial planets.	S/E/S	Orbiter, Aerostats	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	VeX/VCO	
		2. Search for evidence of volcanic gases in inner planet atmospheres.	S/E/E	Orbiter, Probe(s), Aerostat(s)	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	New Mission	
d. What are the resources of the inner solar system?		1. Assess volatile resources.		S/E/E	Orbiter, Probe(s), Aerostat(s)	Near-IR spectral imaging, GCMS	New Mission



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2. Measure noble gas compositions of atmospheres	S/S/S	Single Probe	GCMS	New Mission
3. Measure oxygen isotopic ratios of the unaltered surface and atmosphere.	S/S/S	Single Probe	GCMS	New Mission
1. Make high-precision measurements of noble gases/light stable isotopes	S/S/S	Single Probe	GCMS	New Mission
2. Determine the composition of magmatic volatiles	S/M/E	Aerostat	GCMS	New Mission
1. Determine the general circulation dynamics of atmospheres.	E/E/E	Orbiters + Multi-Level Aerostats, Multi Probes	Cloud tracking, Radio tracking, Temps, Vertical motions, 0-400 km alt GCMS	New Mission(s)
2. Determine atmospheric composition, especially trace gases and isotopes.	M/E/M			
3. Determine how sunlight, thermal radiation and clouds drive greenhouse effects	M/M/S	Orbiter, Multi Probes, High-altitude Aerostat	Temps, Nephelometers,GCMS, Net-Flux, UV-IR Global Spec. Imaging	New Mission(s)
4. Determine processes and rates of surface/atmosphere interaction.	M/M/M	Low-Altitude Aerostat	GCMS, temps, Near-IR spectral Imaging	New Mission
1. Characterize current volcanic and/or tectonic activity and outgassing.	M/E/S	Orbiter, Aerostat	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	VeX/VCO
3. Characterize magnetic fields and relationships to surface, atmosphere, and the interplanetary medium.	S/E/M	Orbiter	INMS, Plasma waves. Magnetic field (VeX: ASPERA + Magnetometer)	VeX
2. Quantify processes in the uppermost atmospheres of the terrestrial planets.	S/M/M	Orbiter	UV/NIR occultations, radio occultations, INMS (VeX: SPICAV + VeRA + ASPERA)	VeX



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1. Characterize the greenhouse effect through meteorological observations.	M/M/S	Orbiter, Multi-Probes, Aerostat	Temps, Nephelometers, GCMS, Net-Flux, UV-IR Global Spec. Imaging	
1. Assess the distribution and age of volcanism on the terrestrial planets.	S/E/S	Orbiter, Aerostats	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	VeX/VCO
2. Search for evidence of volcanic gases in inner planet atmospheres.	S/E/E	Orbiter, Probe(s), Aerostat(s)	UV/ Near-IR spectral imaging, GCMS (VeX: SPICAV, VIRTIS, PFS, VMC)	New Mission
1. Assess volatile resources.	S/E/E	Orbiter, Probe(s), Aerostat(s)	Near-IR spectral imaging, GCMS	New Mission



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What Next?

- Meet Today at Lunch Time
- Start Discussion on Science Objectives....
(Modify Table I)
- If time permits, begin Mission Architecture
Discussion (Modify Table II)