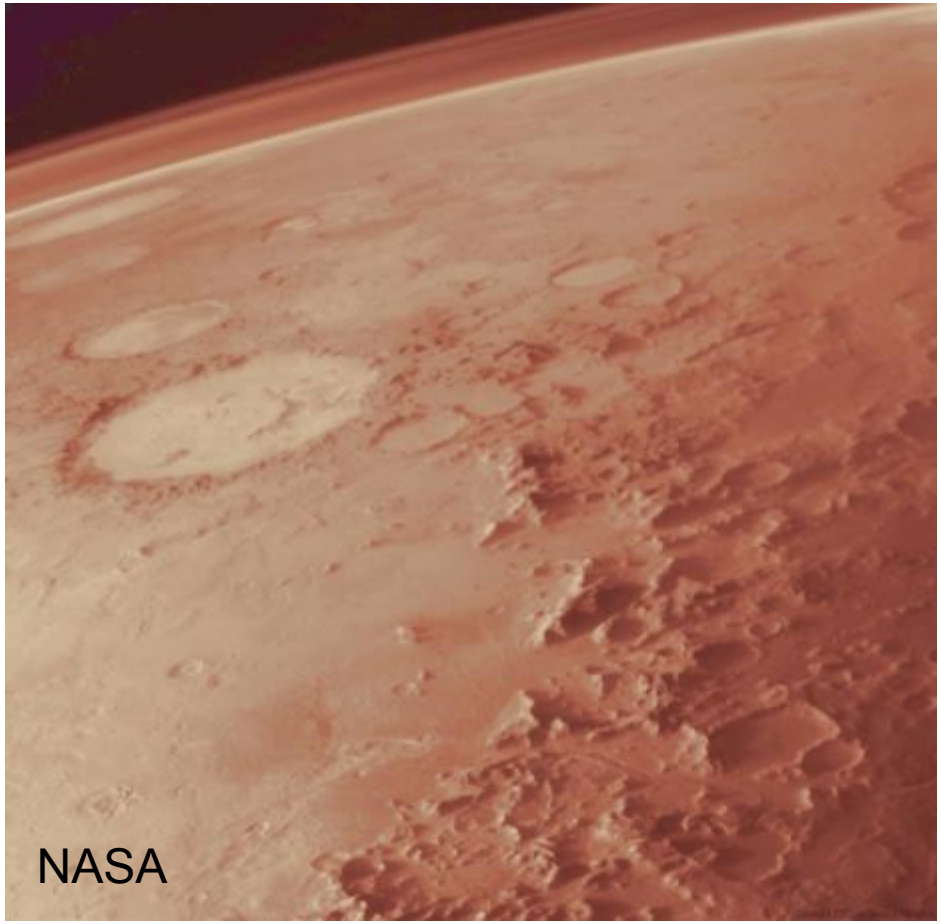
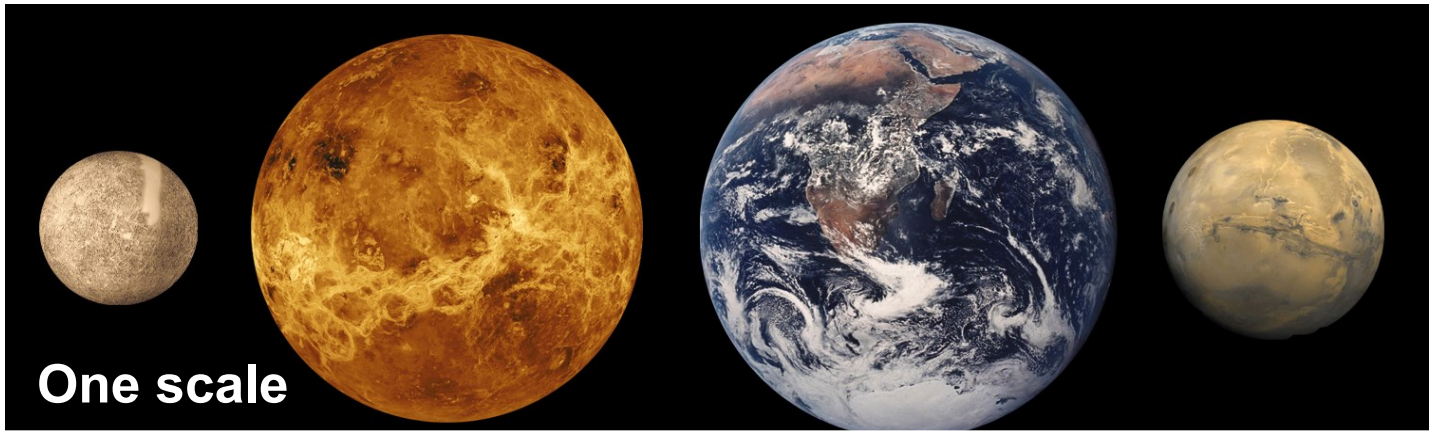
Mars

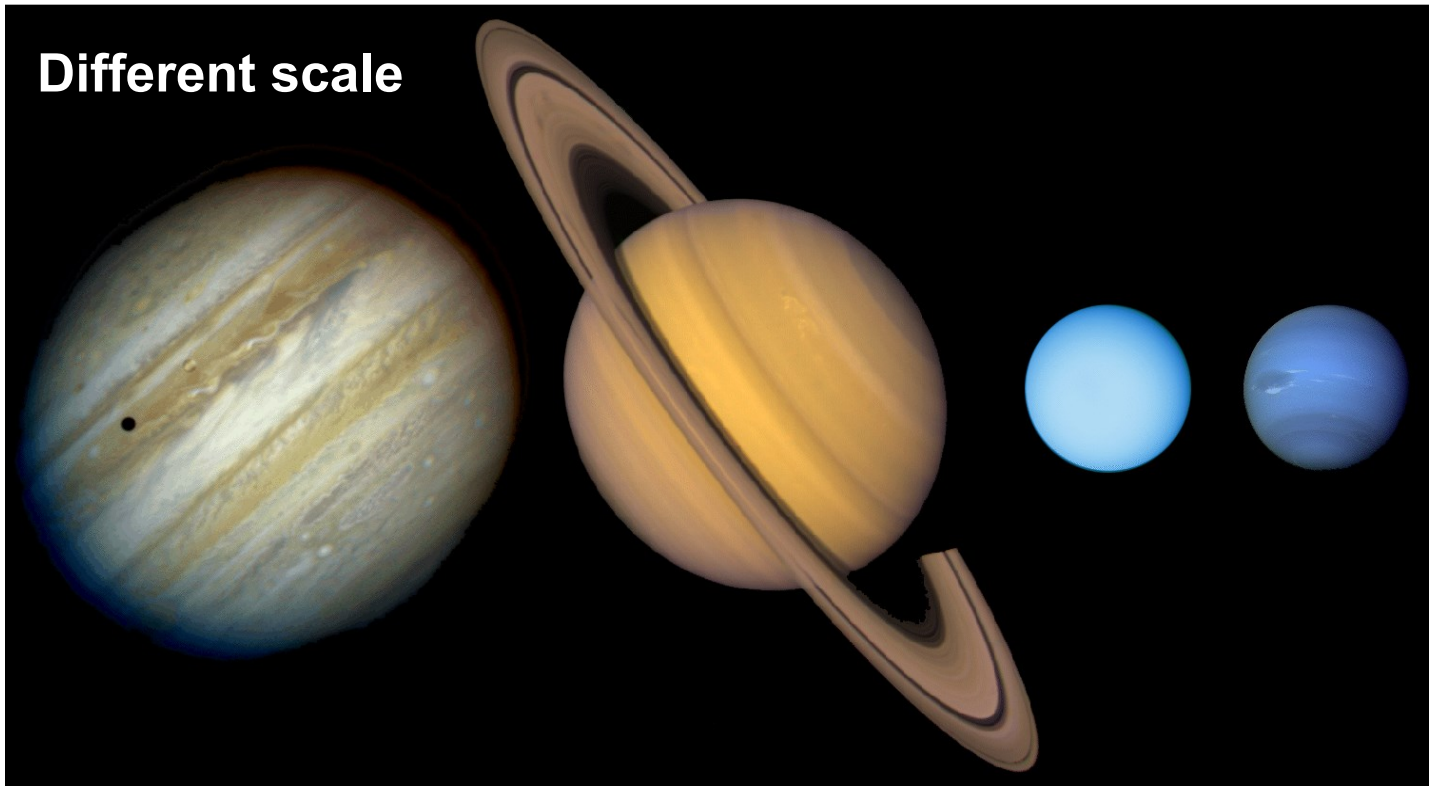


Professor Withers
Boston University
(withers@bu.edu)

Guest lecture in AS105
Alien Worlds

Thursday 2014.10.02
14:00





www.solarviews.com

This is ⟵ Mars

0.5 x R-Earth

1.5 AU from Sun

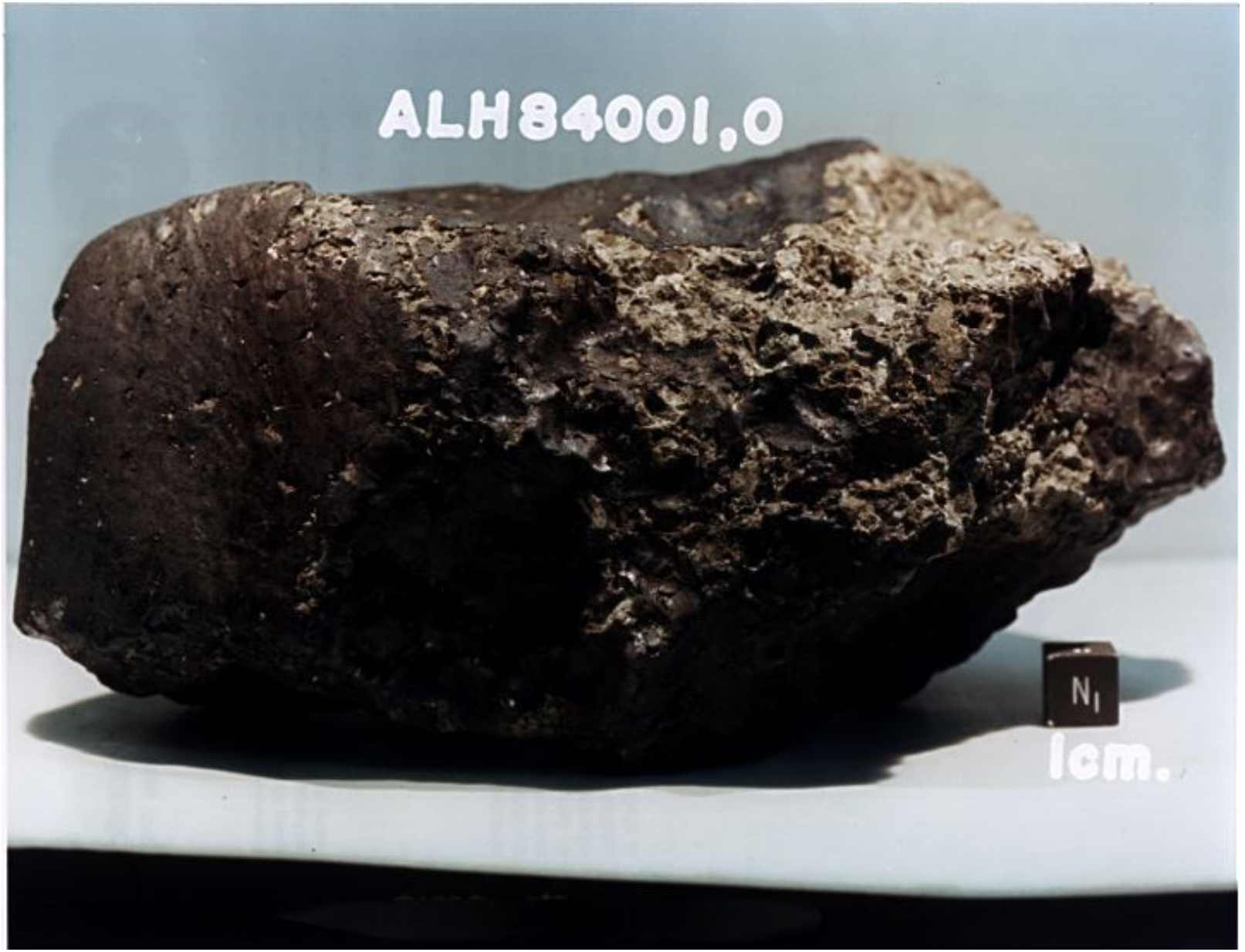
Same rotation rate as Earth

Carbon dioxide atmosphere

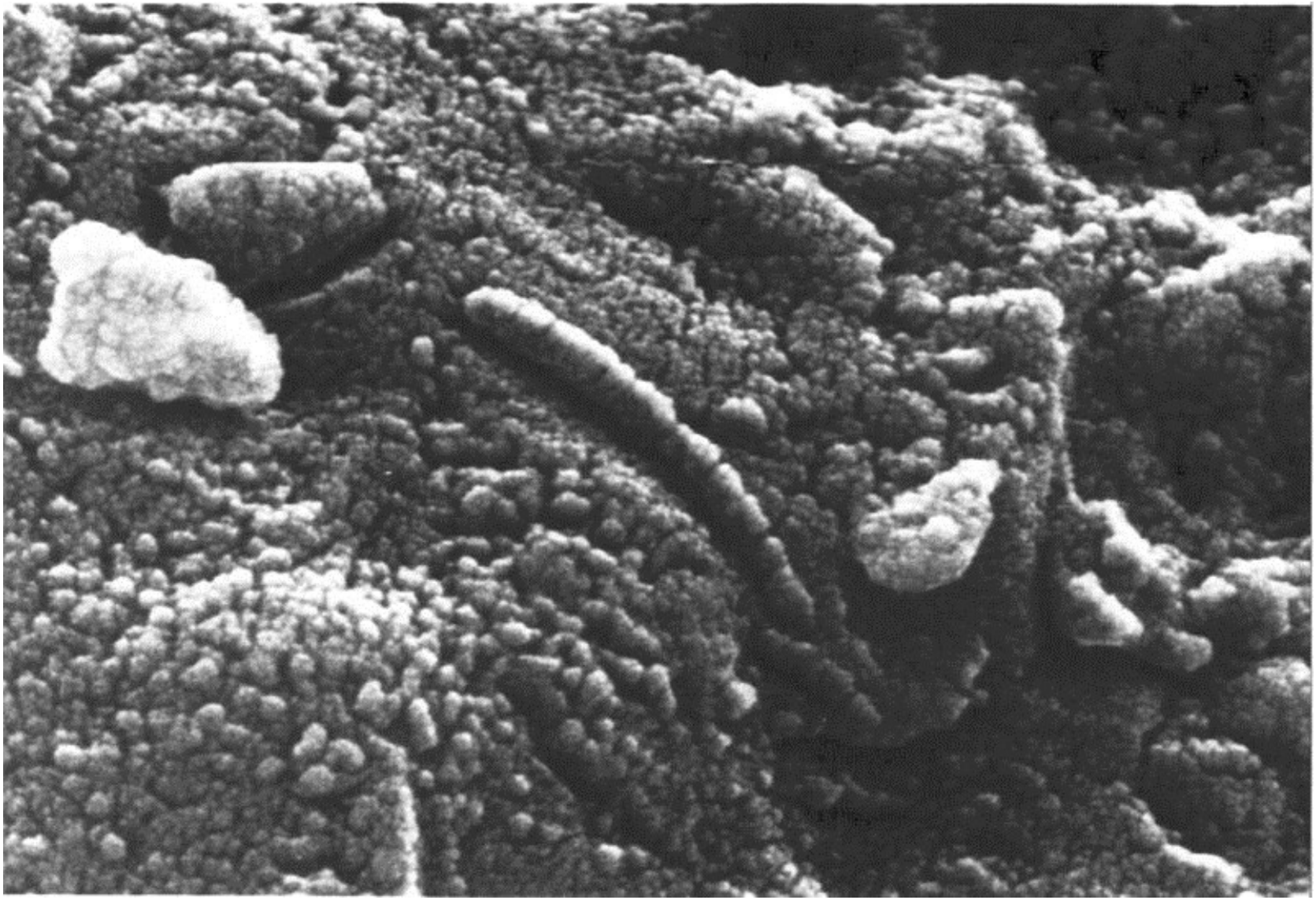
100x smaller surface pressure

Target of many spacecraft in last 20 years

http://scienceroadshow.files.wordpress.com/2013/01/p1020303.jpg



http://members.cruzio.com/~inscript/images/MarsM.jpg



http://en.wikipedia.org/wiki/File:ALH84001_structures.jpg

Image is about 1 micrometer across

RESEARCH ARTICLE

Search for Past Life on Mars: Possible Relic Biogenic Activity in Martian Meteorite ALH84001

