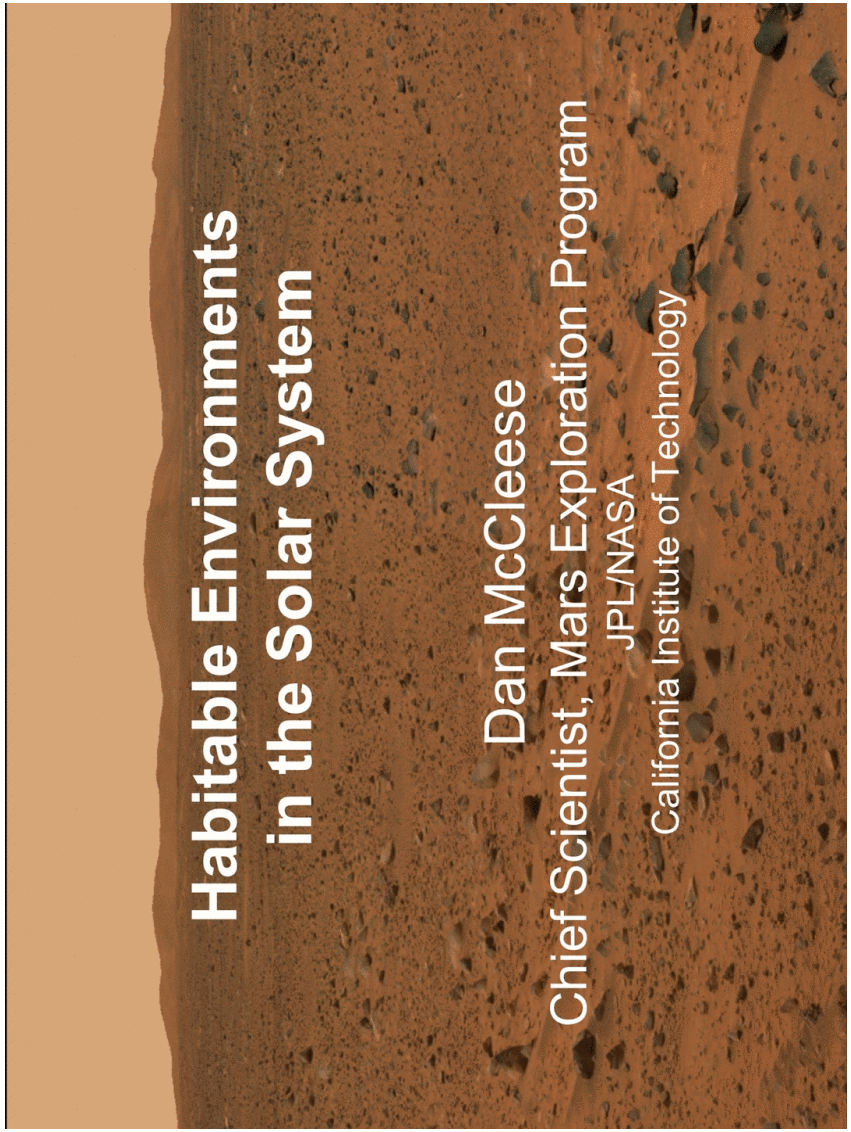
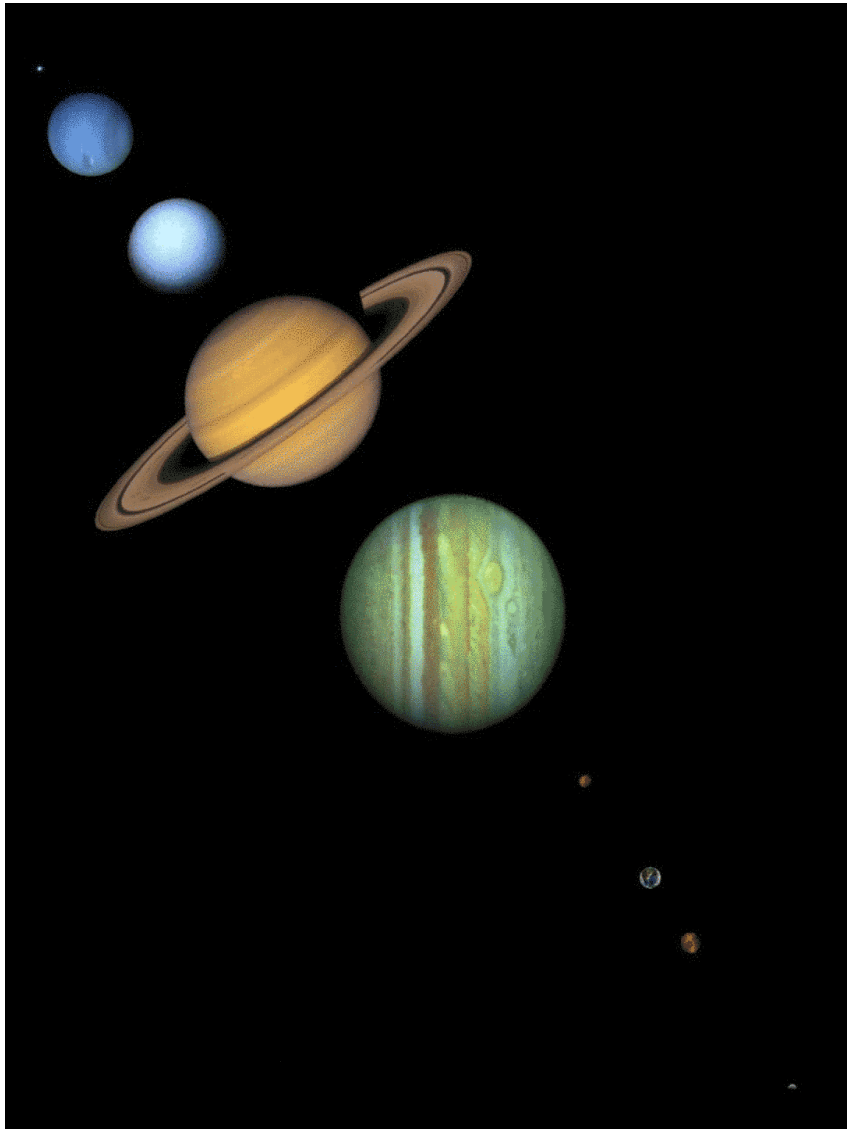
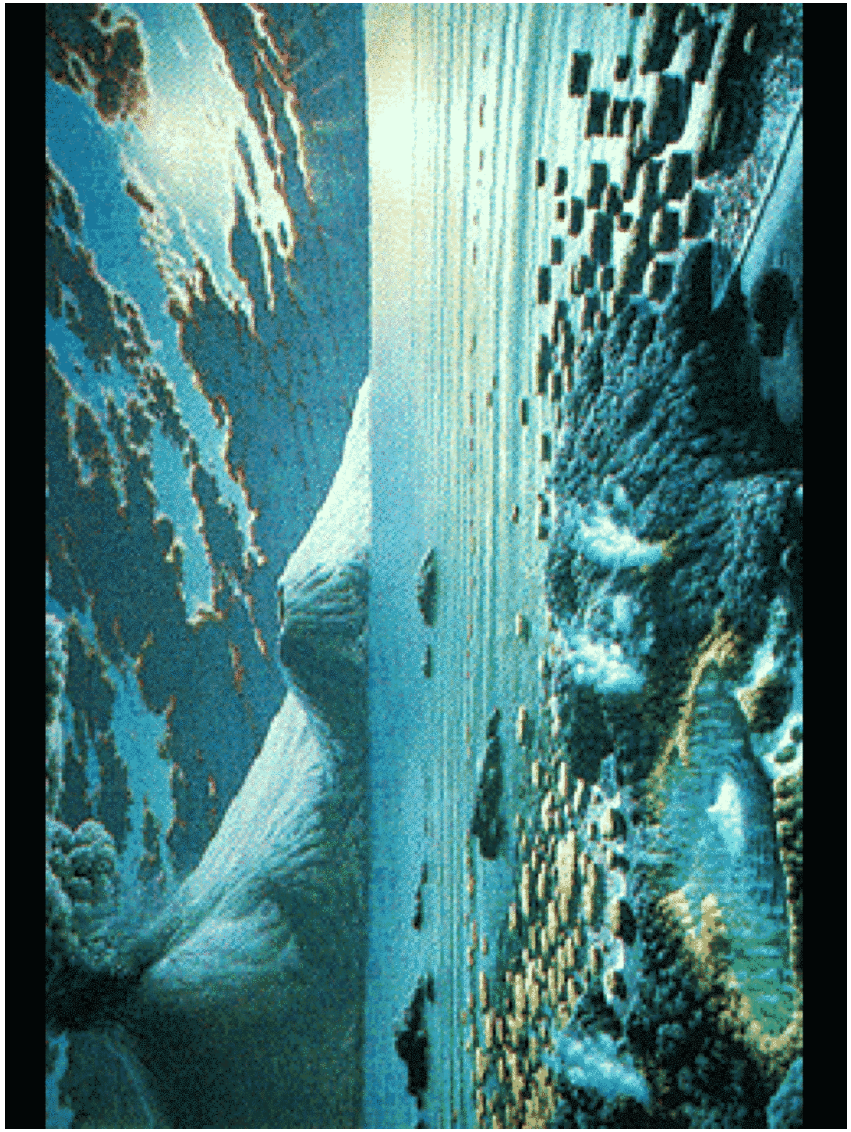
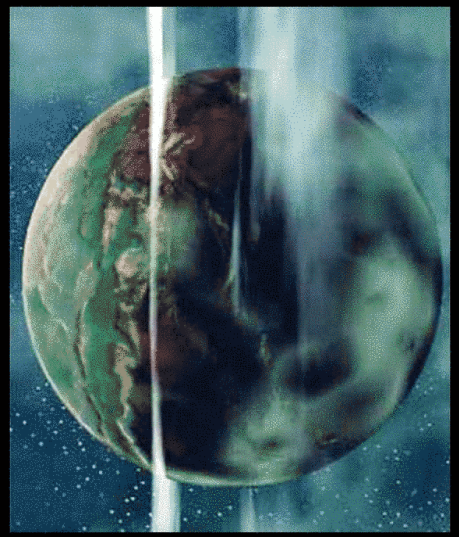

Habitable Environments
in the Solar System
Dan McCleese
Chief Scientist, Mars Exploration Program
JPL/NASA
California Institute of Technology





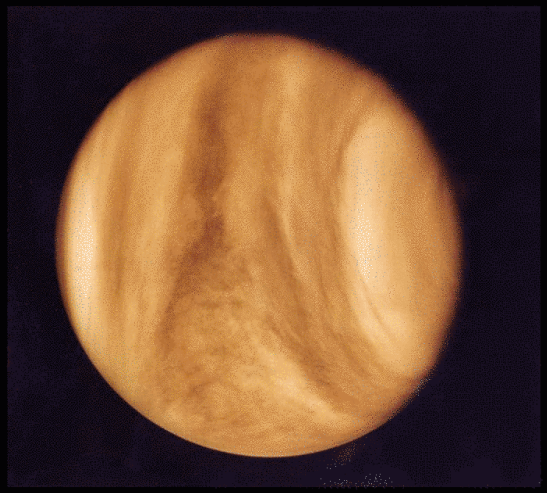
Habitability



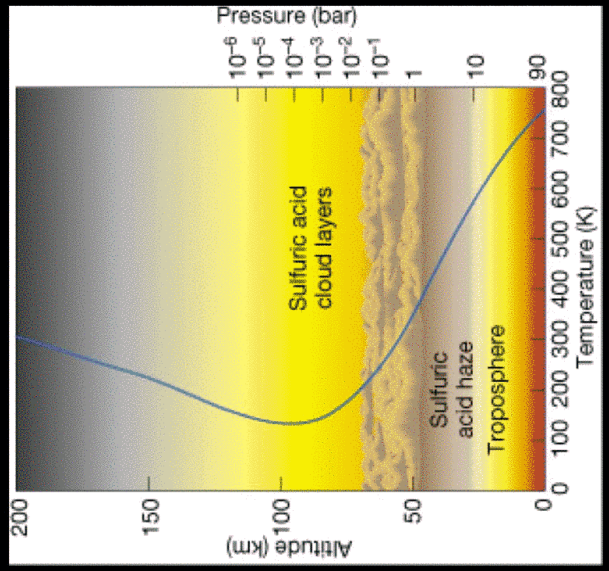
A planet or planetary satellite is *habitable* if it can sustain life that originates there or if it sustains life that is carried to it...

