SAGE Science Overview

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VISE science objectives from NF-3

- Understand the physics and chemistry of Venus' atmosphere through measurement of its composition, especially the abundances of its trace gases, sulfur, light stable isotopes, and noble gas isotopes;
- Constrain the coupling of thermochemical, photochemical, and dynamical processes in Venus' atmosphere and between the surface and atmosphere to understand radiative balance, climate, dynamics, and chemical cycles;
- Understand the physics and chemistry of Venus' crust through analysis of near-IR descent images from below the clouds to the surface and through measurements of elemental abundances and mineralogy from a surface sample;
- Understand the properties of Venus' atmosphere down to the surface through meteorological measurements and improve our understanding of Venus' zonal cloud level winds through temporal measurements over several Earth days;
- Understand the weathering environment of the crust of Venus in the context of the dynamics of the atmosphere of Venus and the composition and texture of its surface materials; and
- Map the mineralogy and chemical composition of Venus' surface on the planetary scale for evidence of past hydrological cycles, oceans, and life and constraints on the evolution of Venus' atmosphere.

SAGE Science Themes

I. Why is Venus so different from Earth?

II. Was Venus ever like Earth?

III. Does Venus represent Earth's fate?

SAGE 2009 Science Objectives - Detail

Ia. What does the composition of the crust and atmosphere tell us about planetary accretion?

Ib. Did Venus have an ocean (and thus, Earth-like volatiles)?

Ic. How was the early climate different? How did crustal composition influence climate and vice versa?

Iia. What are the surface weathering processes?

IIb. What is the composition and style of plains volcanic resurfacing?

IIc. What are the interactions among volcanism, weathering and aeolian processes?

IId. What is the geochemistry of the atmosphere and how has it evolved?

IIIa. Model past Venus history and extend models into the future for Venus and Earth.

IIIb. Determine the observable characteristics of Extra-Solar Planets like Venus.

SAGE Fundamental Requirements

- Acquire approach images of entry site and winds
- Atmospheric descent measurements of wind and composition
- NIR nested descent images of surface
- Deliver the lander safely to the surface
- Surface panoramas and microscopic images of excavation site
- Elemental and mineral composition at surface and at 3-10 cm depth

Science Requirements

1. Measure noble gases and their isotopes to constrain Venus history
2. Measure trace gas profiles and sulfur compounds for chemical cycles and surface-atmosphere interactions
3. Meteorological measurements to the surface
4. Measure surface and sub-surface composition
5. Constrain the coupling of radiation, dynamics and chemistry
6. Compare the terrestrial planets in detail to predict and characterize extra-terrestrial planets

Questions to answer

What can Venus tell us about the accretion of the terrestrial planets;

Did Venus have an ocean;

What is the surface weathering on Venus;

What's the style of emplacement and composition of volcanics;

How did the atmospheric chemistry evolve?

Model the past Venus history and extend it to the future of Venus, and possibly Mars and Earth.

Define the observable characteristics of extrasolar planets like Venus.

Implementation & Instrumentation

- Implementation: Descender/lander. Land safely. Survive on the surface for some hours to make the required measurements. Sample the surface and sub-surface.
- Instrumentation: Cameras, spectrometers, NMS/GC, meteorology package, determine mineralogy and surface texture.

Backup Slides

Baseline Mission

+ FBC (on Carrier)
+ Plains landing site, with recent lava flows near volcanic hot spot
+ DPC/MC
+ ASI: 1 boom
+ DWE USO
+ NMS
+ TLS
+ NAGRS
+ LIBS/Raman steerable in one dimension
+ Excavation sampling arm with calibration targets.
+ Excavate 3-10 cm, based on surface physical properties

Science Team

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- David Atkinson (U. Idaho)
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Mission Architecture

The SAGE mission architecture for delivering a Lander to the Venus surface has been successfully proven six times by the Soviet Venera landers

Entry system (Lander packaged in Aeroshell) delivered by a carrier vehicle

Pilot chute removes backshell

Main chute extracts Lander from heatshield

Freefall-descent through the thick Venus atmosphere

Drag plates used to control descent & limit landing to ≤ 10 m/s

Landing force absorbed by crushable

Outriggers used to assure landing stability

- **Launch Date: Late Dec. 2016**
- **Launch Period: 21 days**
- **Launch vehicle: Atlas V 401**
- **Trajectory: Type I Direct Xfer**
- **Max. flight time: 143 days**
- **Arrival date: May 2017**
- **Lander Mission:1-hr descent; 3-hr surface operation**