David S. McKay, Everett K. Gibson Jr.,
Kathie L. Thomas-Keprta, Hojatollah Vali,
Christopher S. Romanek, Simon J. Clemett,
Xavier D. F. Chillier, Claude R. Maechling, Richard N. Zare

Fresh fracture surfaces of the martian meteorite ALH84001 contain abundant polycyclic aromatic hydrocarbons (PAHs). These fresh fracture surfaces also display carbonate globules. Contamination studies suggest that the PAHs are indigenous to the meteorite. High-resolution scanning and transmission electron microscopy study of surface textures and internal structures
contain fine-grained, seconda
carbonate globules are simila
carbonate precipitates. Altho
ules by biogenic processes c
PAHs. The PAHs, the carbona
es and textures could thus b

Donald L. Savage
Headquarters, Washington, DC
(Phone: 202/358-1727)

James Hartsfield
Johnson Space Center, Houston, TX
(Phone: 713/483-5111)

David Salisbury
Stanford University, Palo Alto, CA
(Phone: 415/723-2558)

August 7, 1996

RELEASE: 96-160

METEORITE YIELDS EVIDENCE OF PRIMITIVE LIFE ON EARLY MARS

A NASA research team of scientists at the Johnson Space Center (JSC), Houston, TX, and at Stanford University, Palo Alto, CA, has found evidence that strongly suggests primitive
billion years ago.

President Clinton Statment Regarding Mars Meteorite Discovery

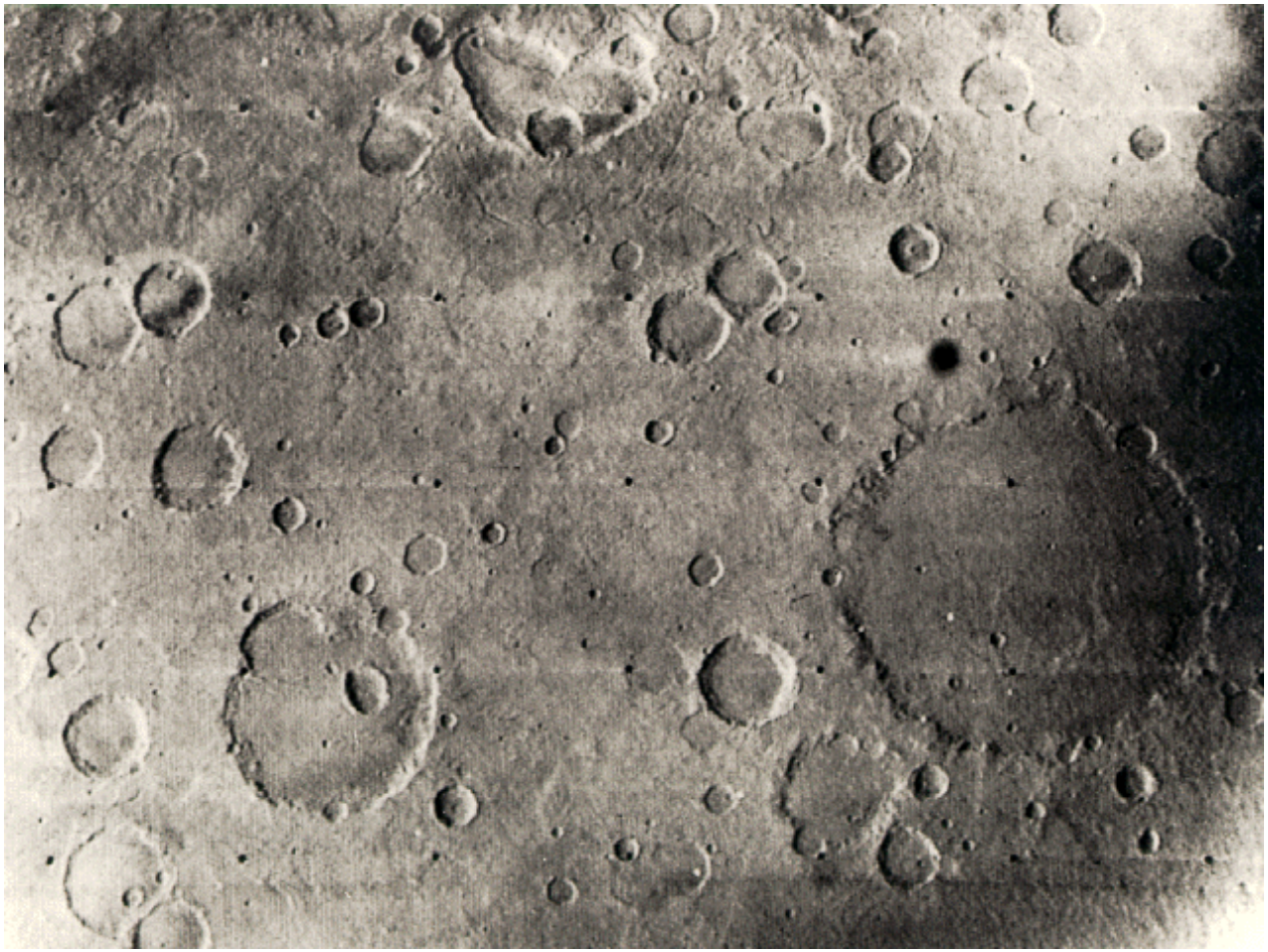
THE WHITE HOUSE
Office of the Press Secretary
For Immediate Release
August 7, 1996

REMARKS BY THE PRESIDENT
UPON DEPARTURE

The South Lawn
1:15 P.M. EDT

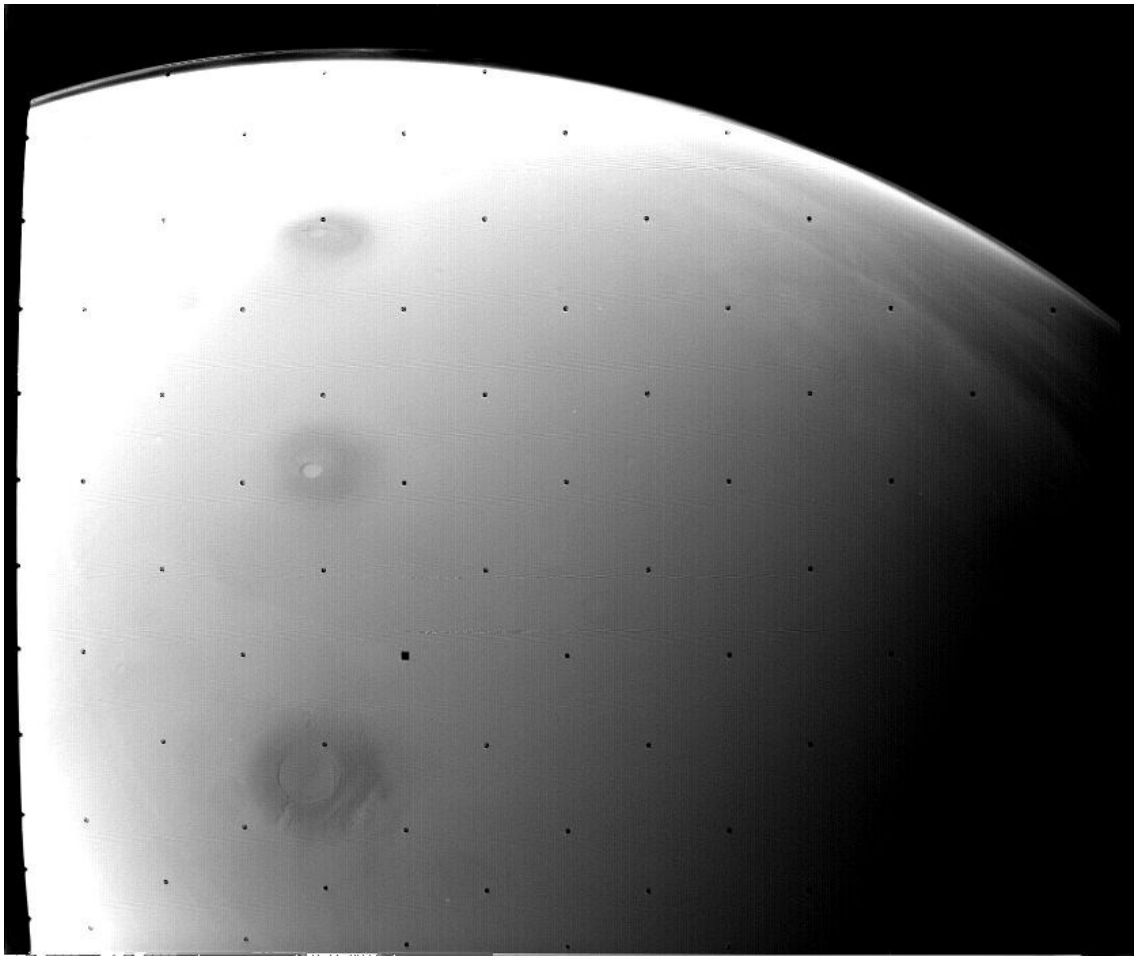
THE PRESIDENT: Good afternoon. I'm glad to be joined by my science and technology adviser, Dr. Jack Gibbons, to make a few comments about today's announcement by NASA.

Mariner 6 and 7, flyby (1969)



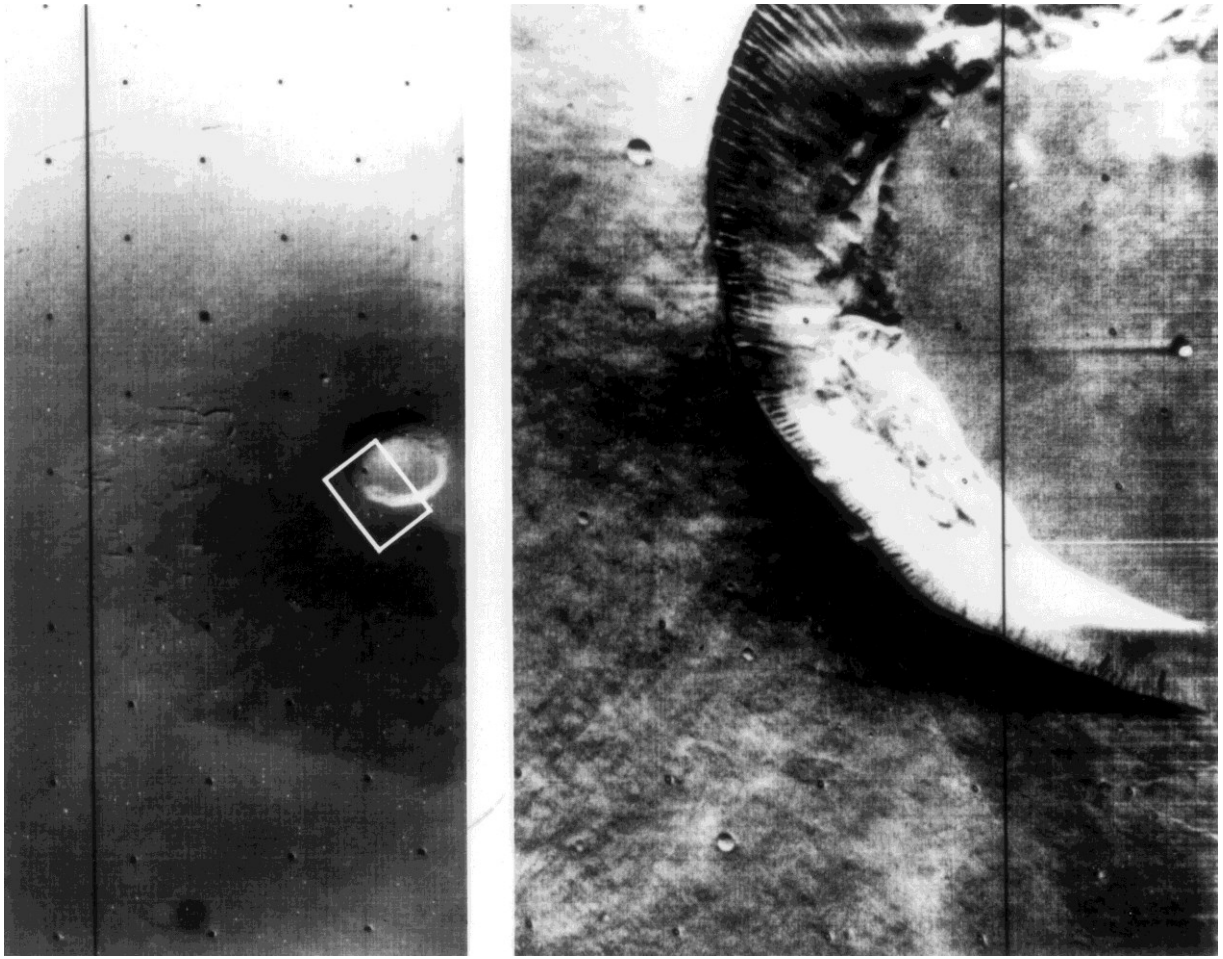
http://tes.asu.edu/SOLAR_SYST_TOUR/Mars.html

Mariner 9, orbiter (1971)