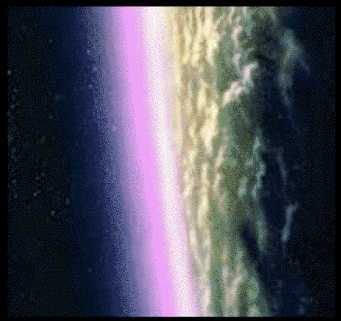
Habitable environments must provide liquid water, conditions favorable for the assembly of complex organic molecules, and energy sources to sustain metabolism.

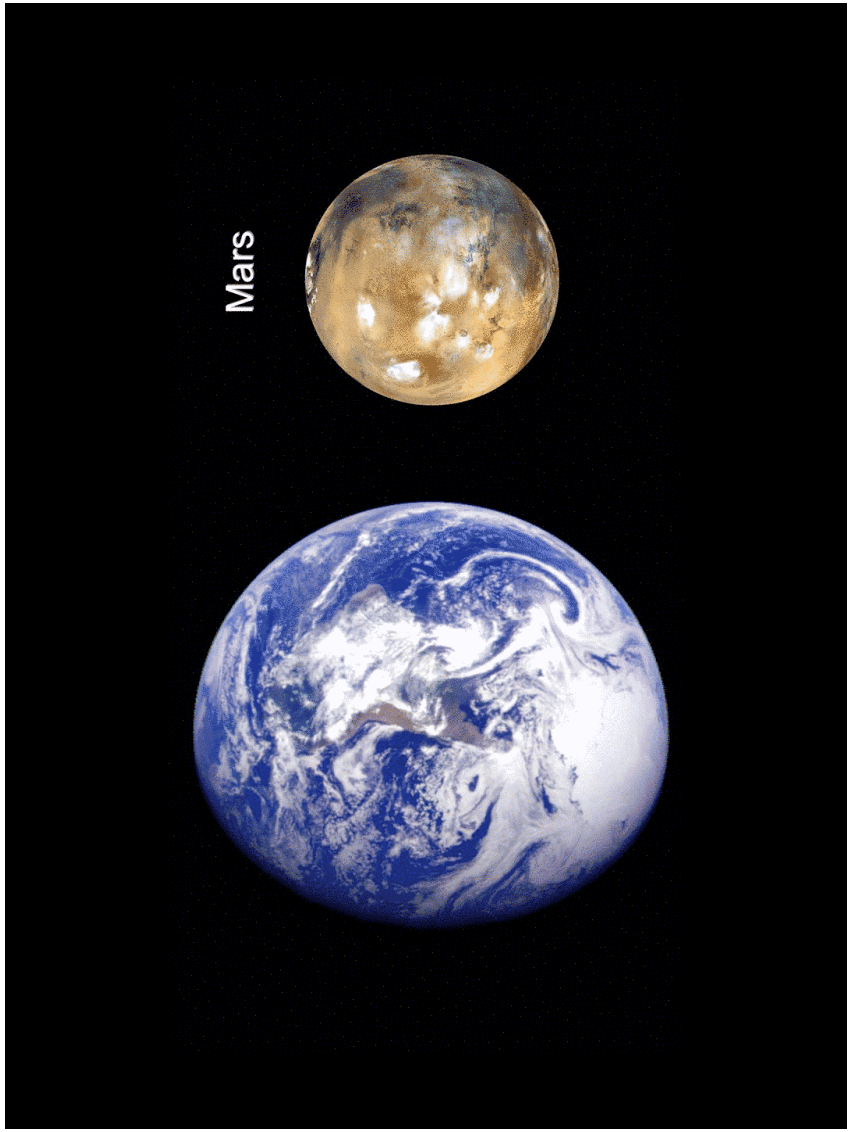
Venus

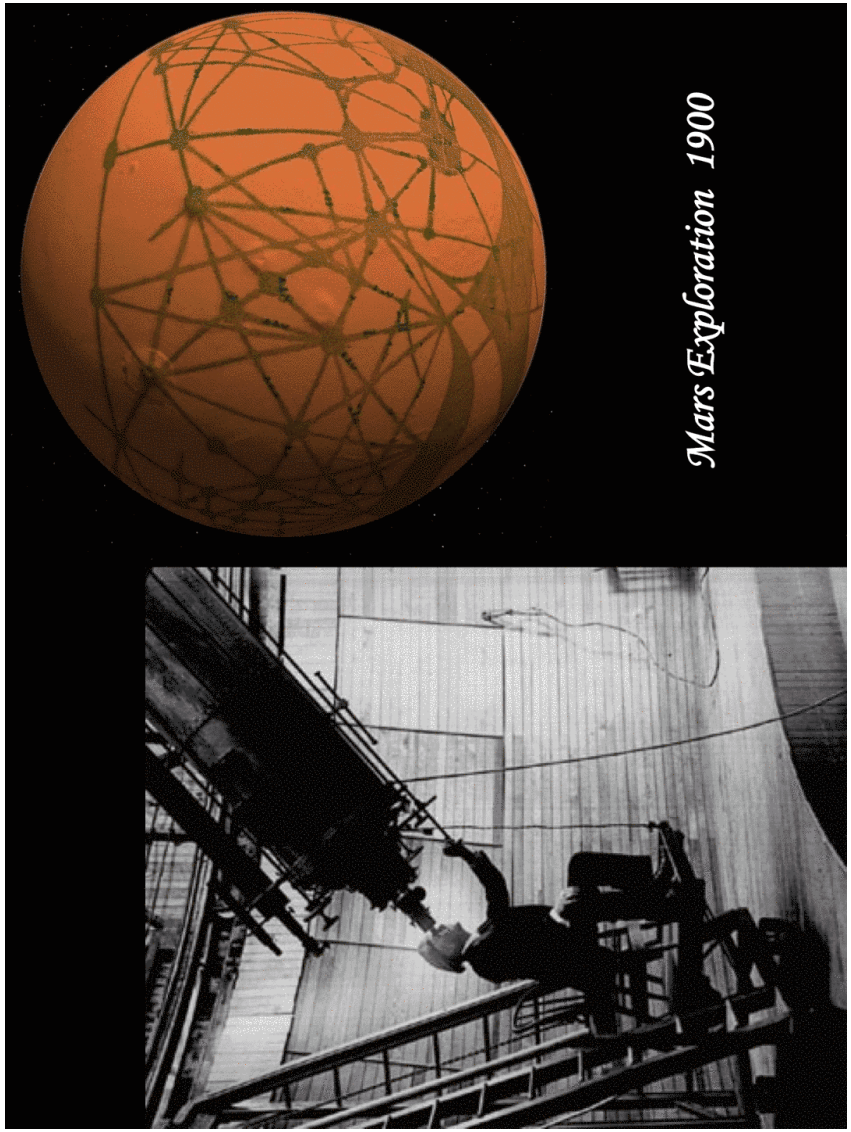


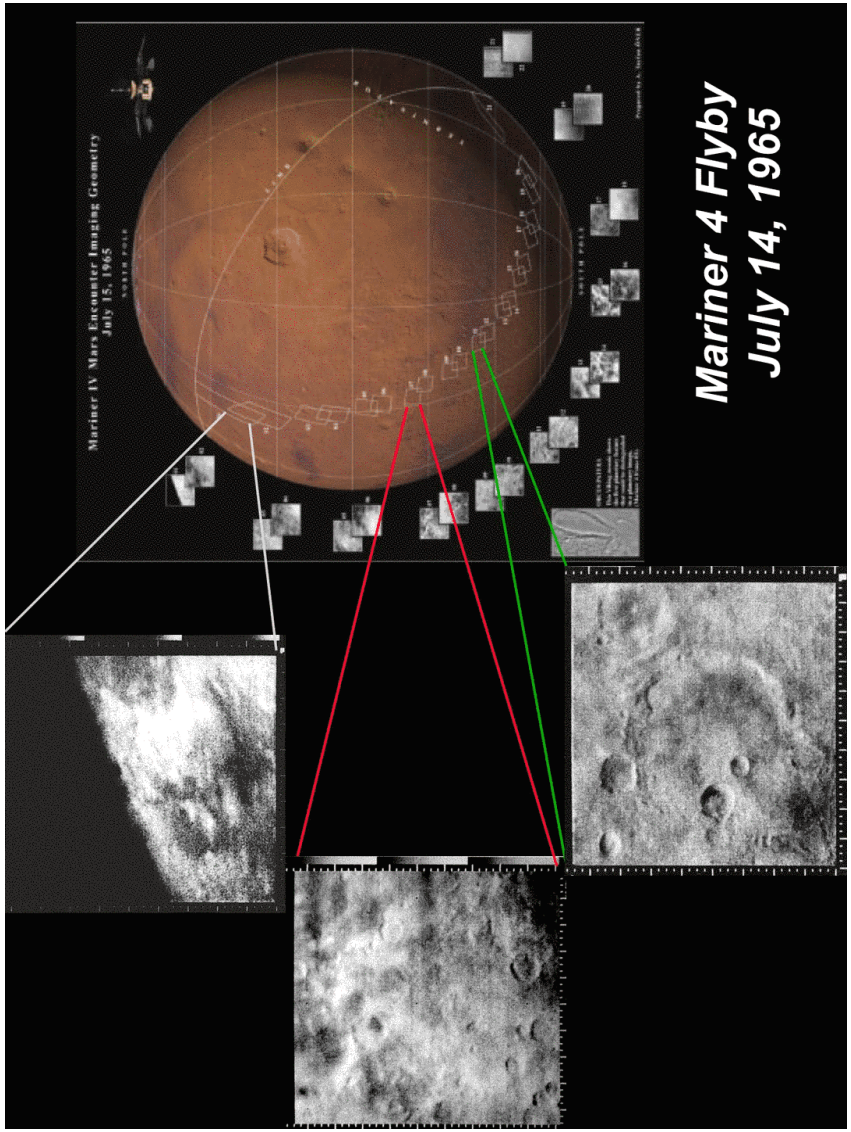
Venus's Atmosphere

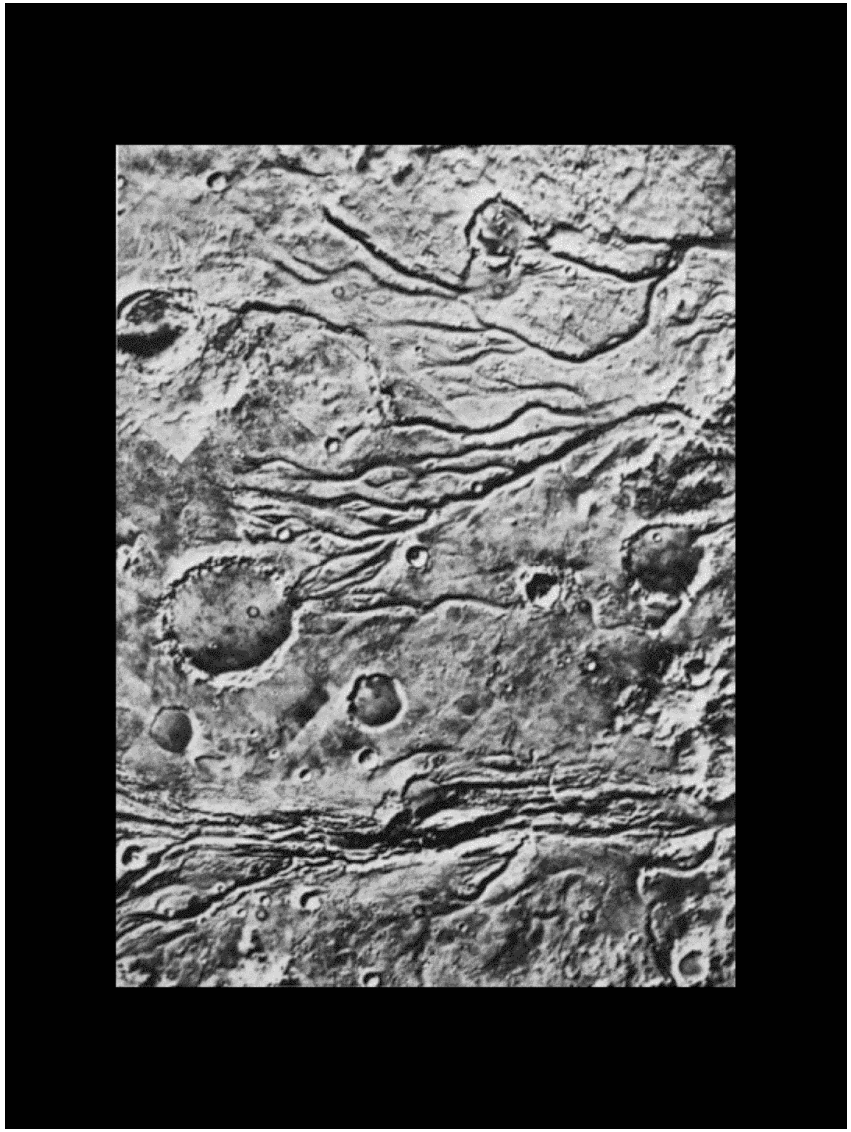


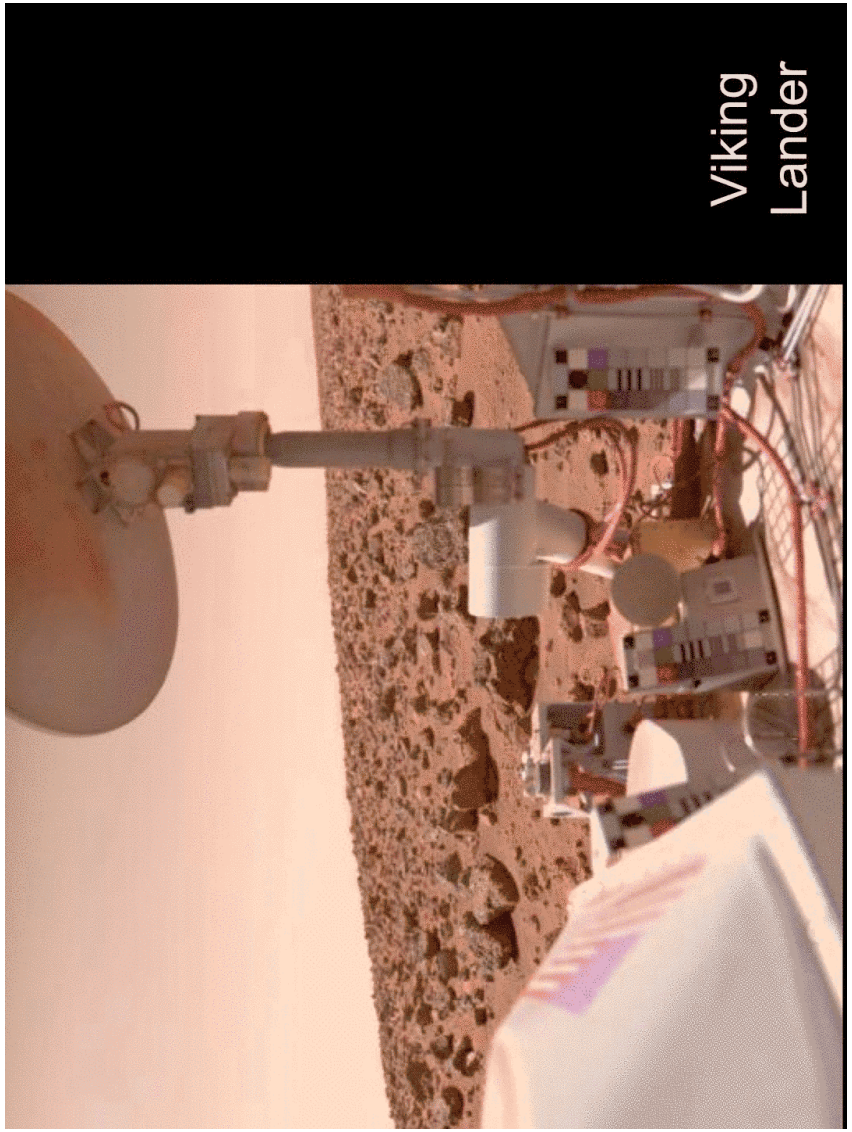


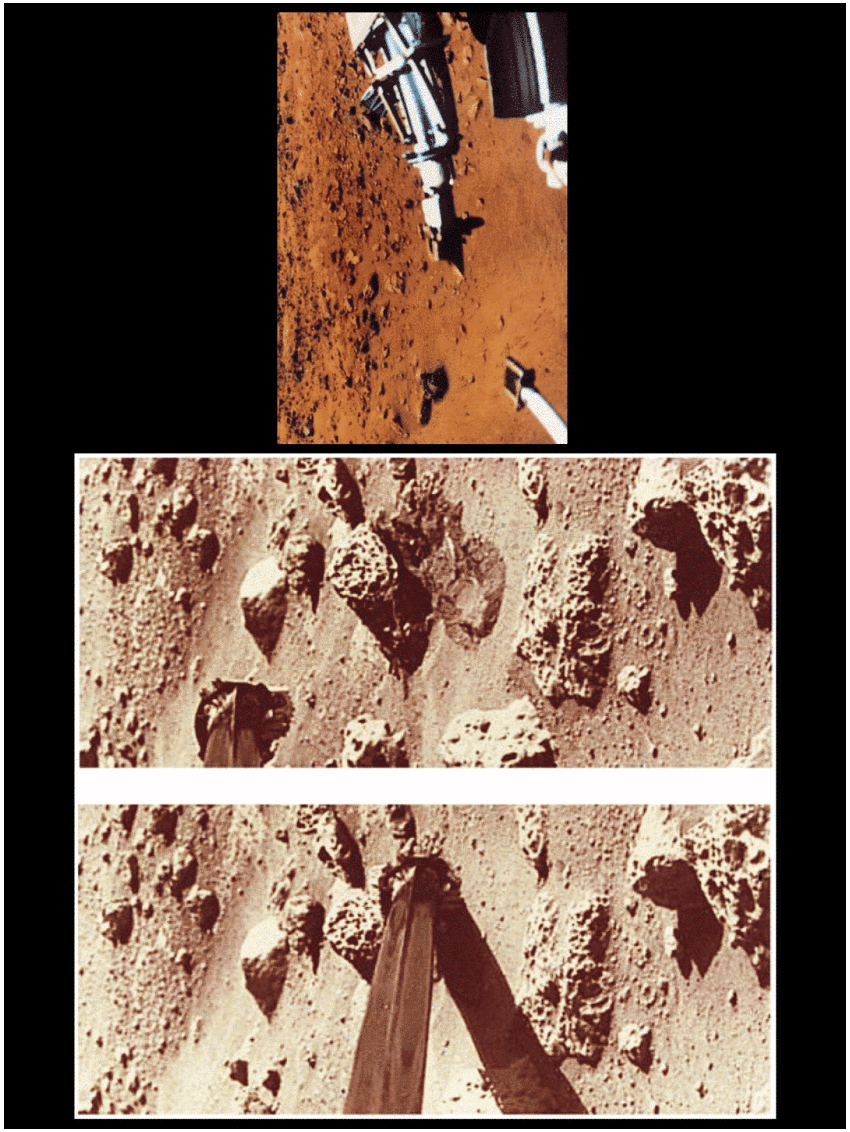

Mars


Mars Exploration 1900

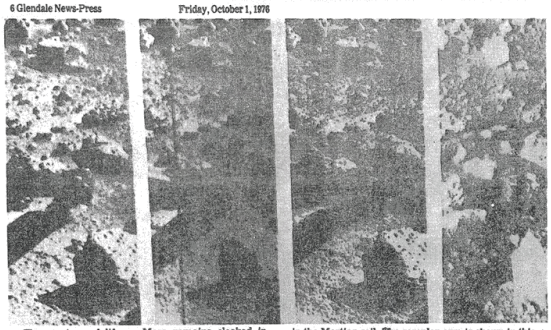

Mariner IV Mars Encounter Imaging Geometry
July 15, 1965
Mariner 4 Flyby
July 14, 1965




Viking
Lander



6 Glendale News-Press Friday, October 1, 1976



The mystery of life on Mars remains cloaked in contradiction after the announcement that the latest soil testing by the Viking 2 sampler arm, pictured here, failed to turn up any signs of organic compounds in the Martian soil. The sampler arm is shown in this sequence of pictures as it dug a one-foot-long trench. The rock in the foreground in all photos is eight inches high.

Search for Mars life reaches a dead-end

America's search for life on another planet has run into a dead-end with Viking 2's failure to find life-essential organic materials on Mars.

New information from the robot on Thursday showed that no organic compounds were found by Viking 2 in its first look. Organics are chains of carbon atoms found in all life as we know it.

Scientists were quick to point out that the initial failure did not positively signal the absence of life on the Red Planet, but one Viking team member admitted it was difficult to "explain no organics."