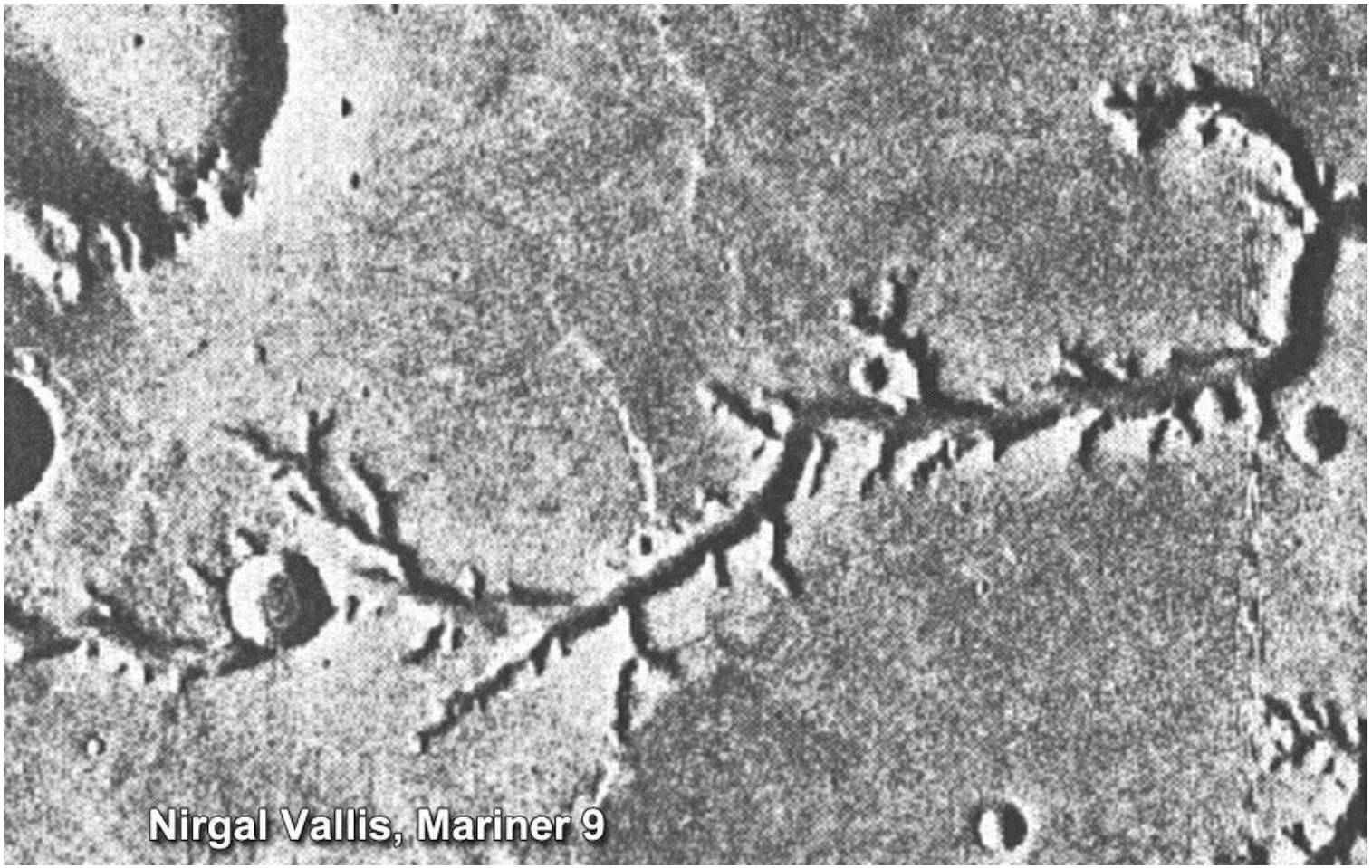
http://blogs.agu.org/martianchronicles/2008/05/22/the-search-for-life-on-mars-part-2/

Mariner 9, orbiter (1971)



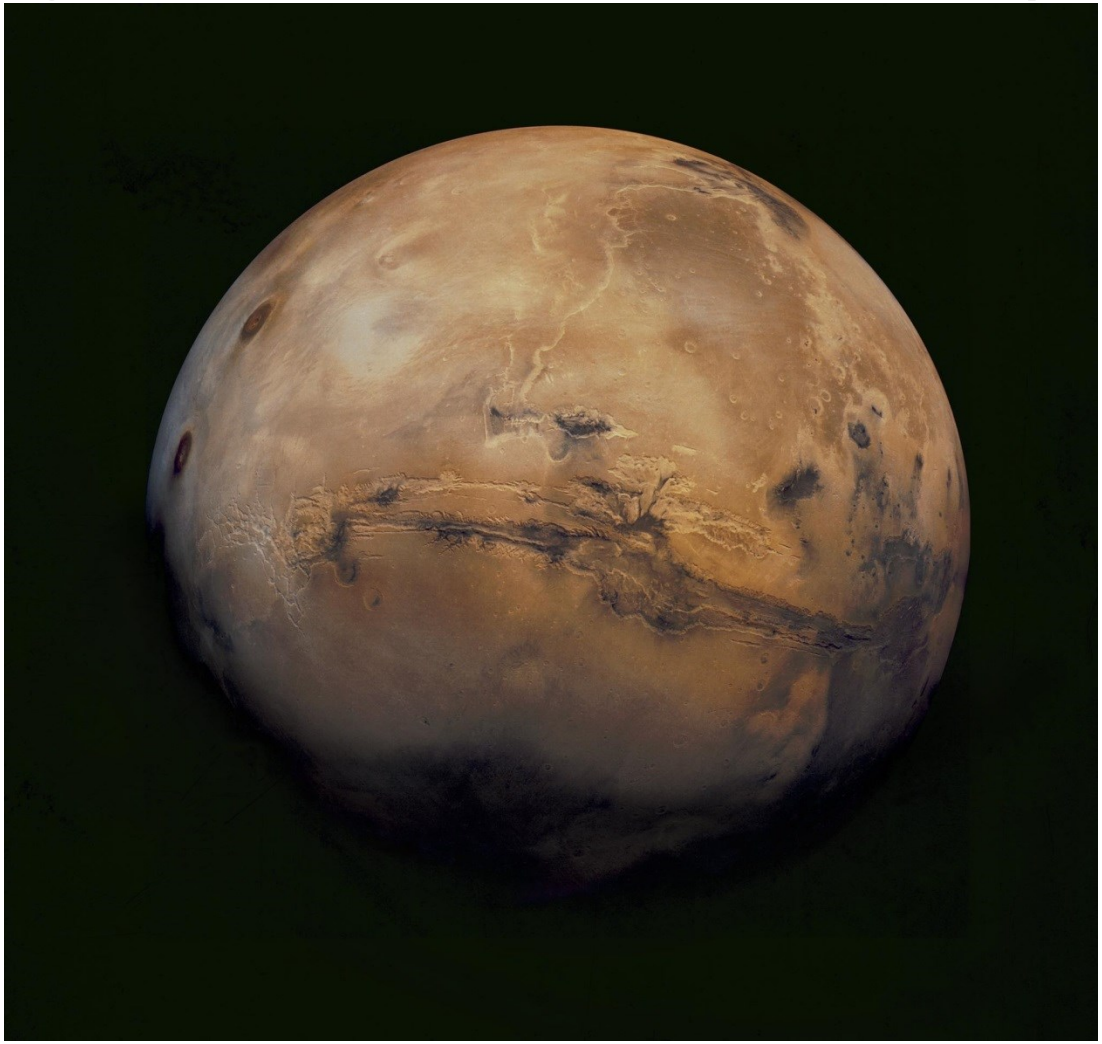
http://photojournal.jpl.nasa.gov/jpeg/PIA02983.jpg

Mariner 9, orbiter (1971)



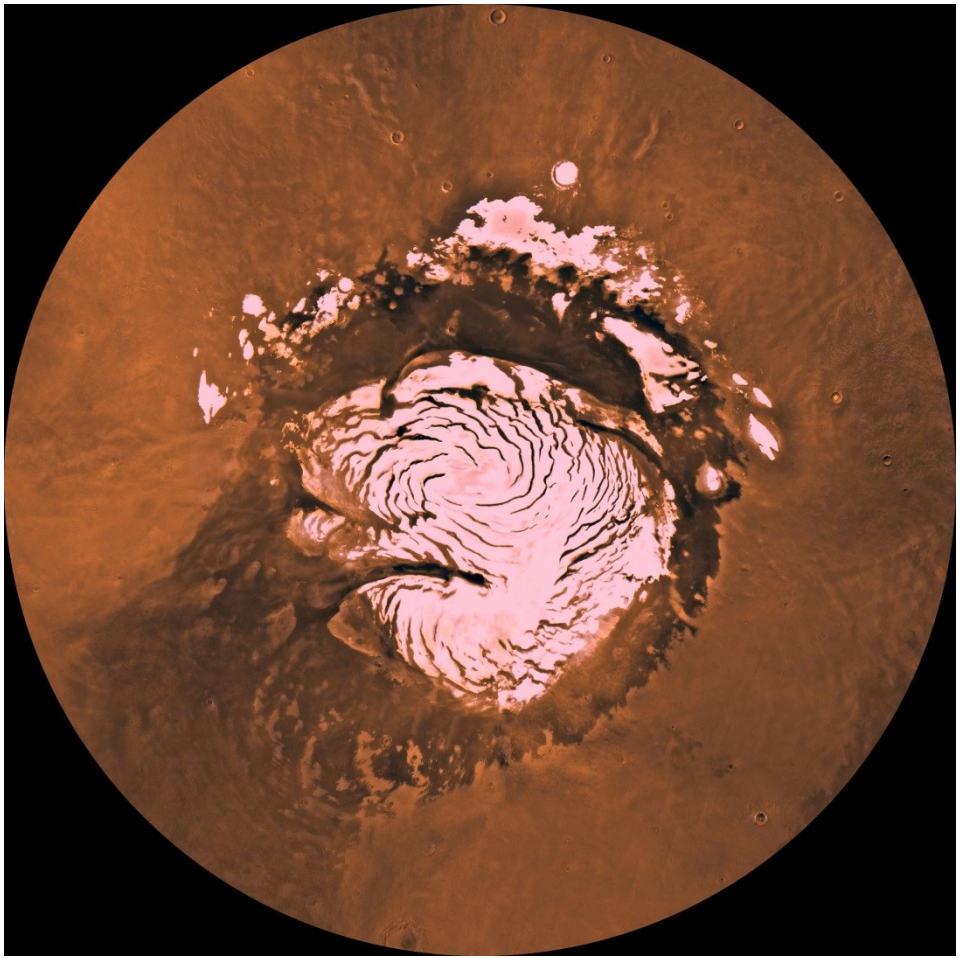
http://photojournal.jpl.nasa.gov/jpeg/PIA15090.jpg

Viking 1 and 2, orbiters (1976)



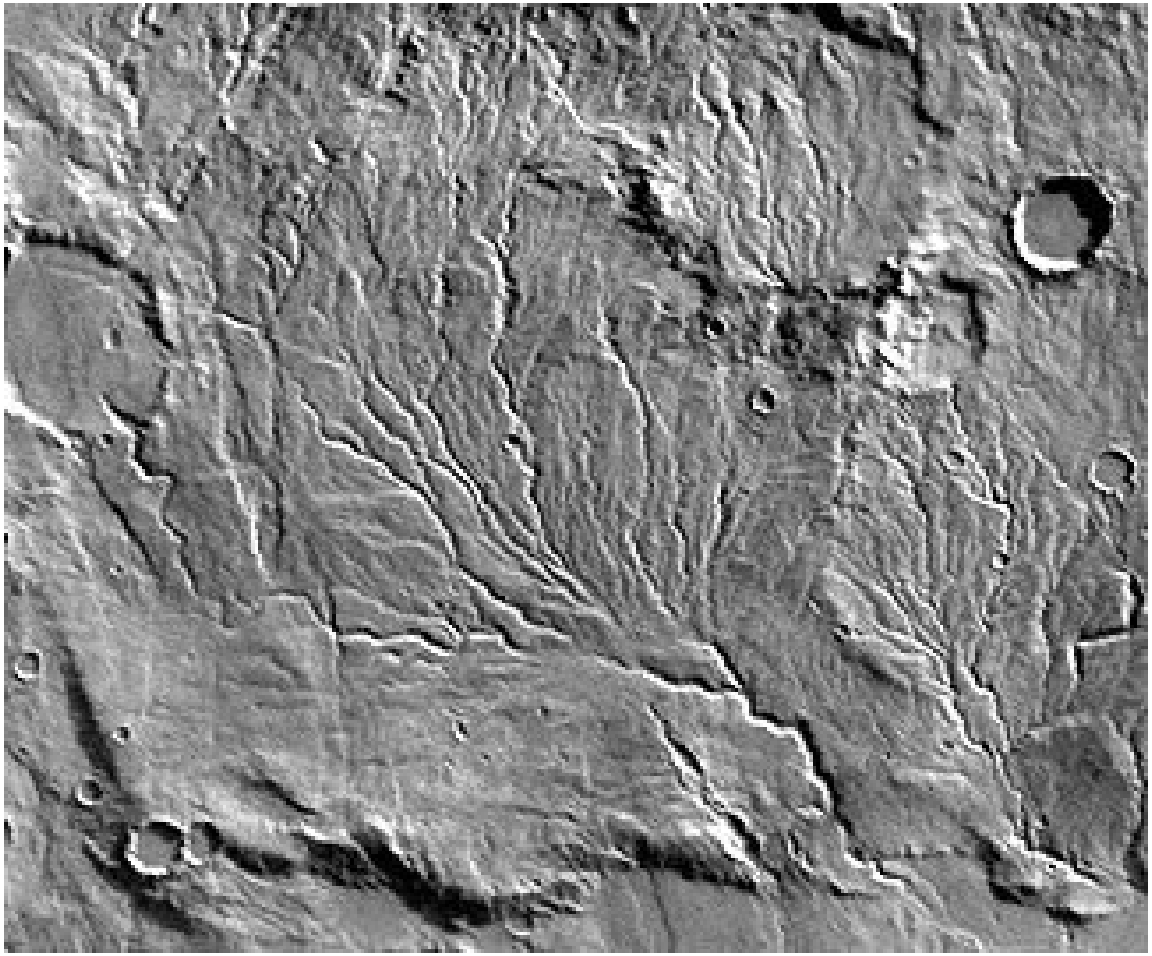
http://photojournal.jpl.nasa.gov/jpeg/PIA04304.jpg

Viking 1 and 2, orbiters (1976)



http://photojournal.jpl.nasa.gov/jpeg/PIA00161.jpg

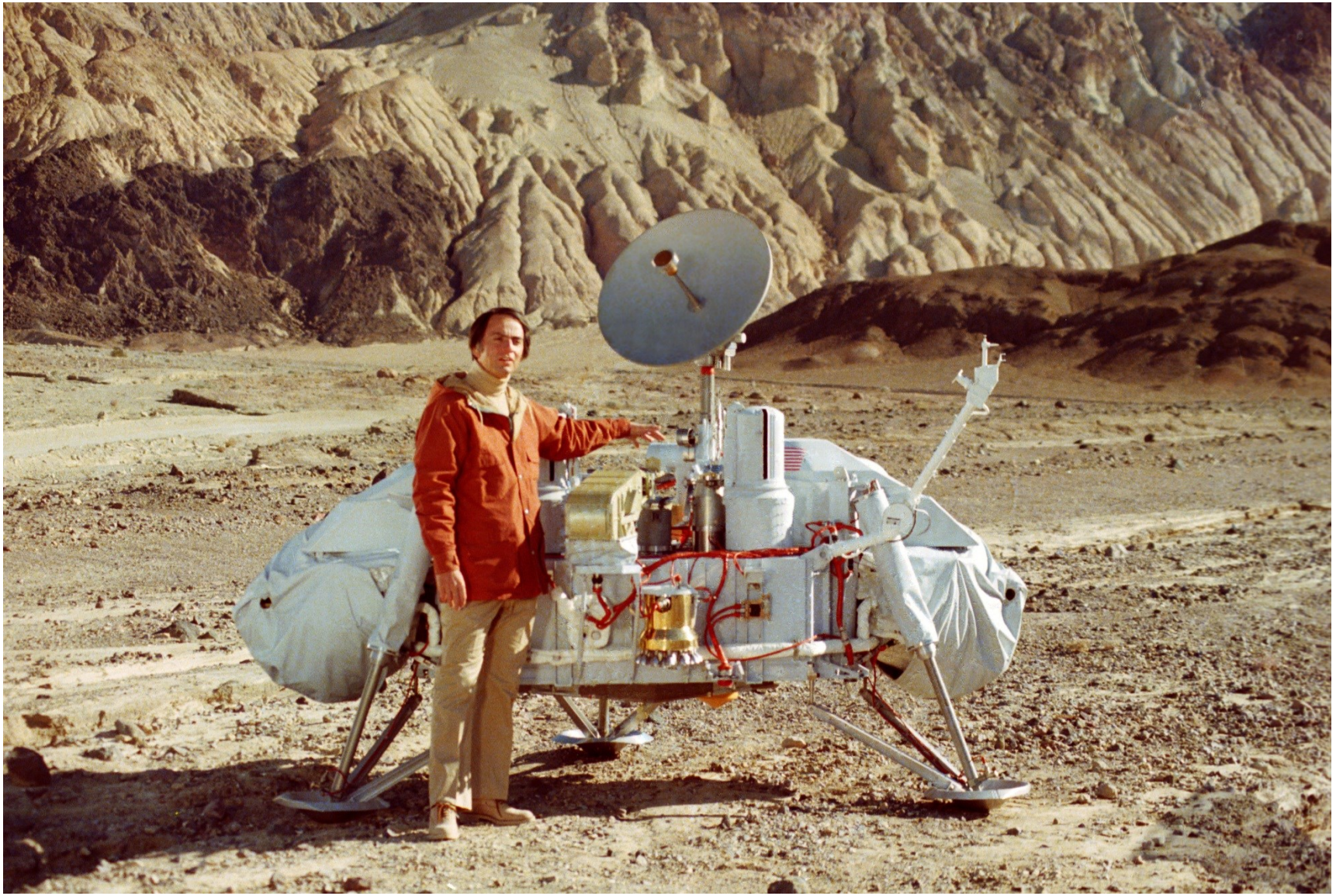
Viking 1 and 2, orbiters (1976)



http://blogs.agu.org/martianchronicles/2008/05/22/the-search-for-life-on-mars-part-2/