It is possible that organics were in the dirt but not vaporized, so the experiment will be conducted three more times at progressively higher temperatures. The lander's arm will scoop more soil from beneath a Martian rock.

The organics experiment searches for "the building blocks of life" by heating a clump of soil to 200 degrees fahrenheit in the hope of vaporizing any organic compound that might be in the dirt. It differs from the lander's other biology experiments which attempt to detect activities that seem to be caused by living things.

Scientists had been waiting for the results from the organic experiments to confirm or deny that findings by the lander's biology probes really signified life.

The biology experiments aboard Viking 1 and Viking 2 landers sent back information that there were processes going on that resembled the activities of living forms on Earth, such as respiration and elimination of waste. But the latest experiment did not provide scientists with the confirmation they were seeking.

Dr. Norman Horowitz, who designed the pyrolitic release experiment, said positive results from both his experiment and the organic experiment would be necessary before "we could positively say there is life on Mars."

"We have to walk on two feet," he added, "and without both feet, we cannot say there is life on Mars."

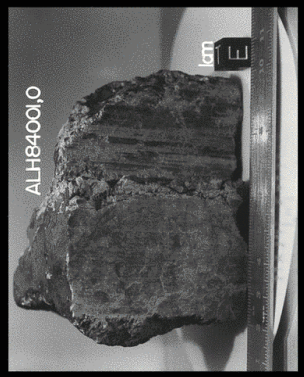
Dr. Klaus Bieman, whose team searched for the elusive organics, cautioned against ruling out the possibility of life on Mars.

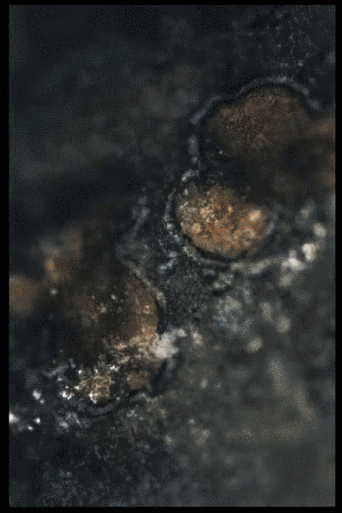
"We can draw no conclusions except that, at 200 degrees in the Bonneville (the nickname of the sample site) sample, we have detected no organic materials," Bieman said.

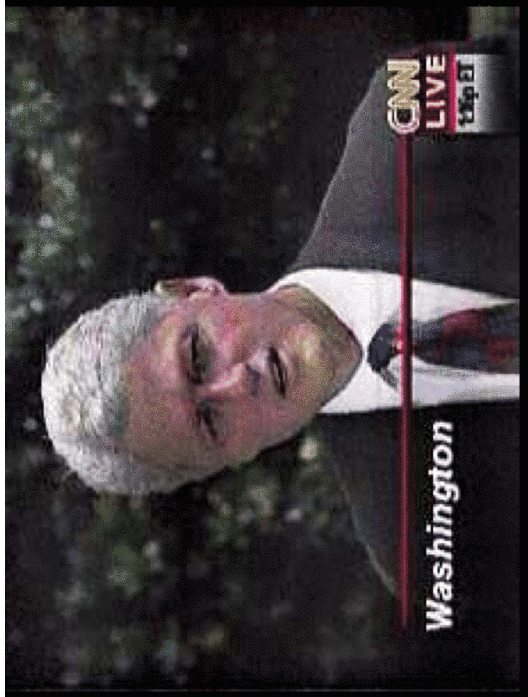
Sojourner at "Yogi"

Life on Mars?

Was Evidence of Life Found in Martian Meteorite?







"Today, Rock 84001 speaks to us across all those billions of years and millions of miles. It speaks of the possibility of life. If this discovery is confirmed, it will surely be one of the most stunning insights into our universe that science has ever uncovered."

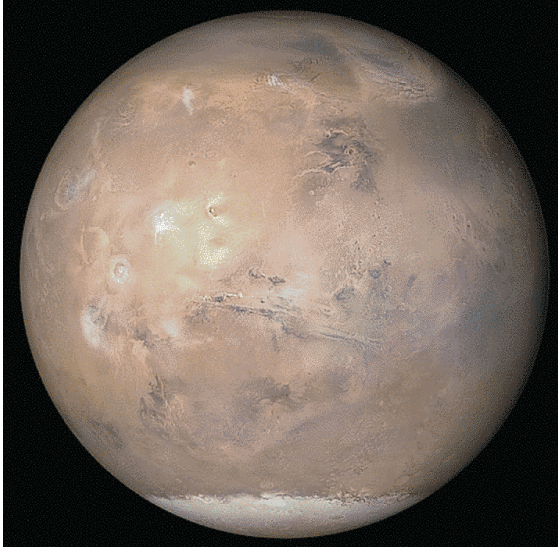
President Bill Clinton, August 7, 1996

Criteria for Recognizing Past Life in Geologic Samples[1] (applied to ALH84001)

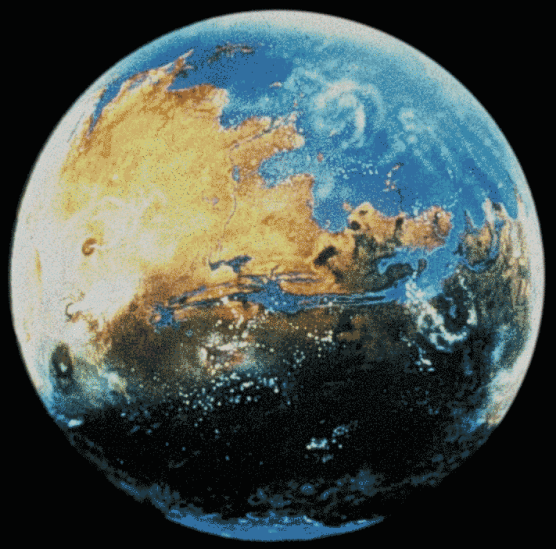
1. Is the geologic context of the sample compatible with past life? NO[2]
2. Is the age of the sample and its stratigraphic location compatible with possible life? Similar to Earth's timeframe[2]
3. Does the sample contain evidence of cellular morphology? and Some disproven[3], some maybe[2]
4. colonies? NO[3]
5. Is there any evidence of biominerals showing chemical or mineral disequilibria? Magnetite, not necessarily biologic[3]
6. Is there any evidence of stable isotope patterns unique to biology? Carbon, not necessarily biologic[3]
7. Are there any organic biomarkers present? PAHs:inorganic? [3]
8. Are the features indigenous to the sample? Some[2]

[1]Schopf and Walker, 1983 & Cloud and Morrison, 1979; [2] Gibson et al., 1999; [3]Subsequent papers by other authors

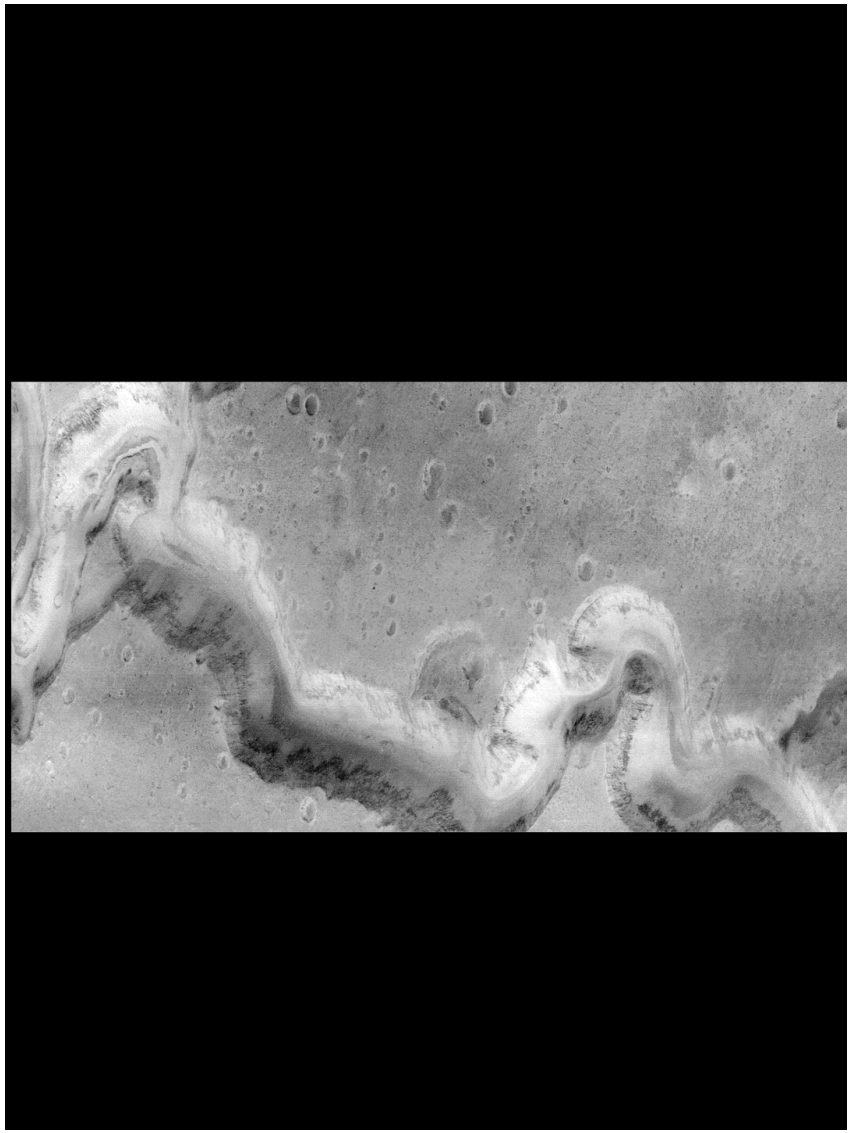
Ancient Mars?