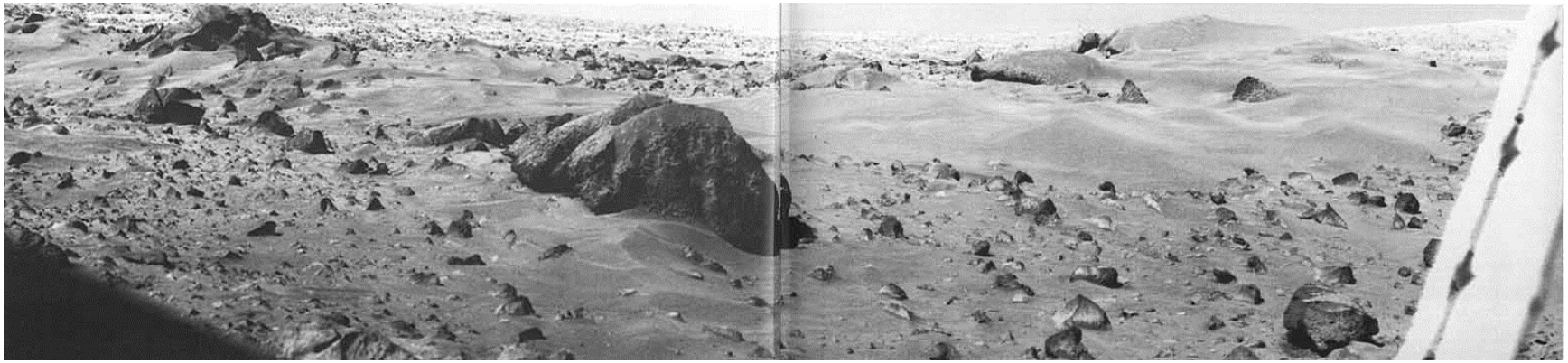
Viking 1 and 2, orbiters (1976)

http://www.solarviews.com/raw/mars/islands.gif



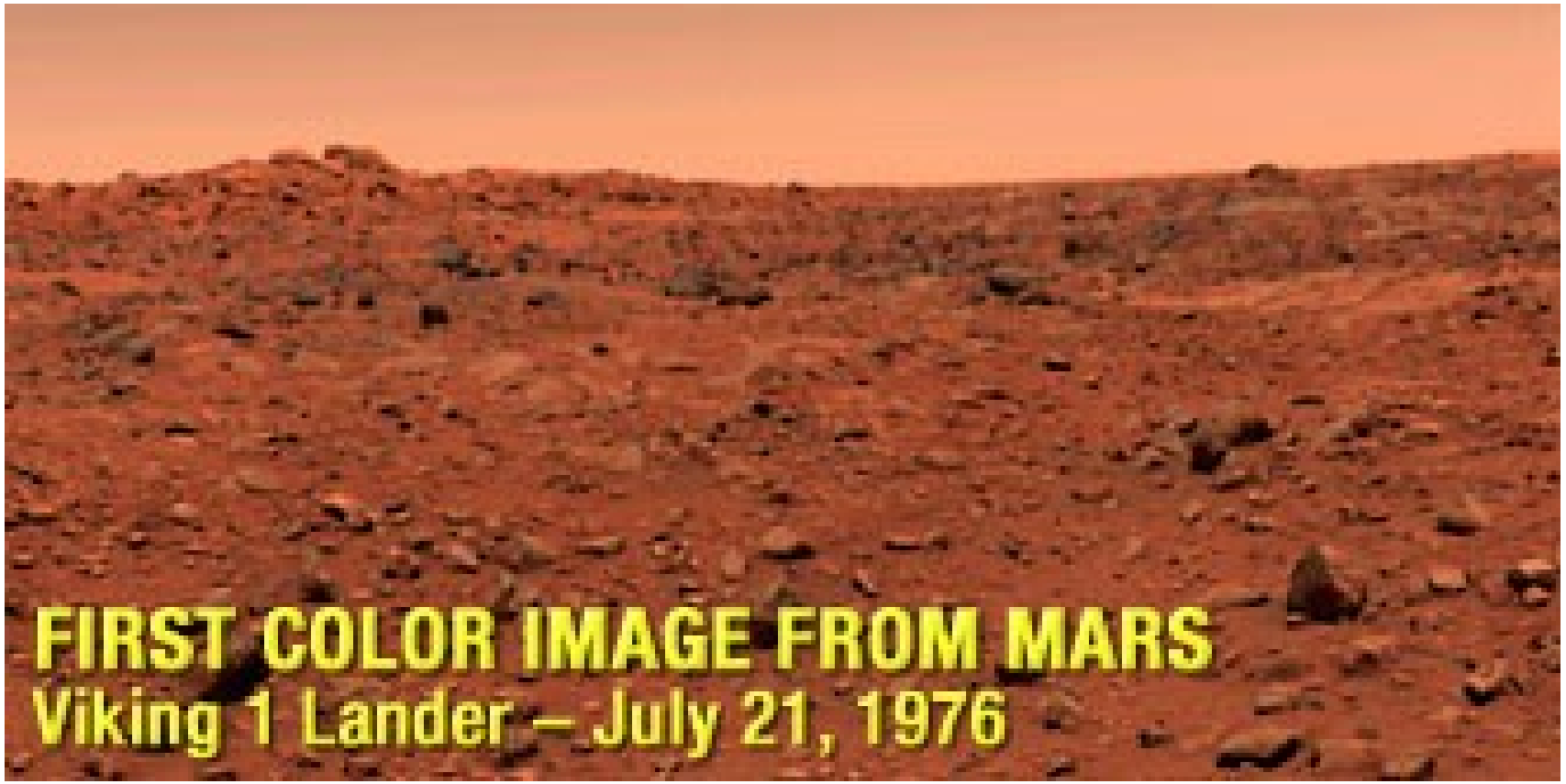
http://upload.wikimedia.org/wikipedia/commons/e/e8/Sagan_Viking.jpg

Viking 1 and 2, landers (1976)



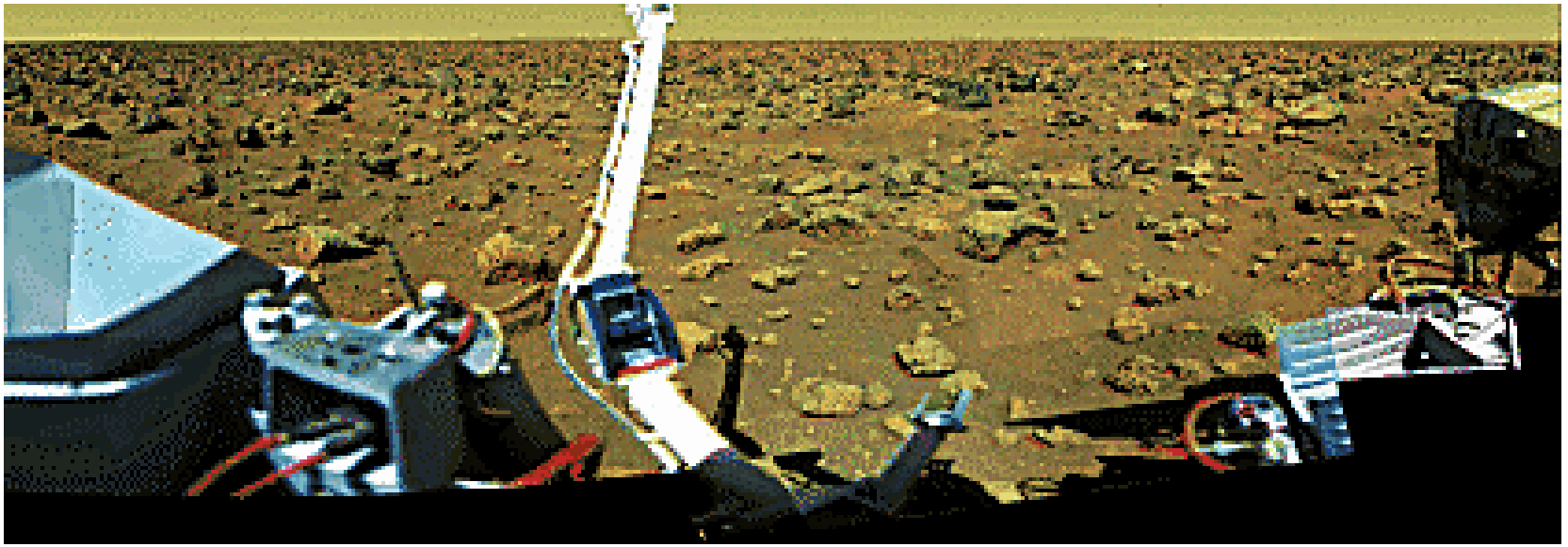
http://history.nasa.gov/SP-425/p3839.htm

Viking 1 and 2, landers (1976)



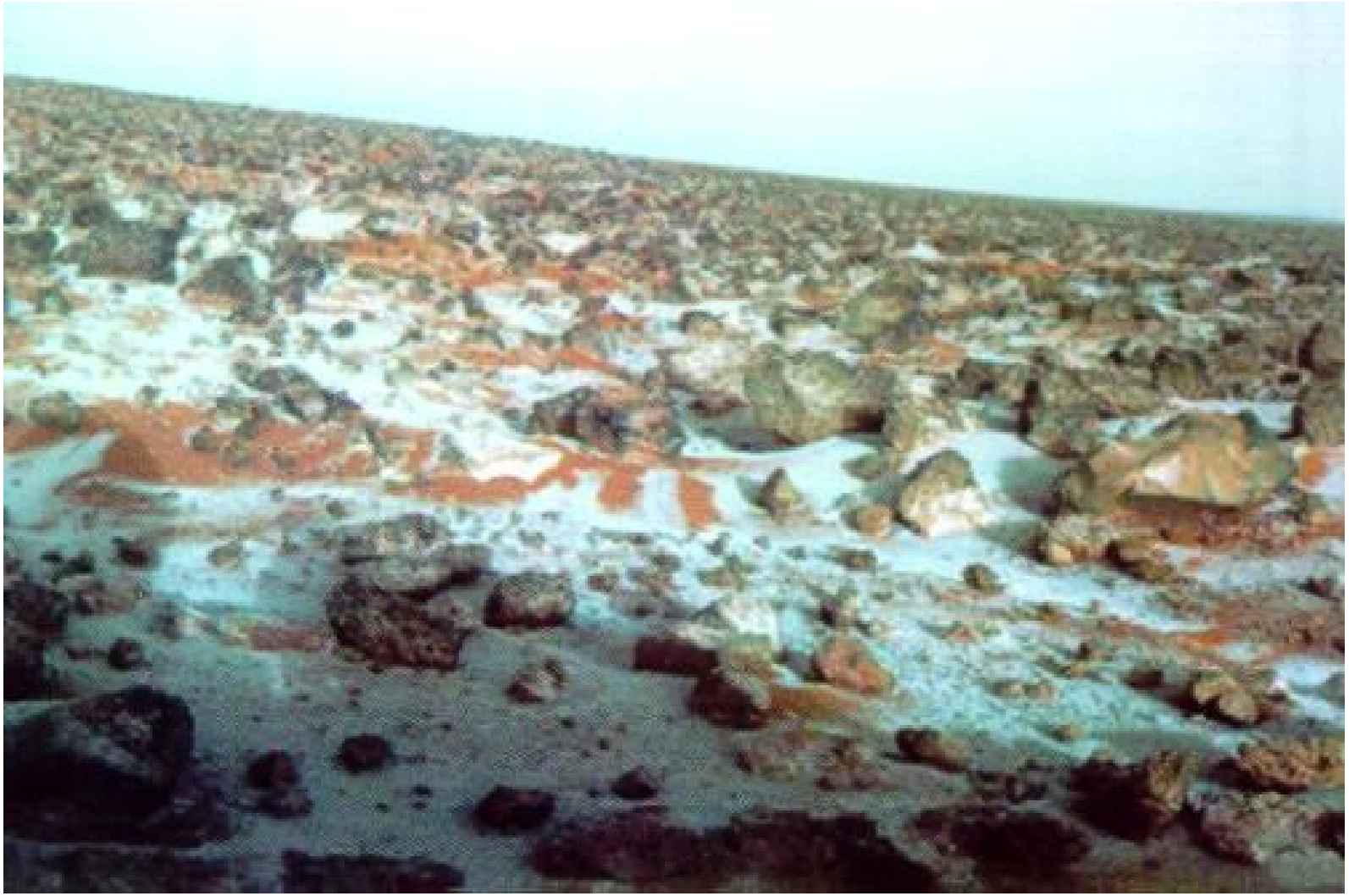
http://www.nasa.gov/centers/langley/events/viking30.html

Viking 1 and 2, landers (1976)



http://nssdc.gsfc.nasa.gov/planetary/viking.html

Viking 1 and 2, landers (1976)



http://www.gillevin.com/Mars/Reprint124_files/Reprint124-SPIE-2003-Paper-GVL.htm

Is there any water on Mars today?

Is there any water on Mars today?

- Yes.

- Ice caps at poles
- Frost at Viking 2 lander
- Clouds
- More recent evidence for subsurface ice

- No liquid water today

Was there once liquid water?

Was there once liquid water?

- Yes (we think)

- Pictures show river channels, streamlined islands, catastrophic flood debris
- All require liquid water

Why is there no liquid water today?

- No water of any form?
- Too hot?
- Too cold?
- Atmospheric pressure too high?
- Atmospheric pressure too low?