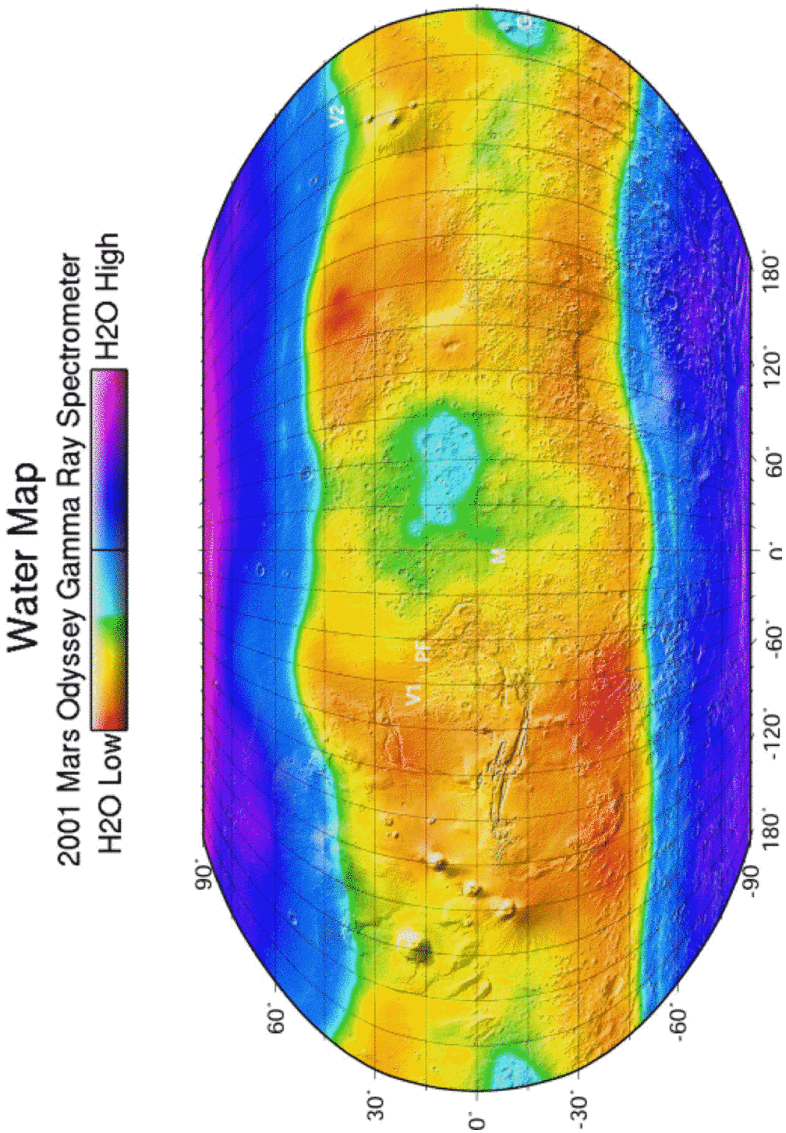


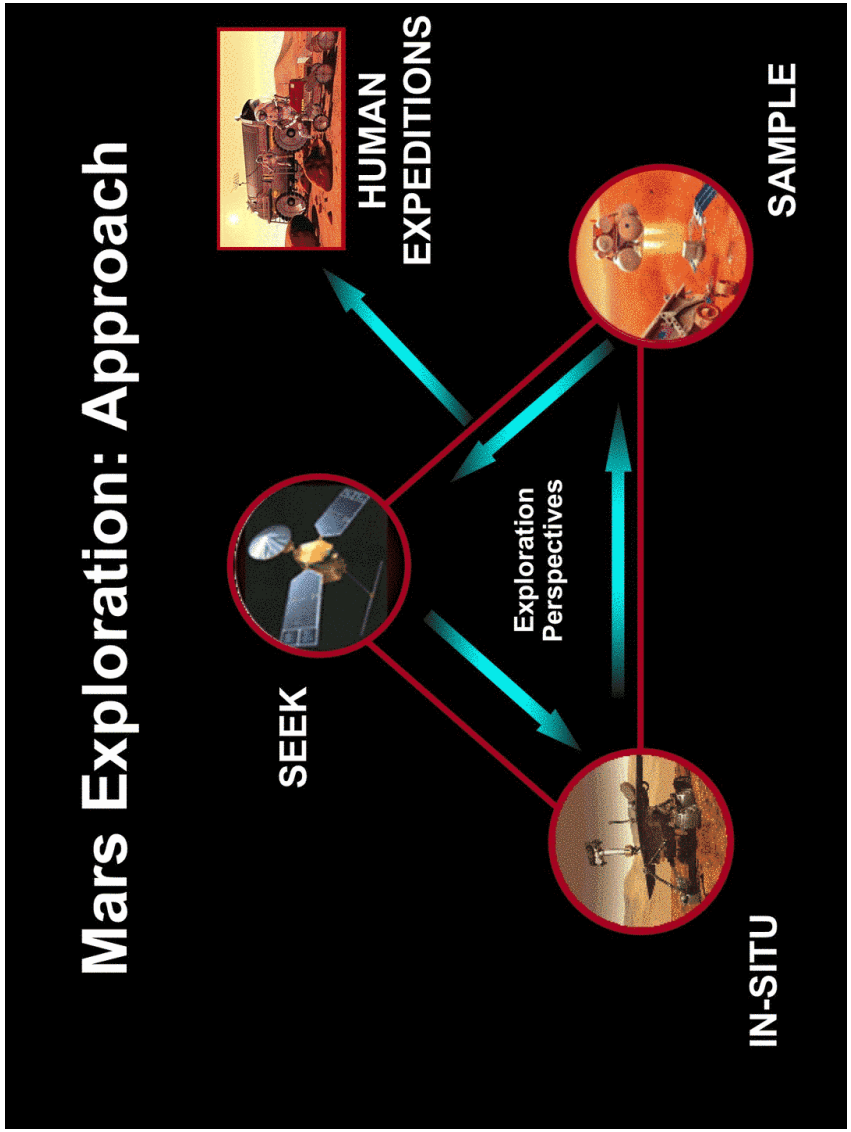
Modern
Cold and Arid

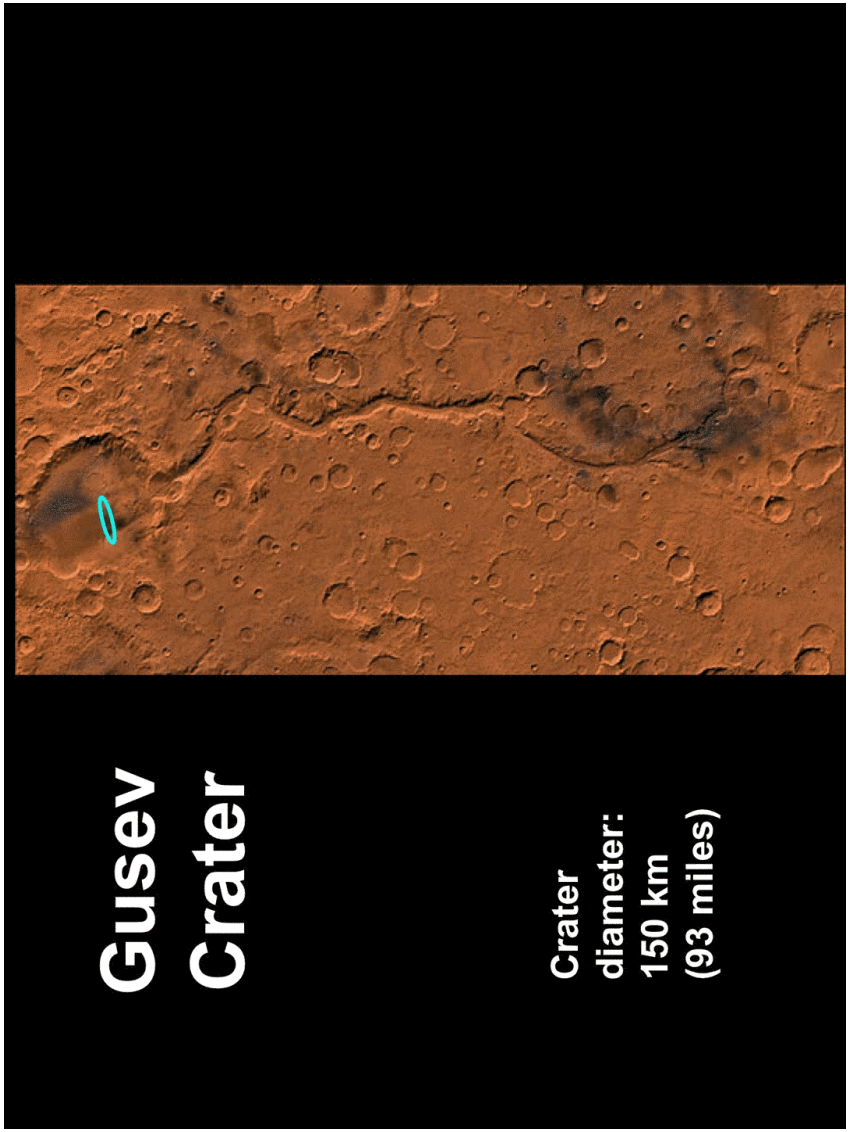


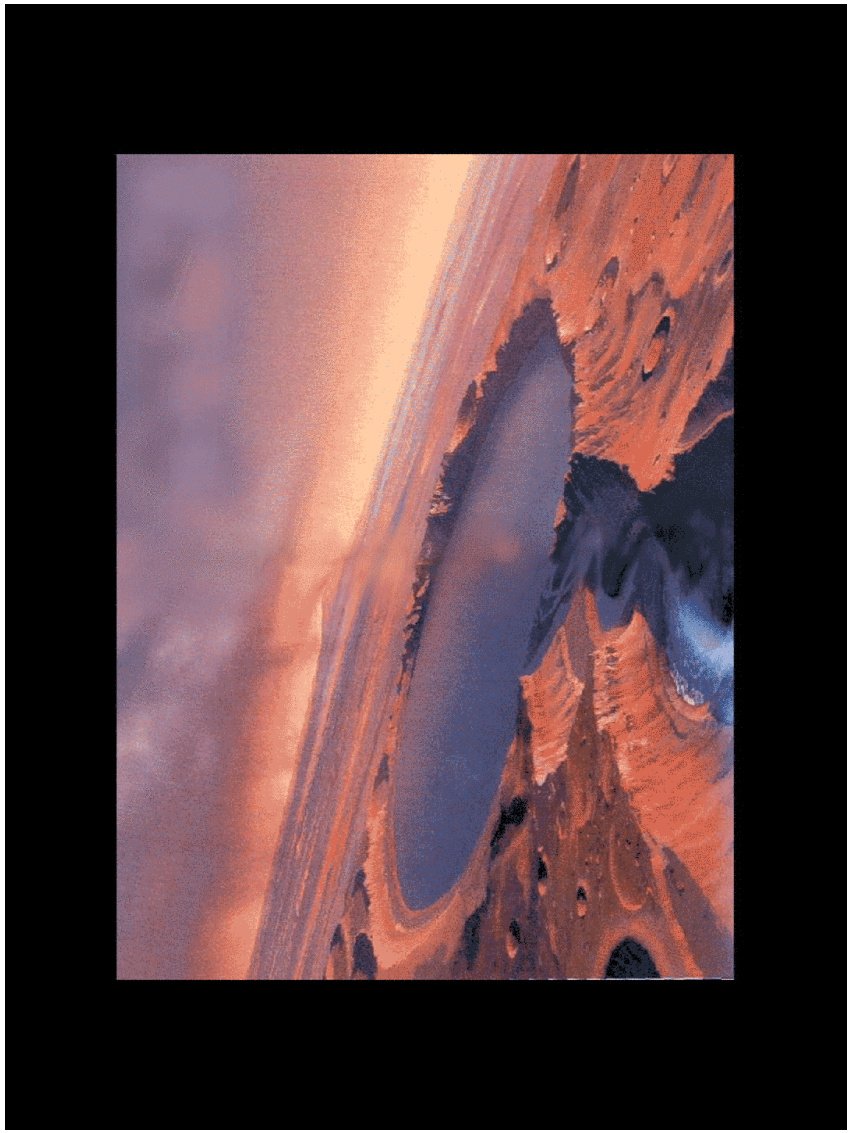
Past
Wet and Warm?

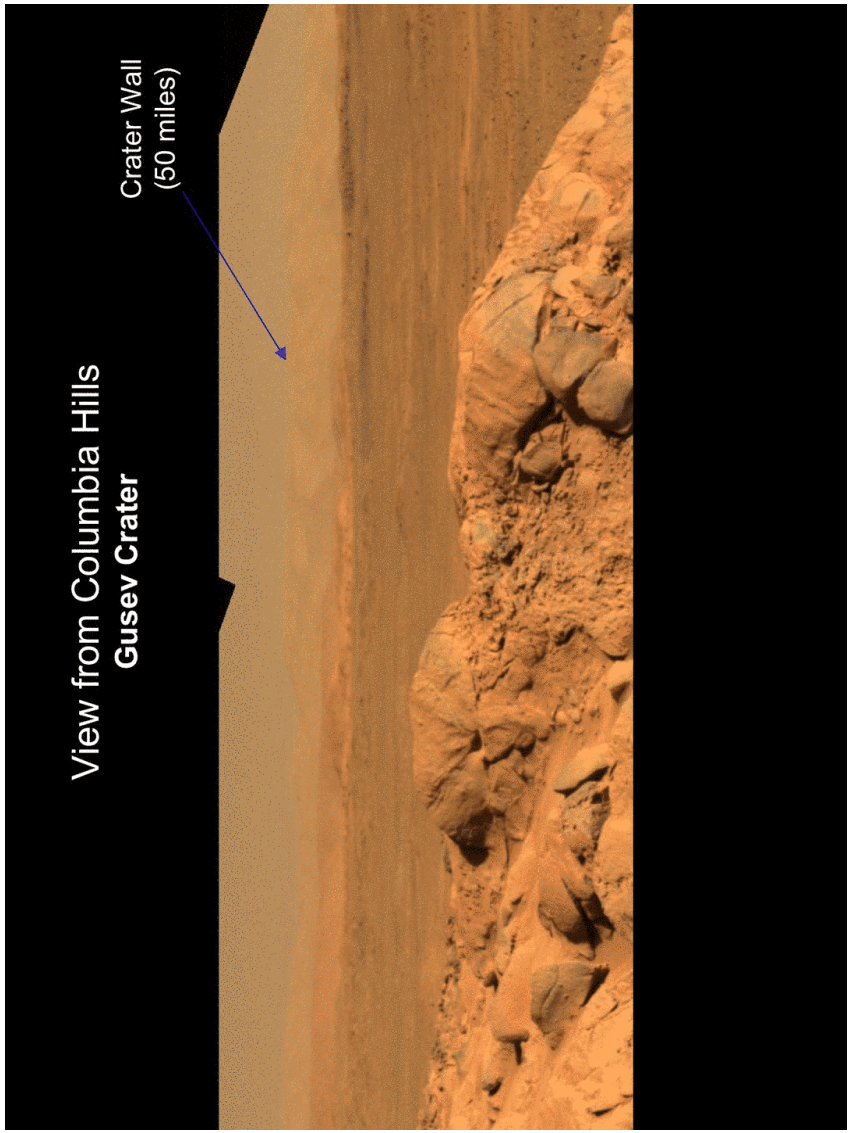


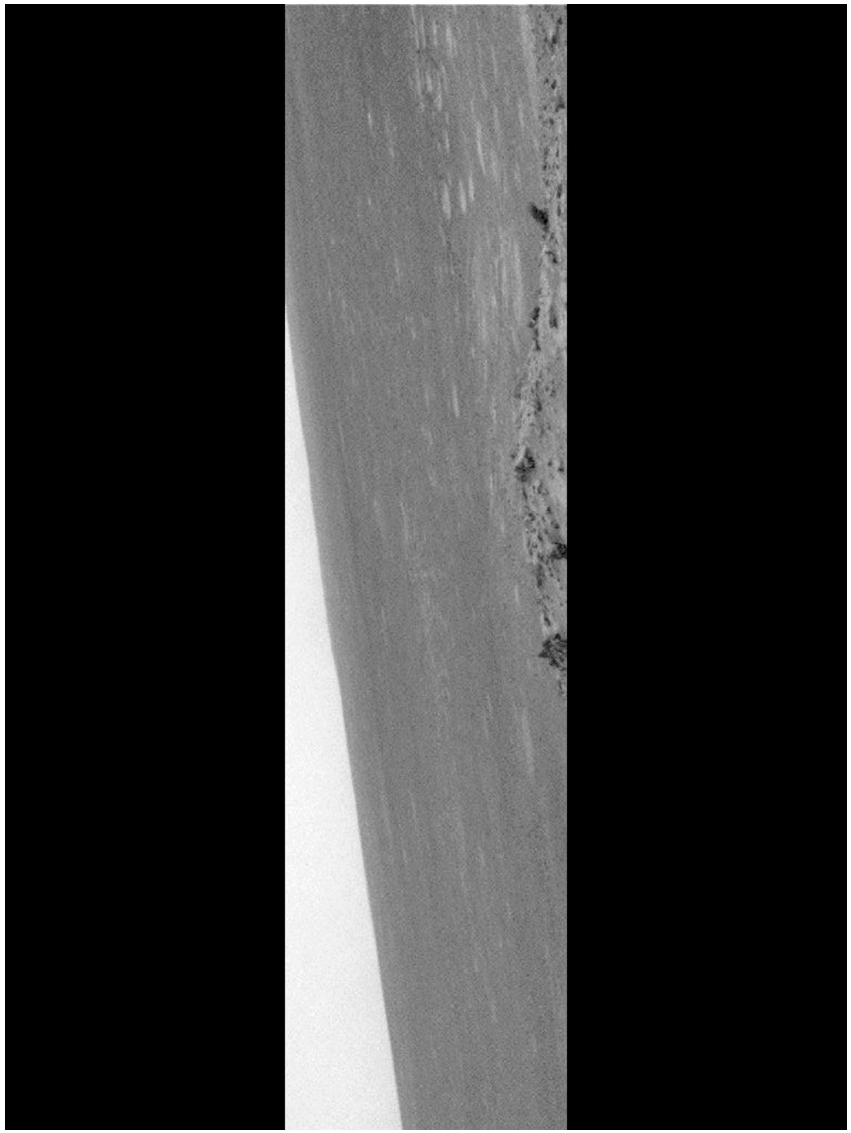

Water Map
2001 Mars Odyssey Gamma Ray Spectrometer
H2O Low
H2O High
90°
60°
30°
0°
-30°
-60°
-90
180°
-120°
-60°
0°
60°
120°
180°
V1
PF
M
V2

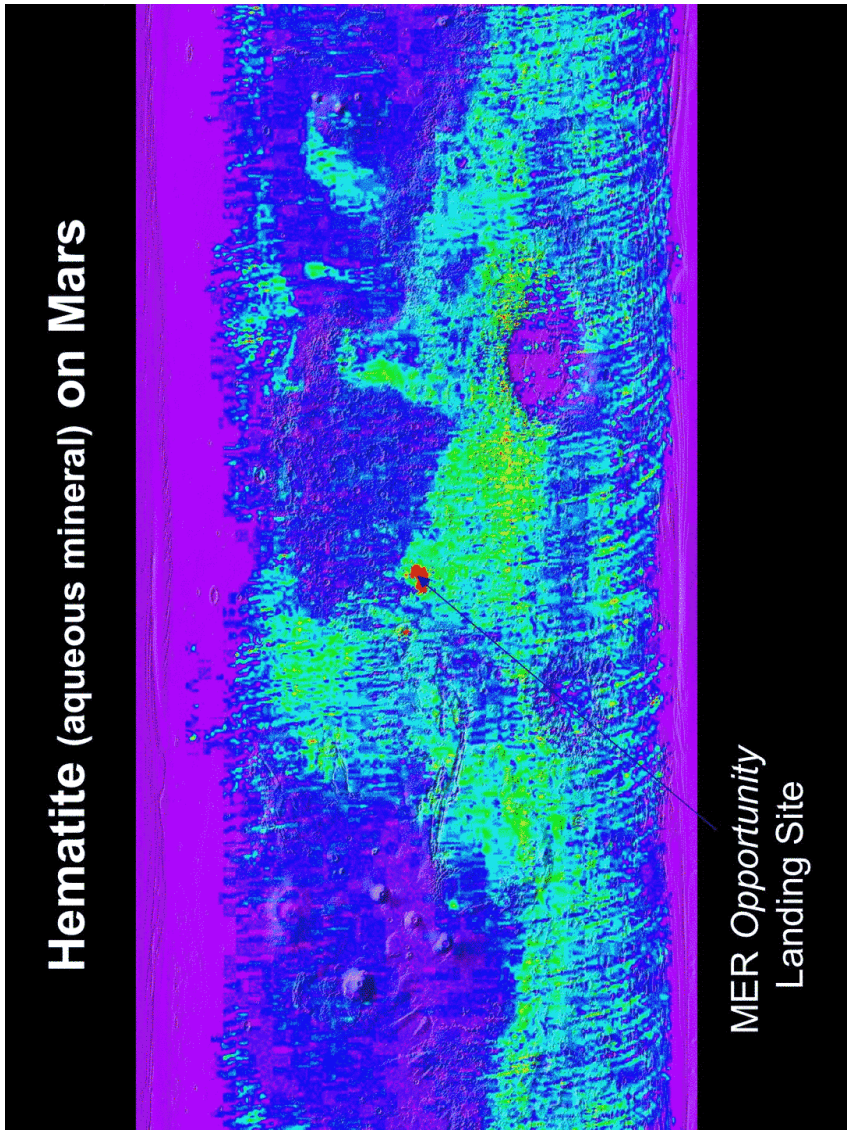

Mars Exploration: Approach
SEEK
HUMAN EXPEDITIONS
SAMPLE
IN-SITU
Exploration Perspectives


Gusev Crater
Crater diameter: 150 km (93 miles)

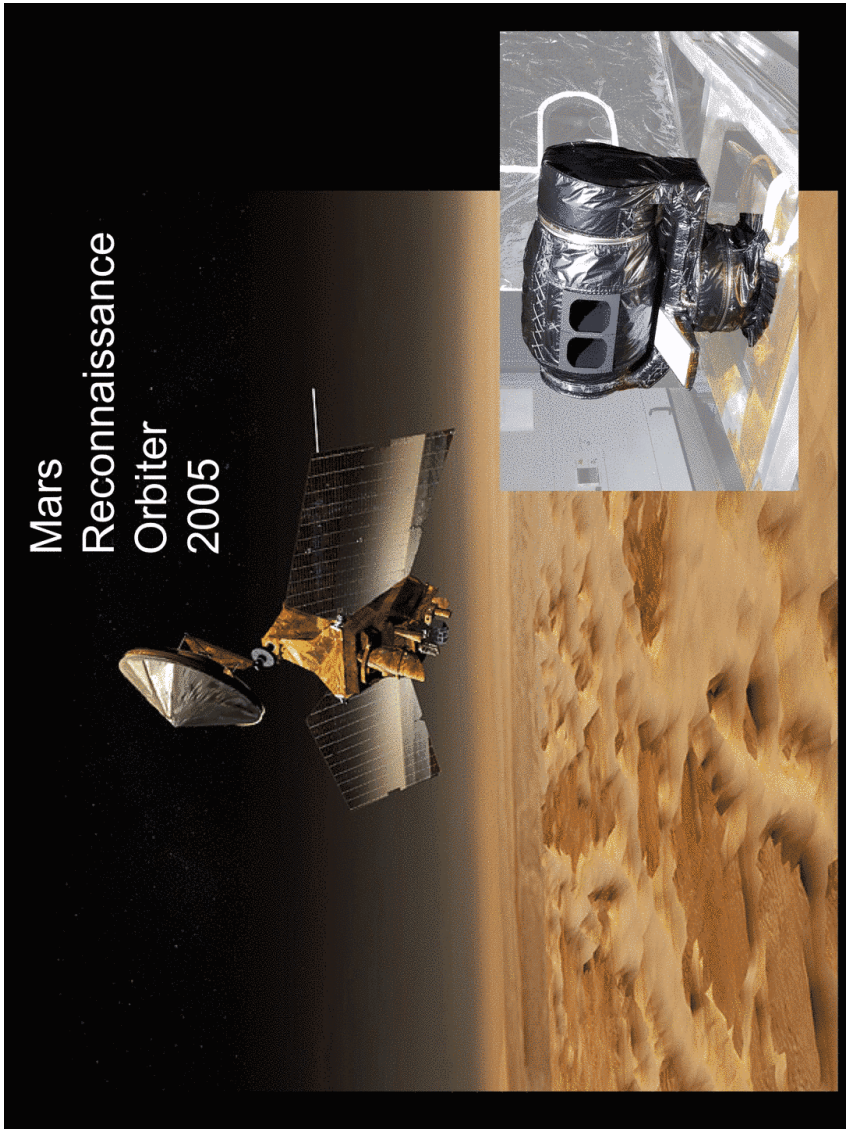



View from Columbia Hills
Gusev Crater
Crater Wall
(50 miles)