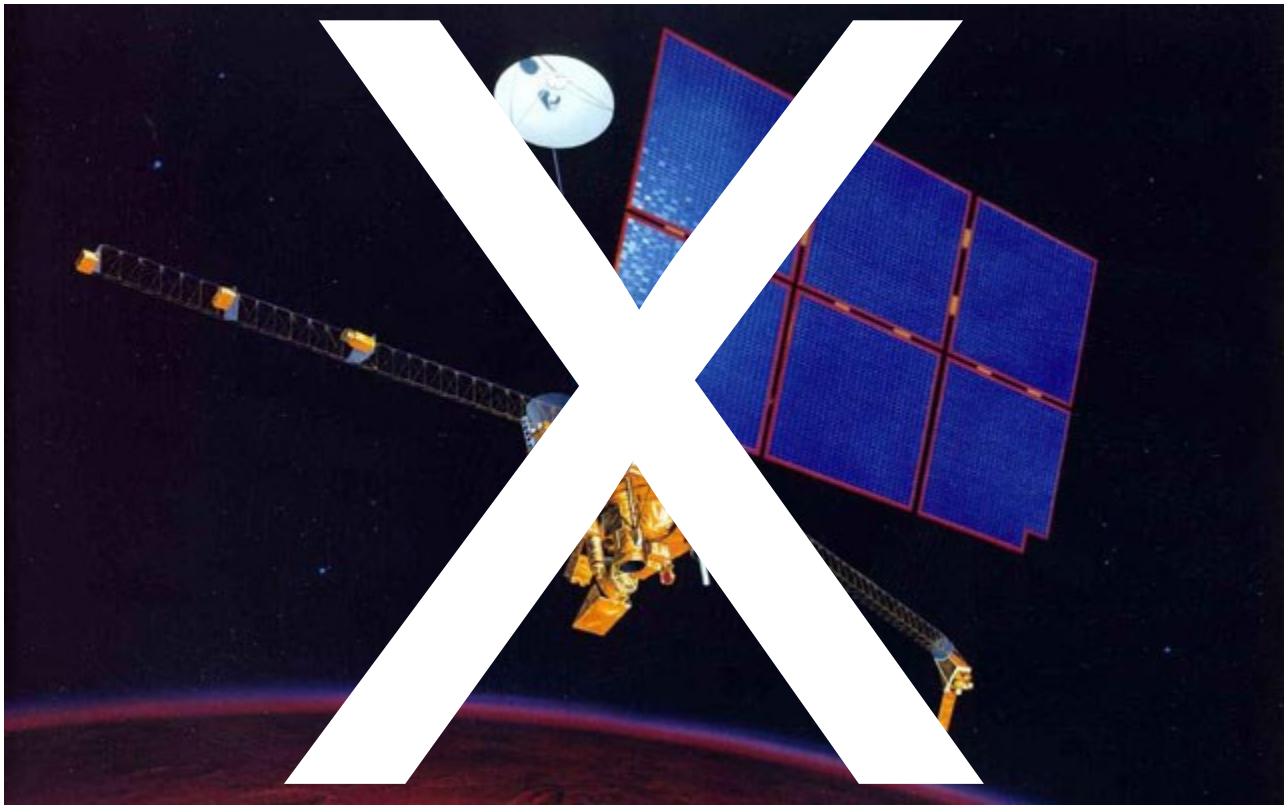
Why is there no liquid water today?

- No water of any form?
- Too hot?
- Too cold?
- Atmospheric pressure too high?

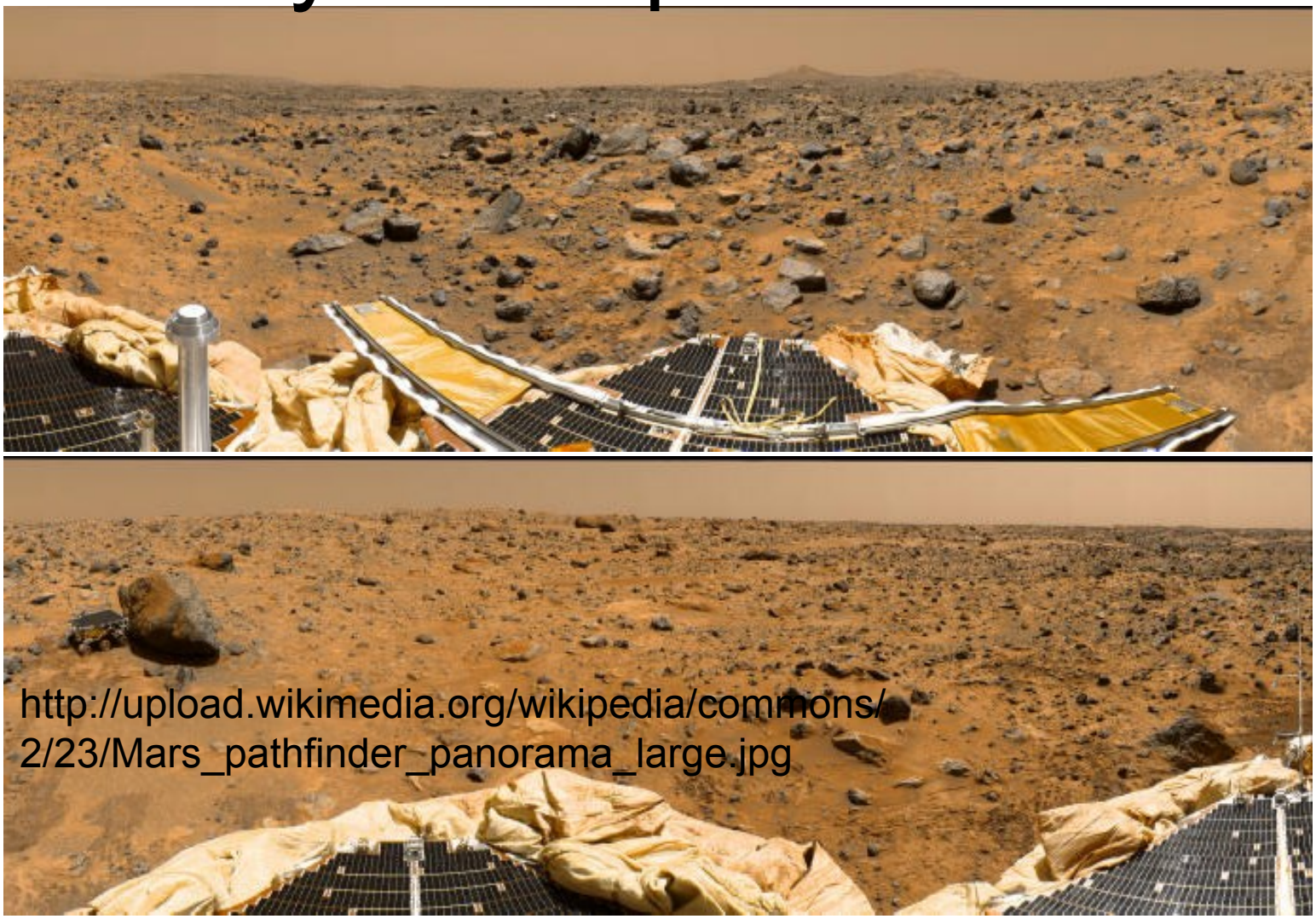
- Atmospheric pressure is too low
- For liquid water to have flowed in the past, the atmosphere must have been thicker

Follow the water

Mars Observer (1992)



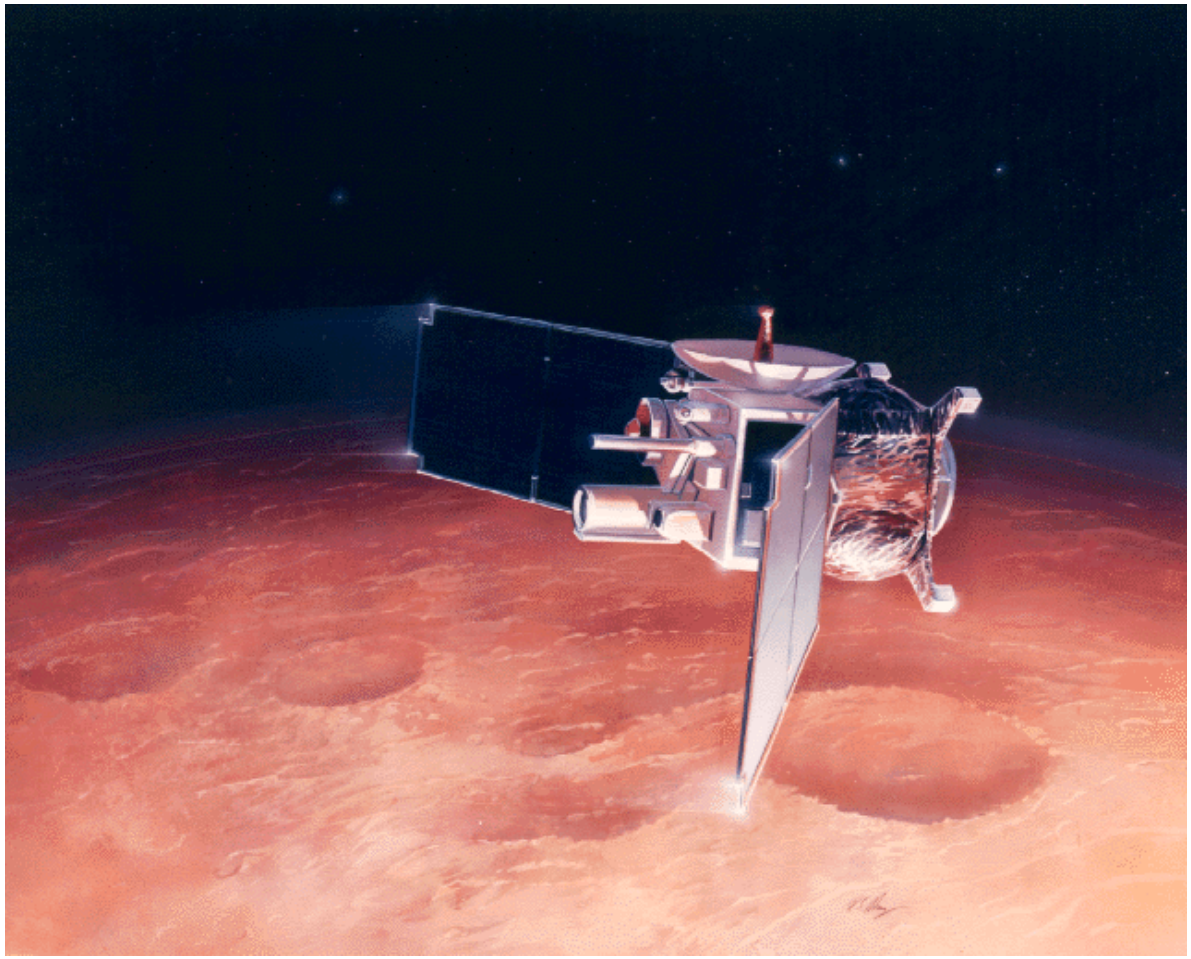
Mars Pathfinder (1996)
Same year as possible fossils



Mars Pathfinder (1996)

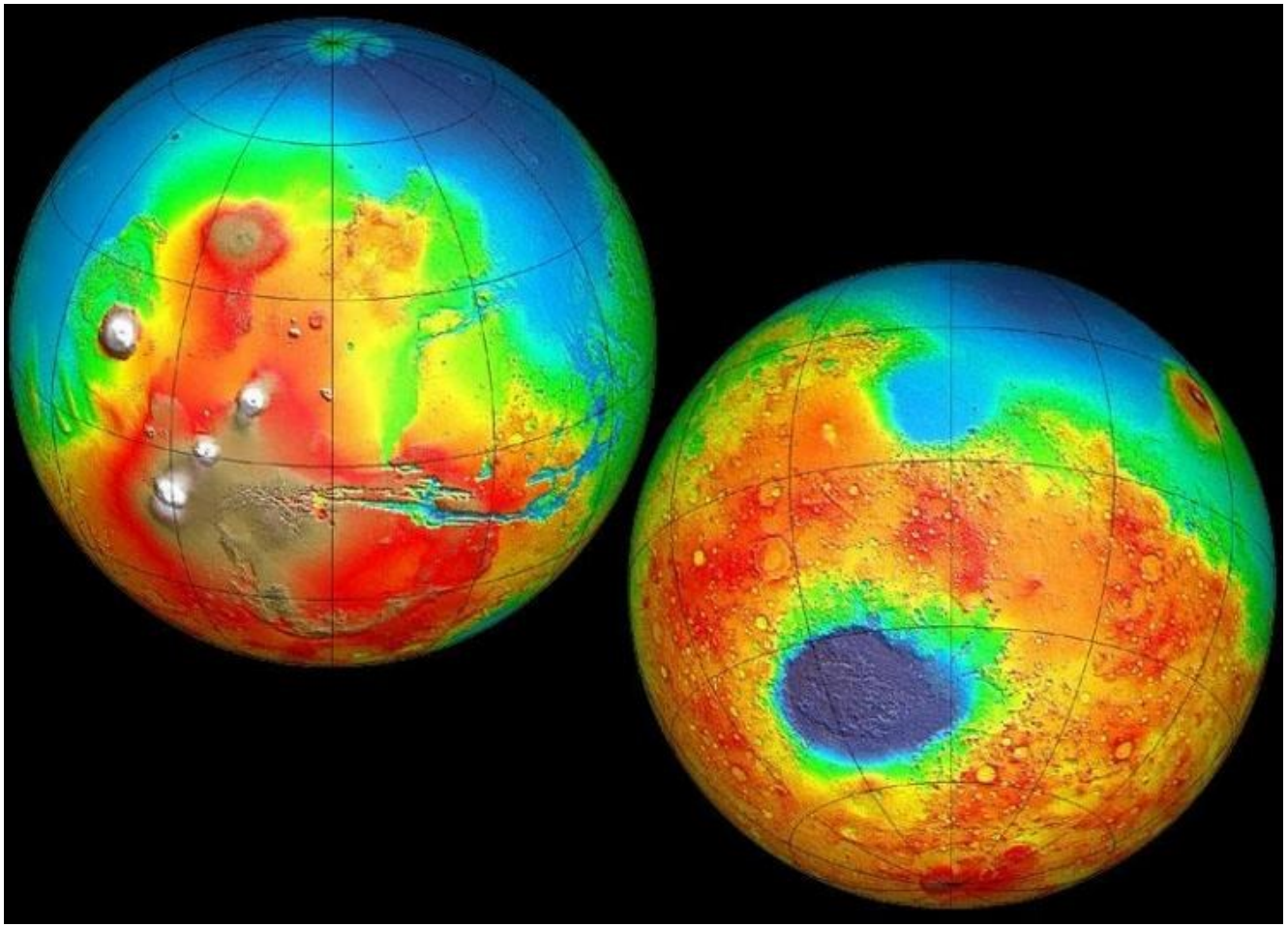
http://upload.wikimedia.org/wikipedia/commons/e/e5/Pathfinder01.jpg

Mars Global Surveyor (1998)