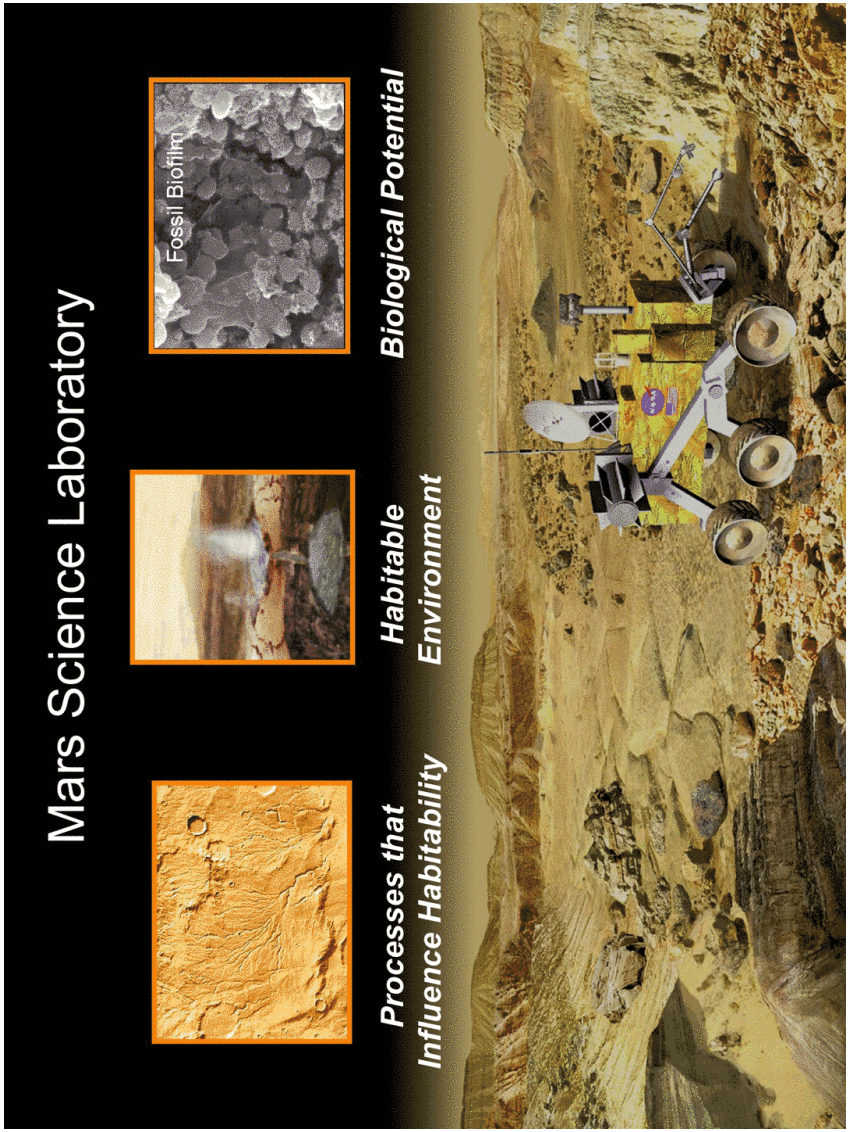



Hematite (aqueous mineral) on Mars
MER Opportunity
Landing Site

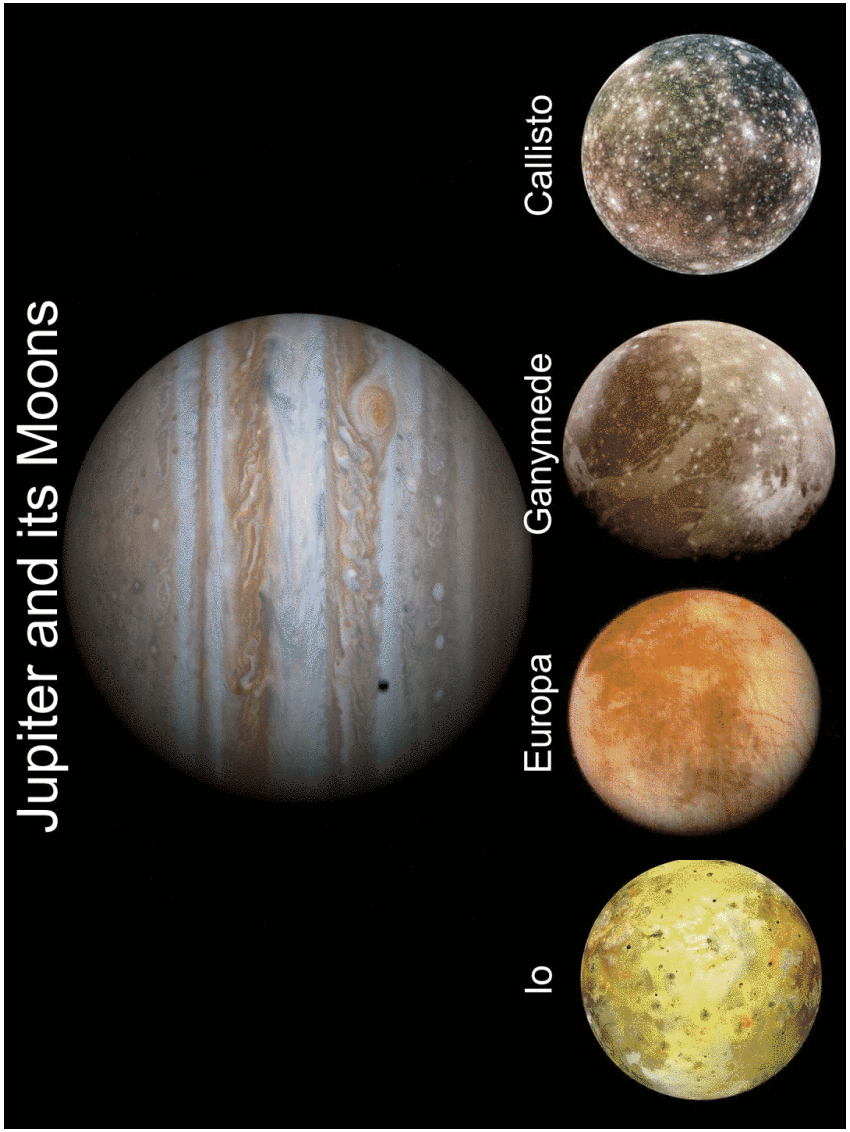

Shore of an Ancient Salty Sea


Mars
Reconnaissance
Orbiter
2005

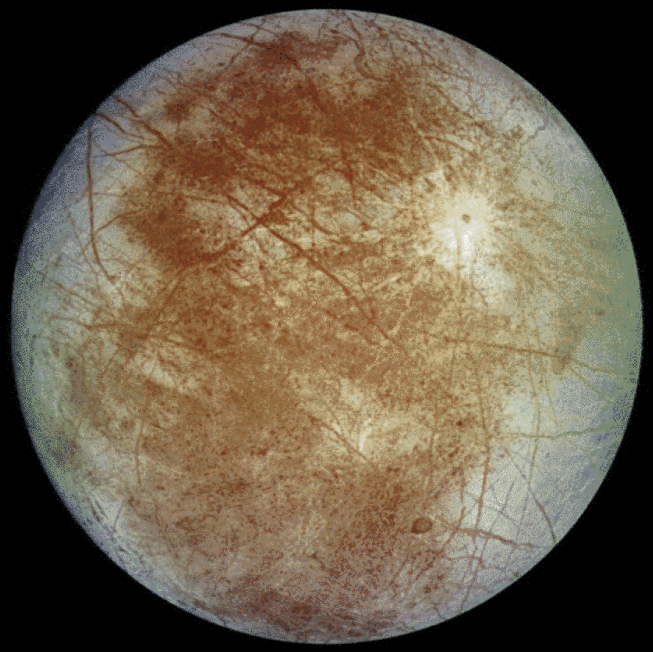

Phoenix 2007


Mars Science Laboratory
Fossil Biofilm
Processes that Influence Habitability
Habitable Environment
Biological Potential