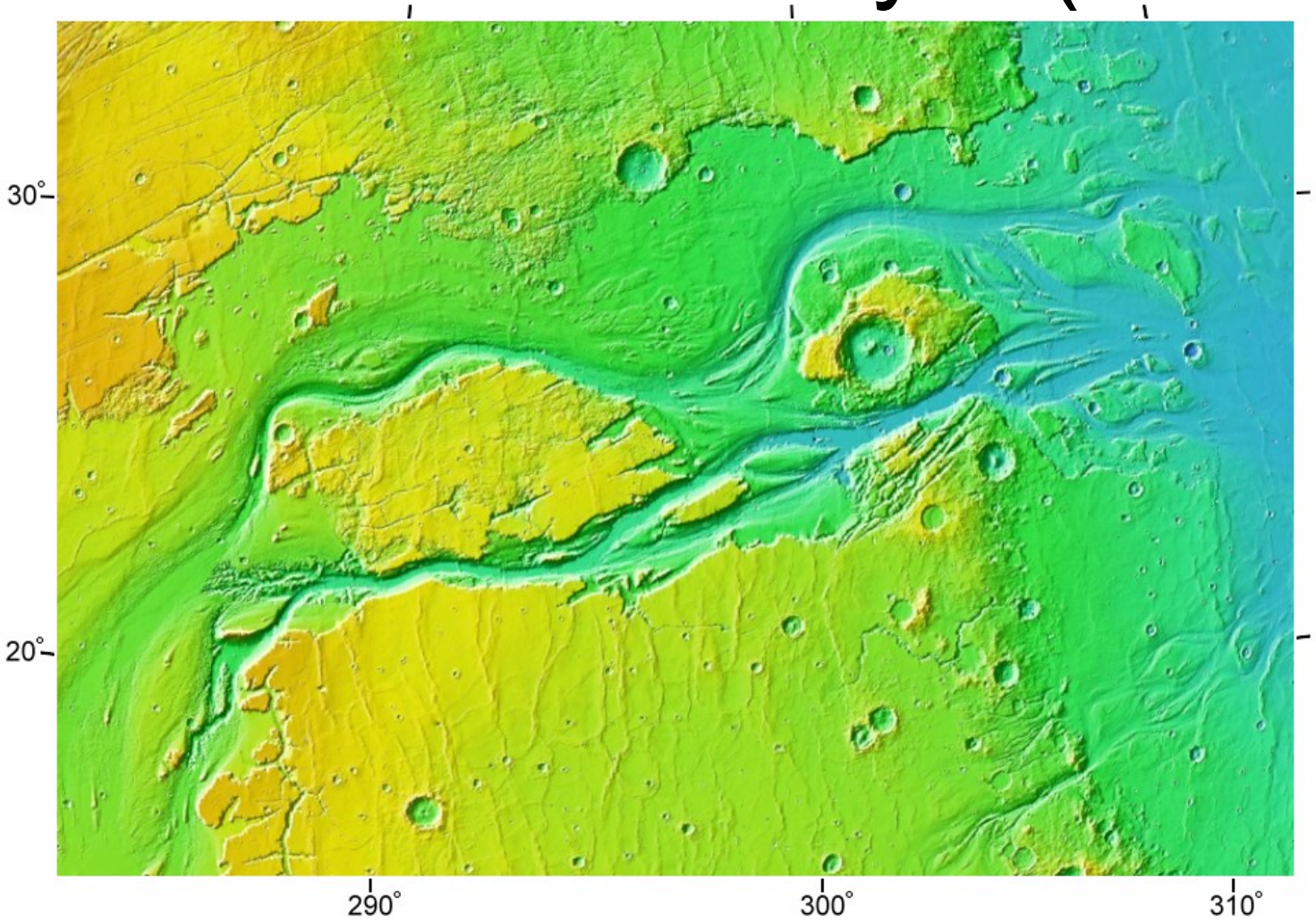


http://apod.nasa.gov/apod/image/9709/aeromgs_jpl.gif

Mars Global Surveyor (1998)



Mars Global Surveyor (1996)

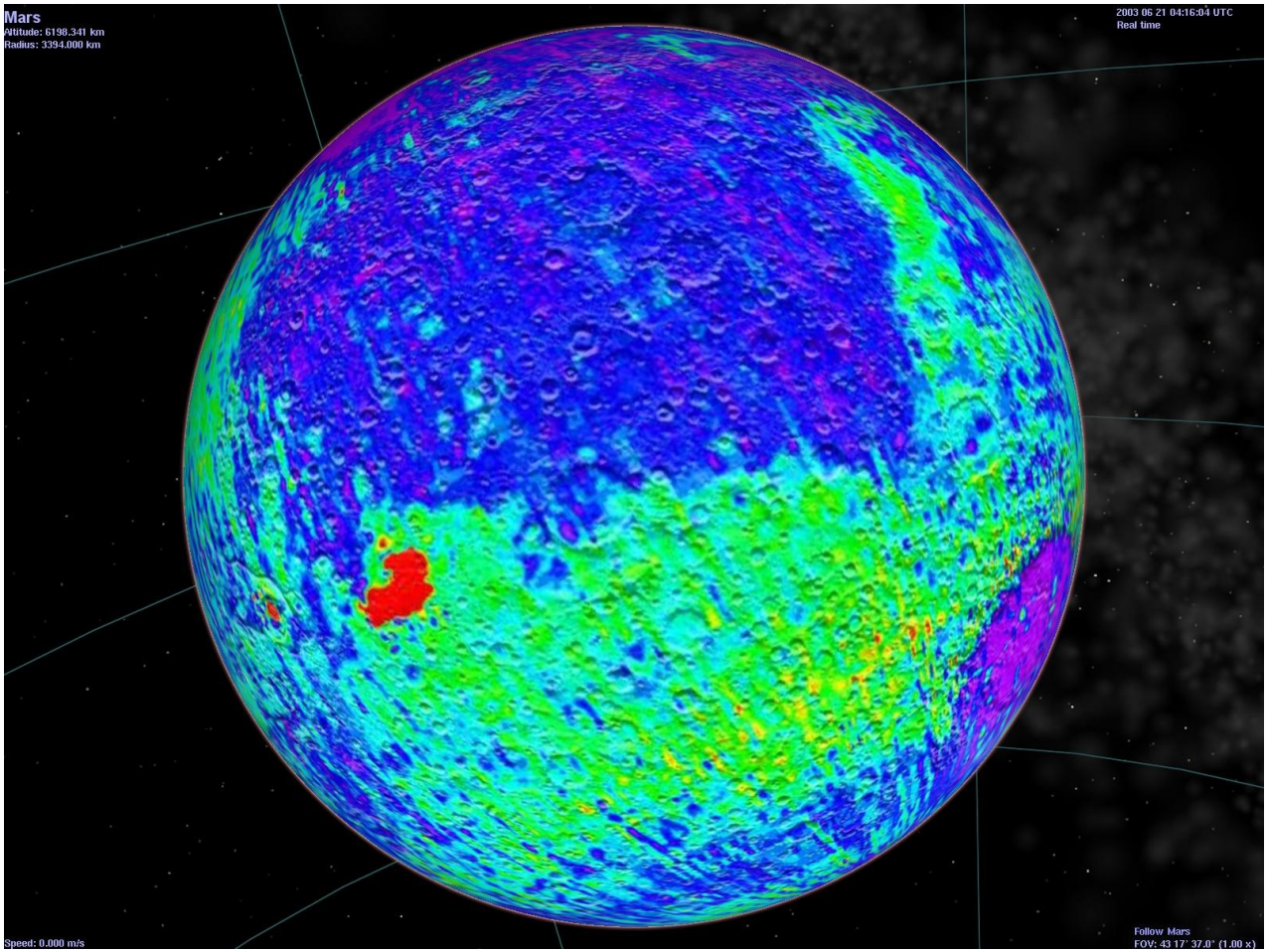


http://upload.wikimedia.org/wikipedia/commons/7/71/Kasei_Valles_topo.jpg

Mars Global Surveyor (1996)

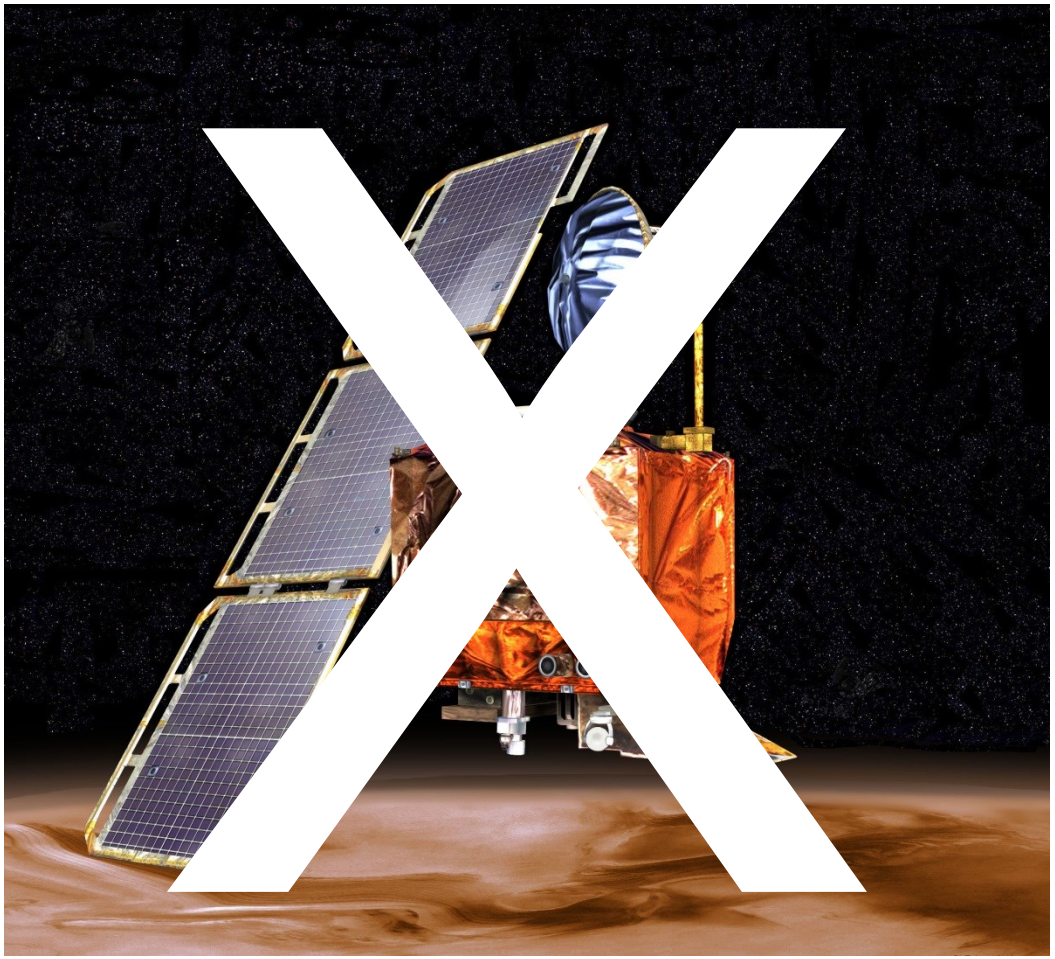
http://upload.wikimedia.org/wikipedia/commons/2/25/Mars_gullies.800px.jpg

Mars Global Surveyor (1996)



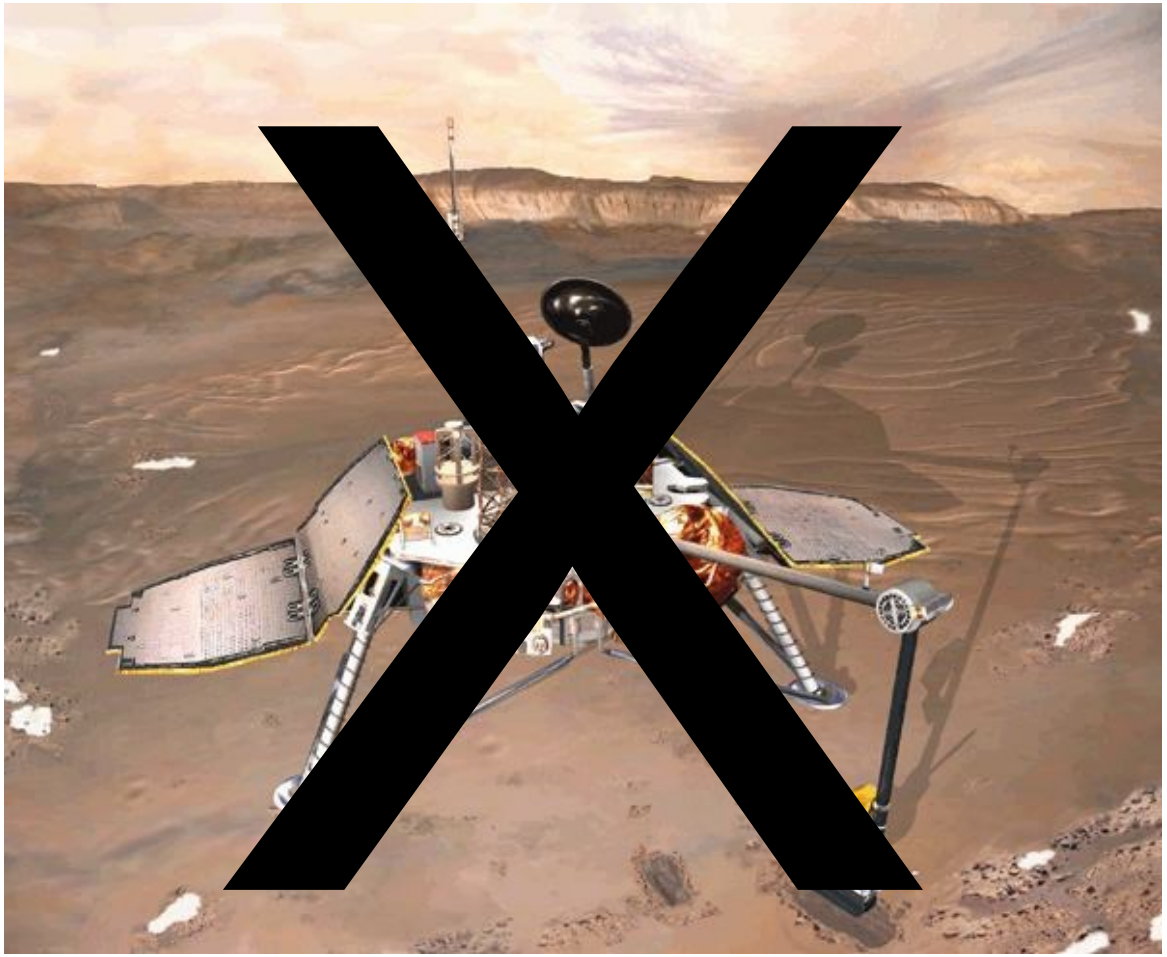
http://www.classe.cornell.edu/~seb/celestia/mars-hematite.jpg

Mars Climate Orbiter



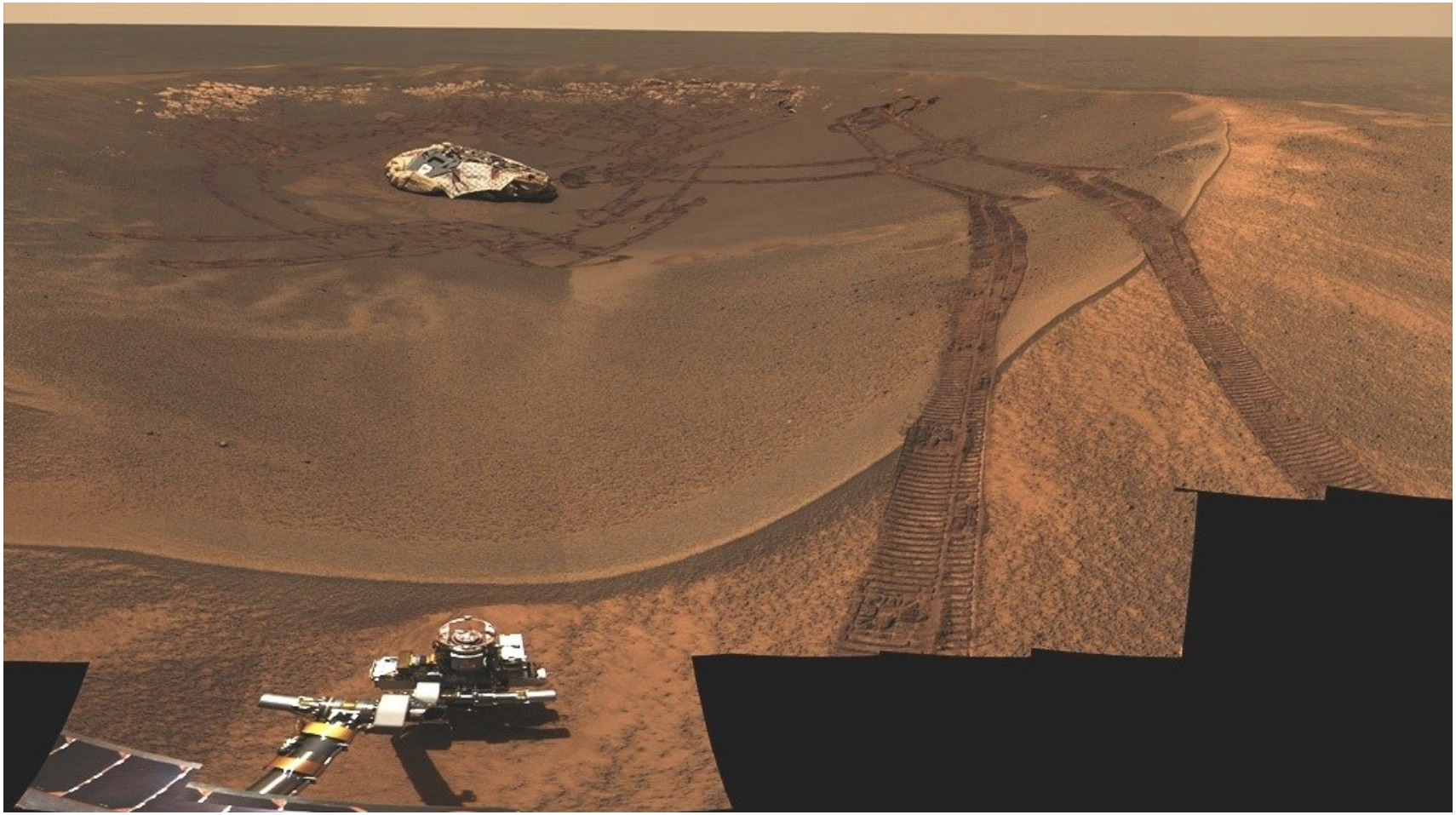
http://upload.wikimedia.org/wikipedia/commons/1/19/Mars_Climate_Orbiter_2.jpg

Mars Polar Lander (1999)



http://nssdc.gsfc.nasa.gov/image/spacecraft/mars_polar_lander.jpg

Spirit and Opportunity, rovers (2003)

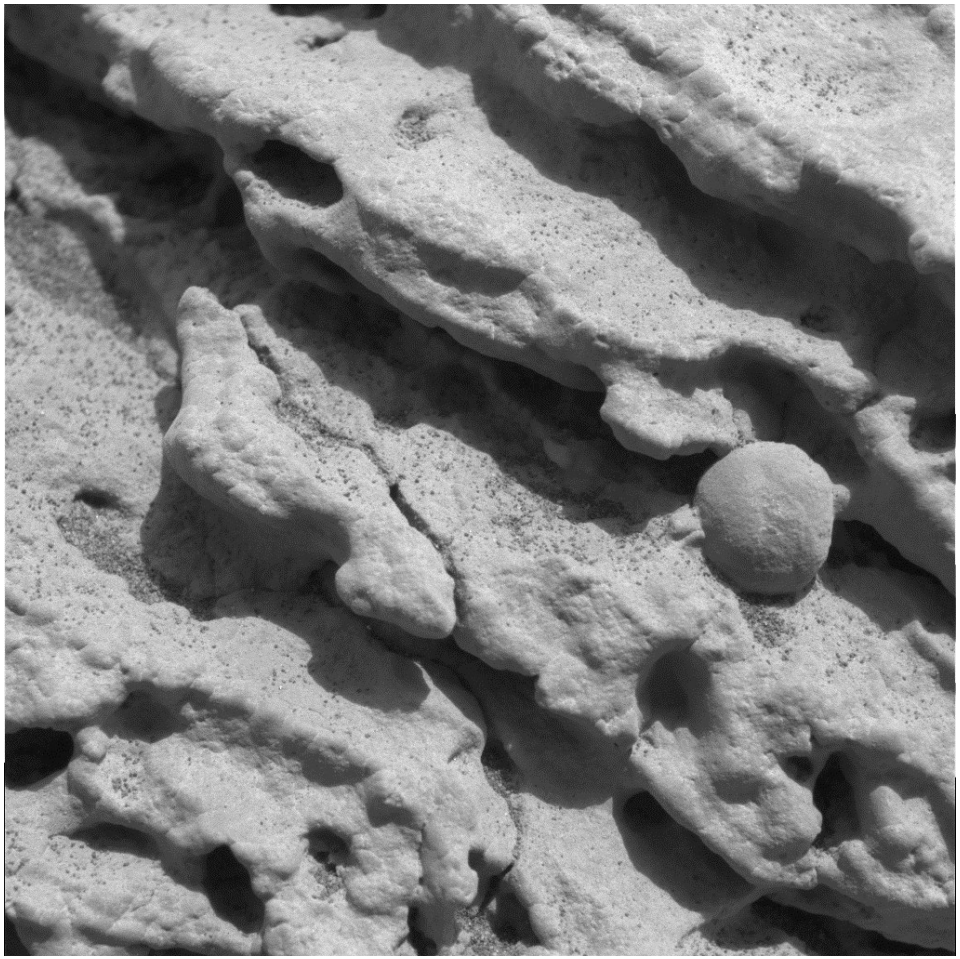


http://upload.wikimedia.org/wikipedia/commons/e/ed/Opportunity_-_Cratera_Eagle.jpg

Spirit and Opportunity, rovers (2003)

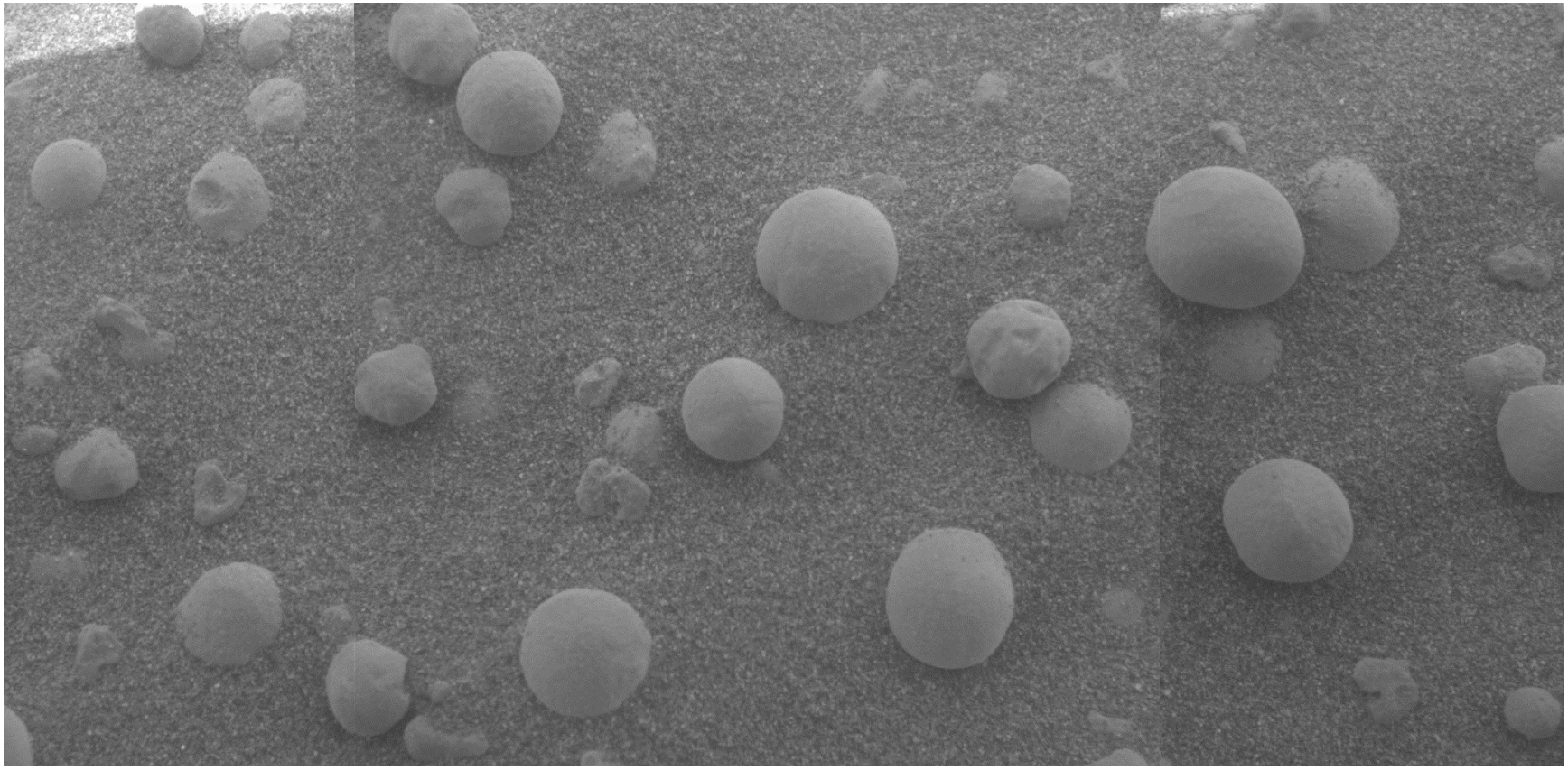
http://upload.wikimedia.org/wikipedia/commons/f/fe/PIA05482_modest.jpg

Spirit and Opportunity, rovers (2003)

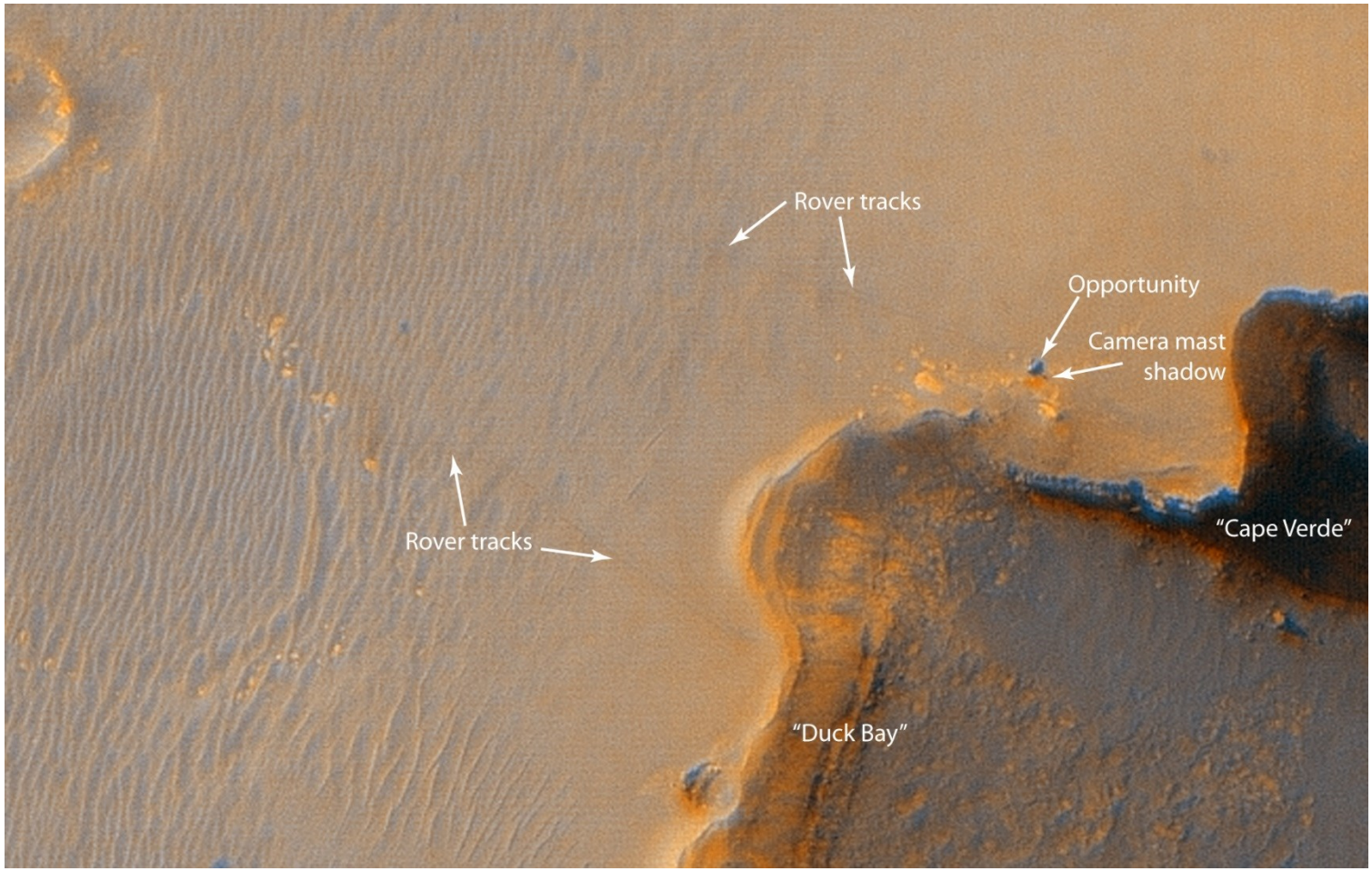


http://upload.wikimedia.org/wikipedia/commons/3/34/Opportunity_photo_of_Mars_outcrop_rock.jpg

Spirit and Opportunity, rovers (2003)