Mars Sample Return

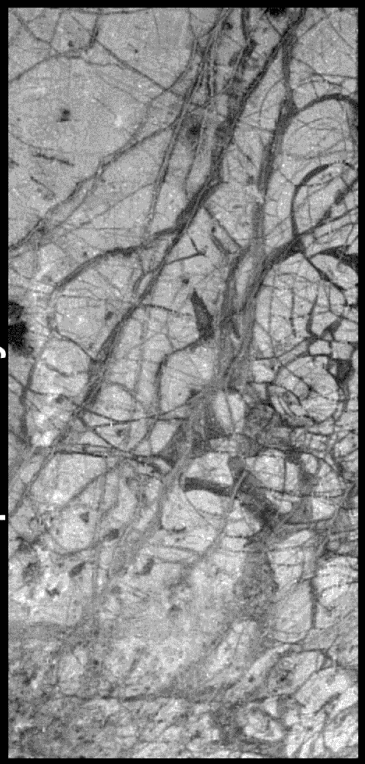

Jupiter and its Moons
Io
Europa
Ganymede
Callisto

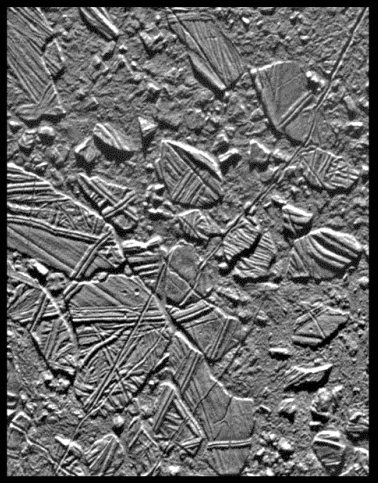
Europa

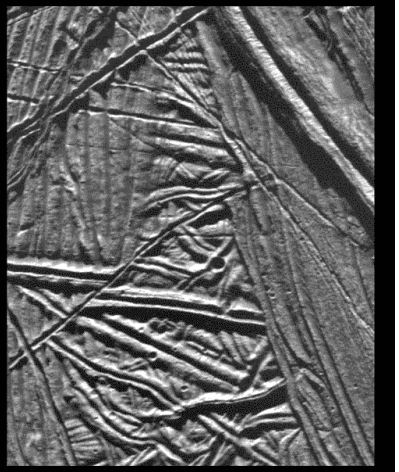


Europa is approximately 90% the size of Earth's moon

Europa's Icy Surface

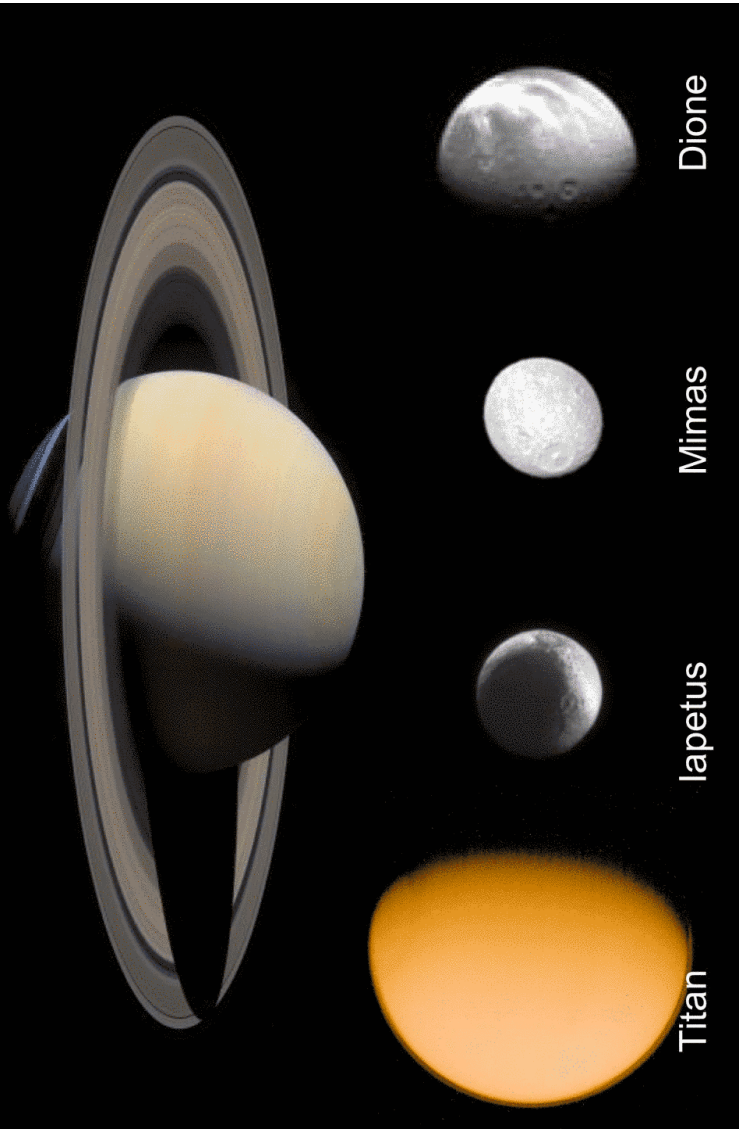




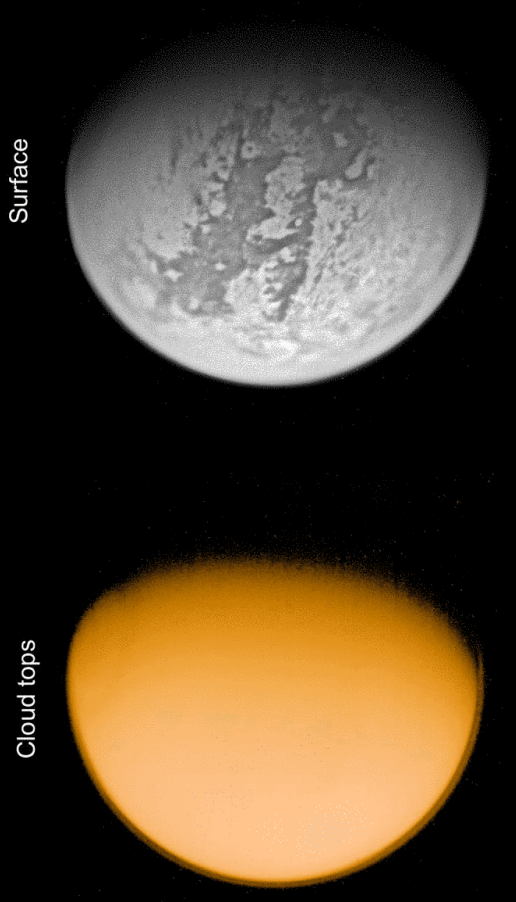


Future Europa Ocean Probe

Saturn and its Moons

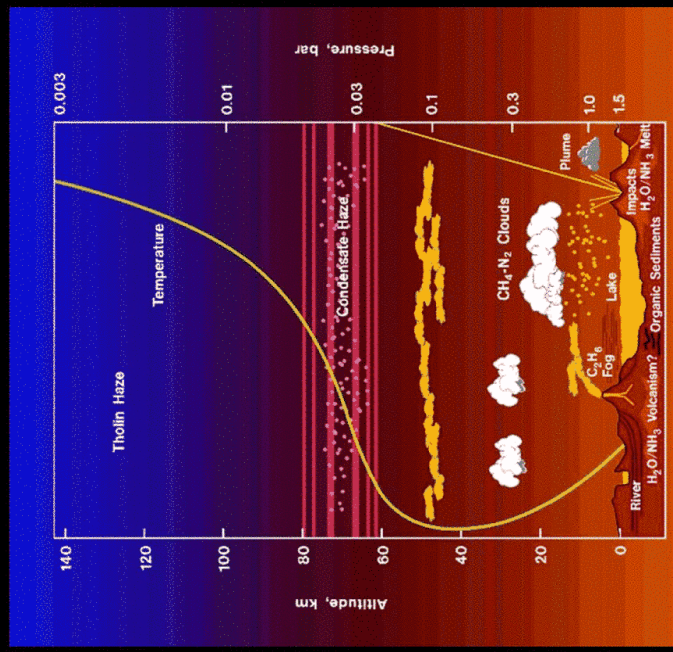


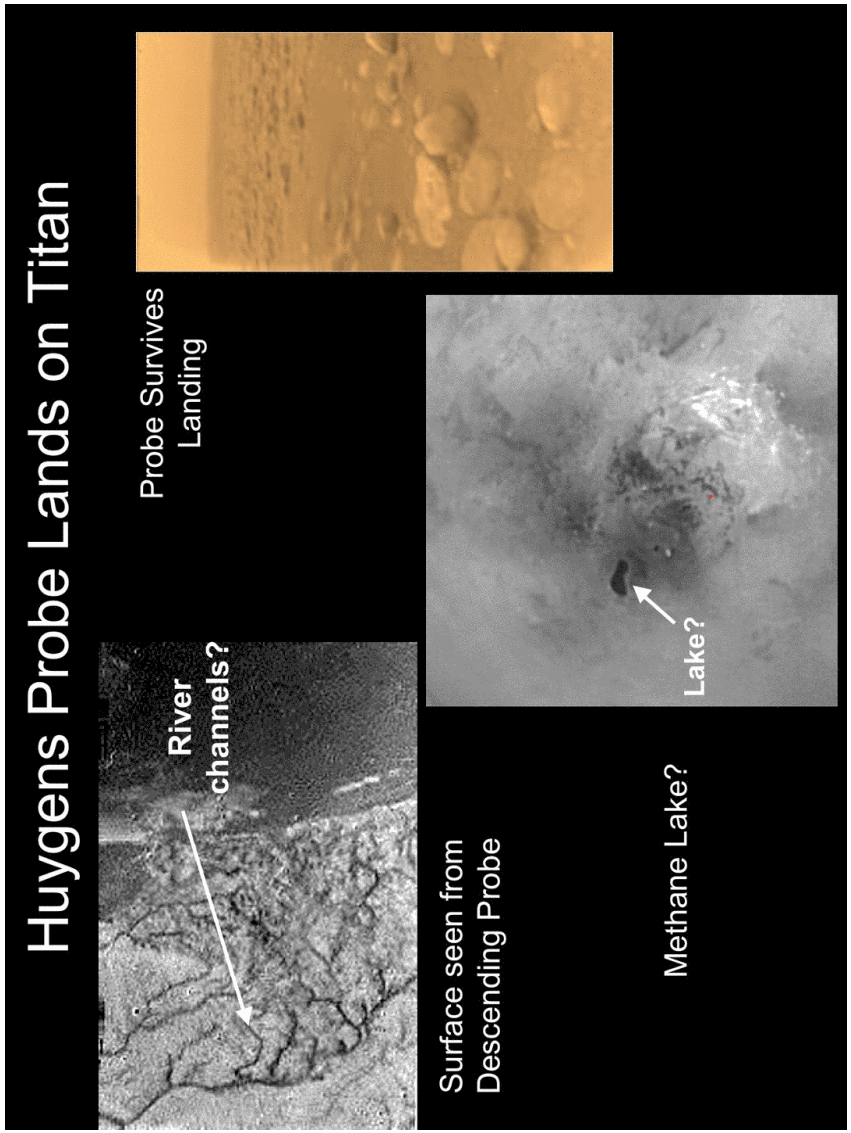
Titan

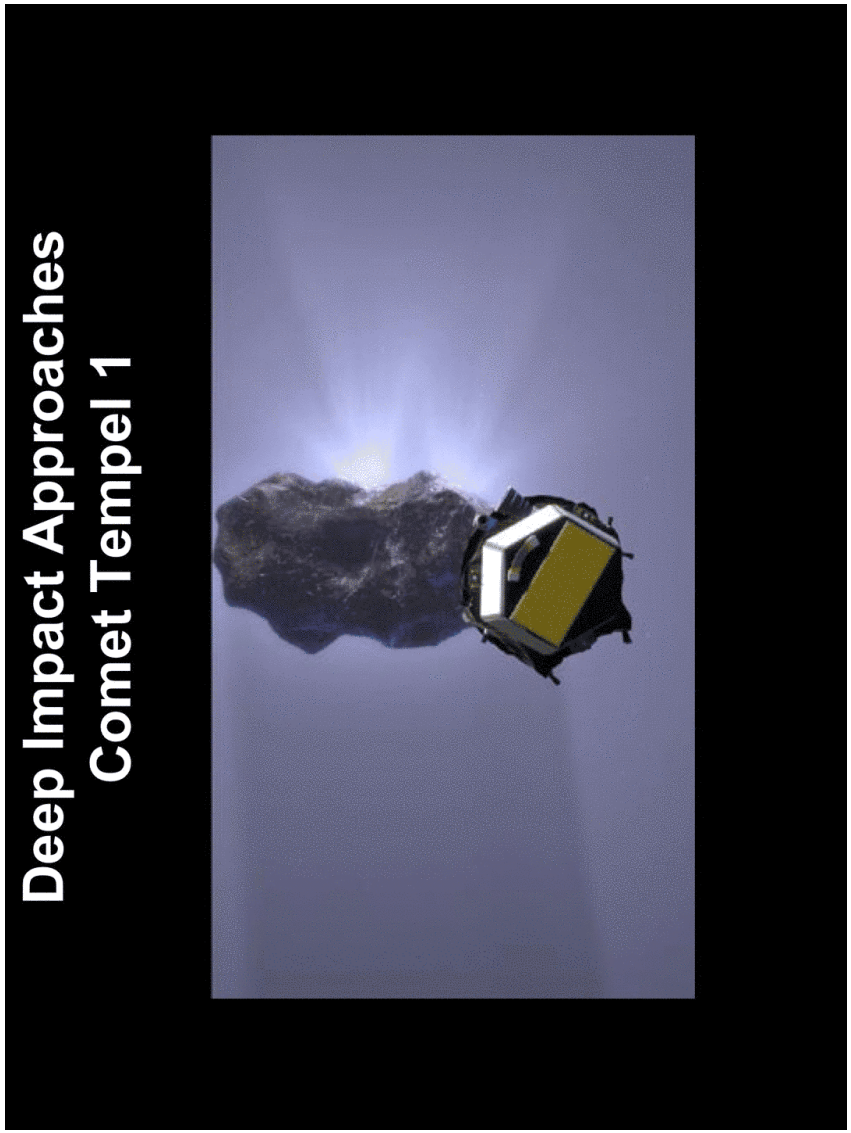


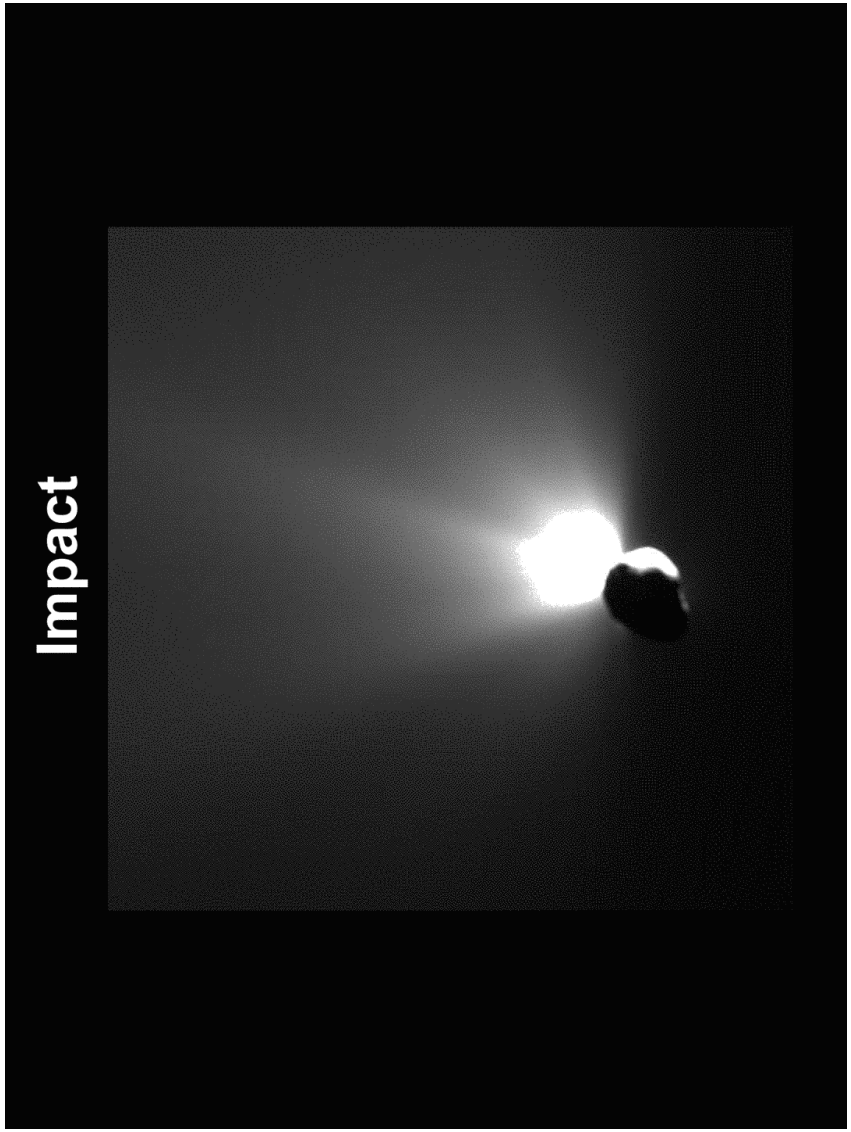
Titan is approximately 40% the size of Earth, or 150% the size of Earth's moon

Titan's Atmosphere & Surface




Huygens Probe Lands on Titan
River channels?
Surface seen from Descending Probe
Probe Survives Landing
Methane Lake?
Lake?


Deep Impact Approaches Comet Tempel 1


Impact