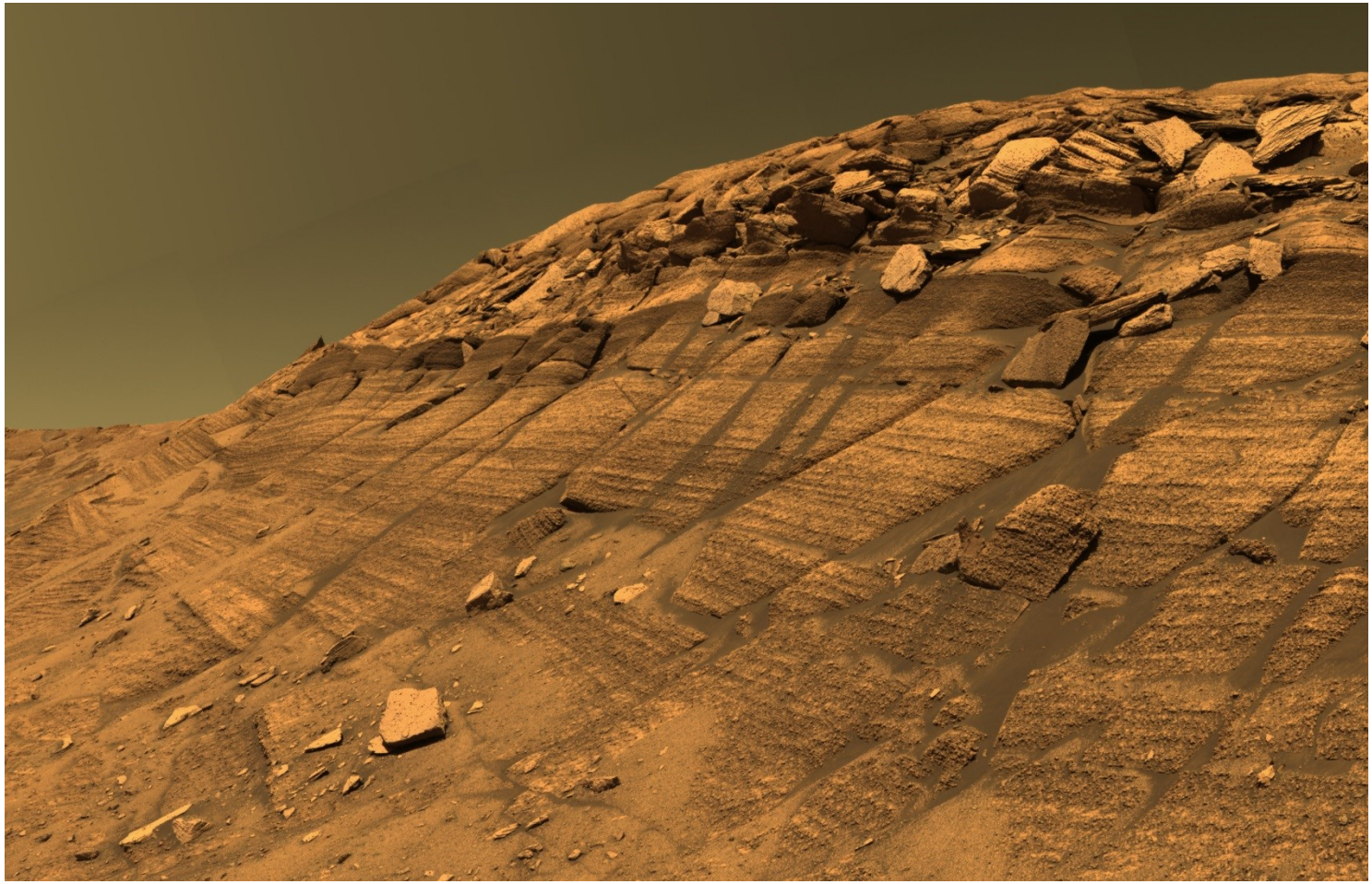
http://www.nasa.gov/centers/ames/images/content/164289main_mro1-hr.jpg



http://apod.nasa.gov/apod/image/0610/opportunity_mro_big.jpg

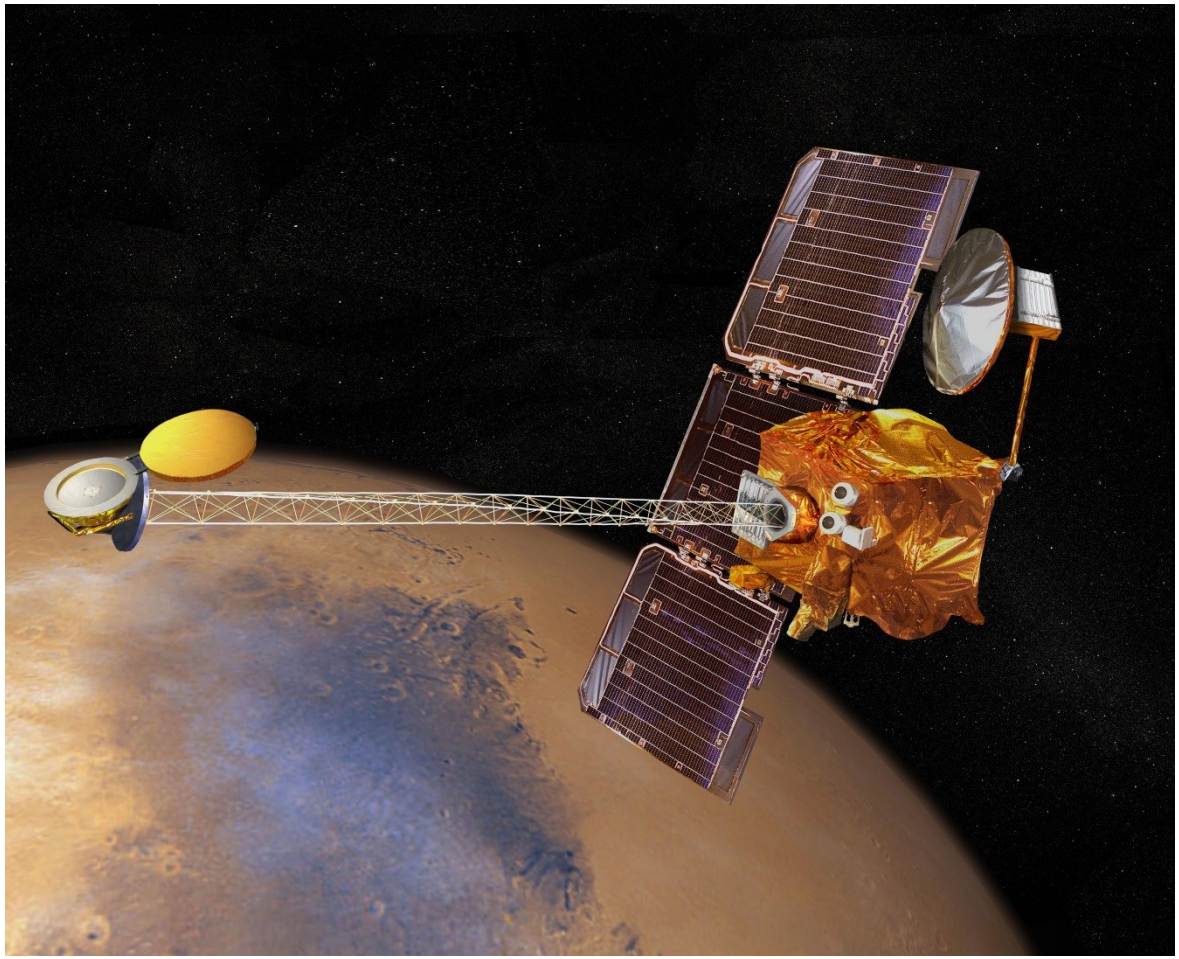
http://apod.nasa.gov/apod/image/0610/opportunity_mro_big.jpg

Spirit and Opportunity, rovers (2003)



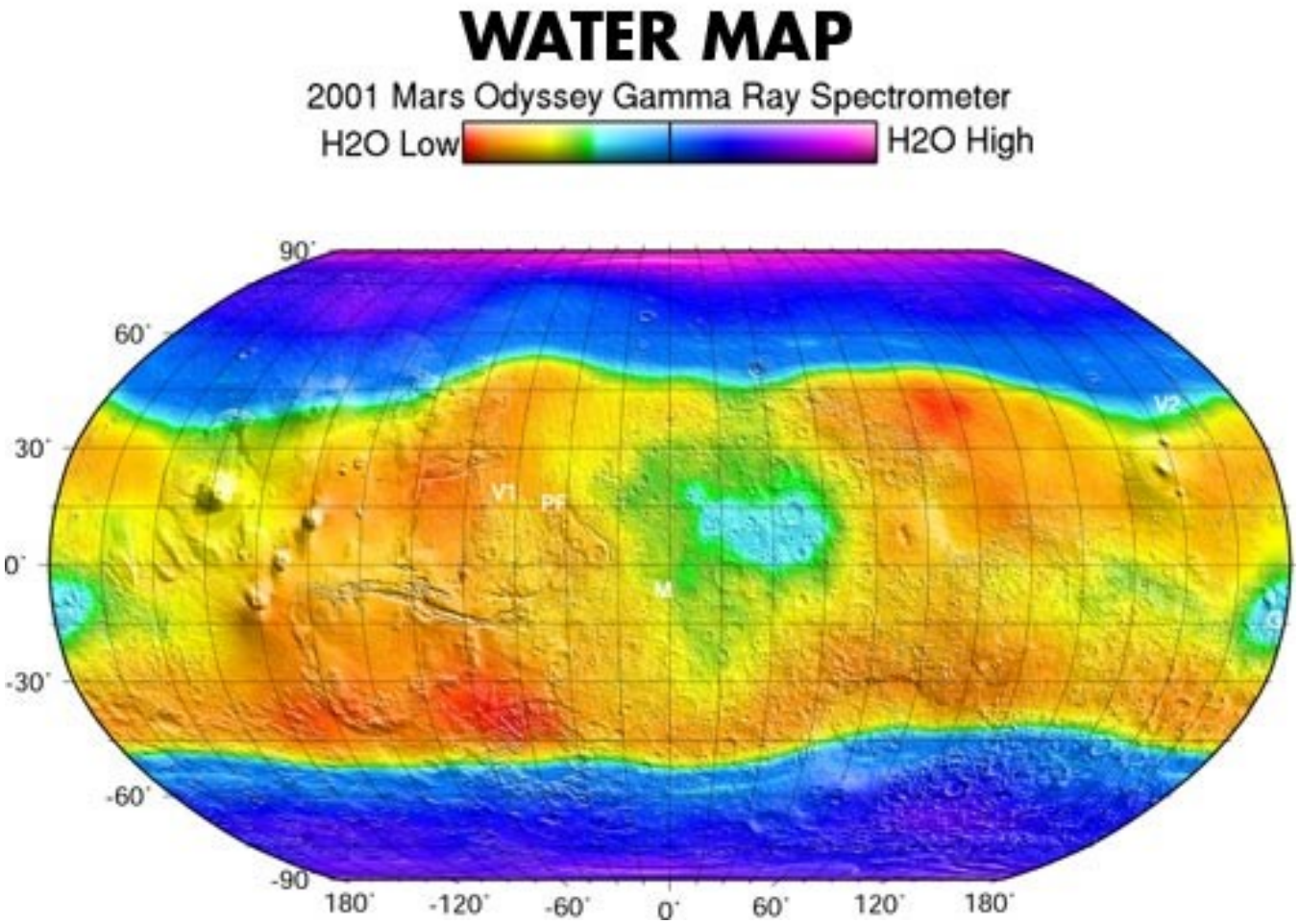
http://upload.wikimedia.org/wikipedia/commons/a/a4/Burns_cliff.jpg

Mars Odyssey (2001)



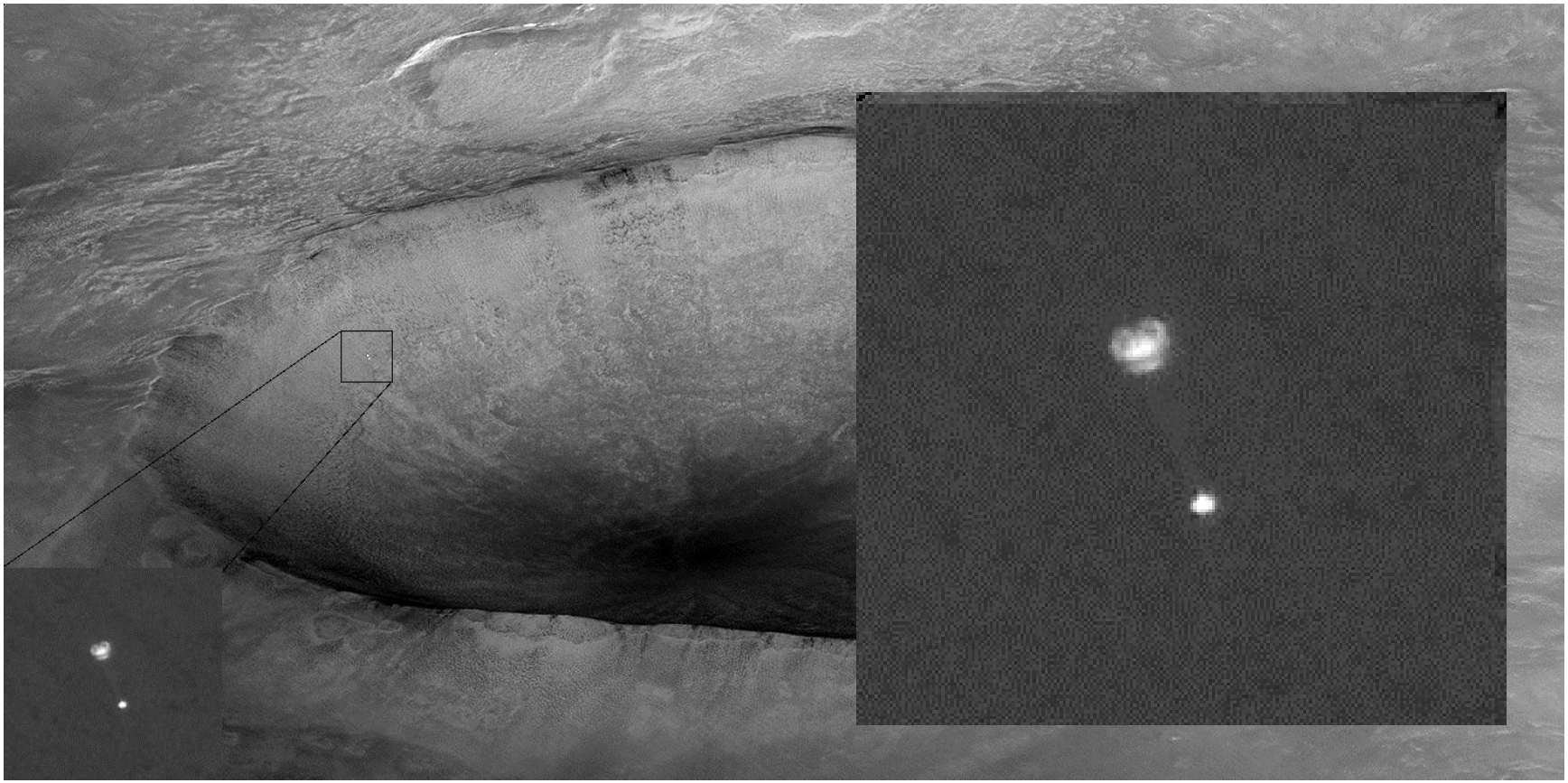
http://upload.wikimedia.org/wikipedia/commons/c/c5/2001_mars_odyssey_wizja.jpg

Mars Odyssey (2001)

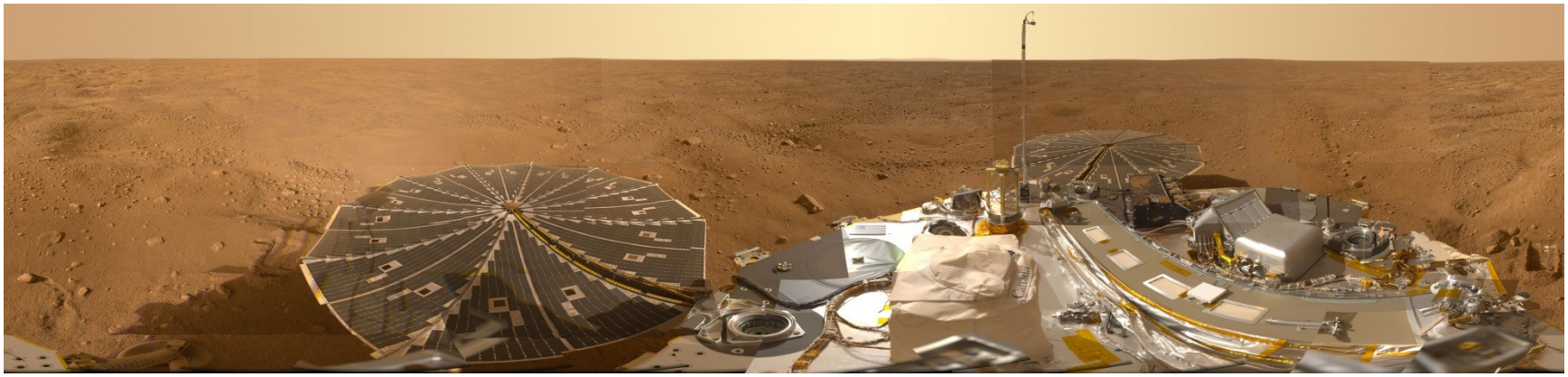


http://mars.jpl.nasa.gov/odyssey/images/odyssey/technology/h2o_map-br.jpg

Phoenix lander (2007)

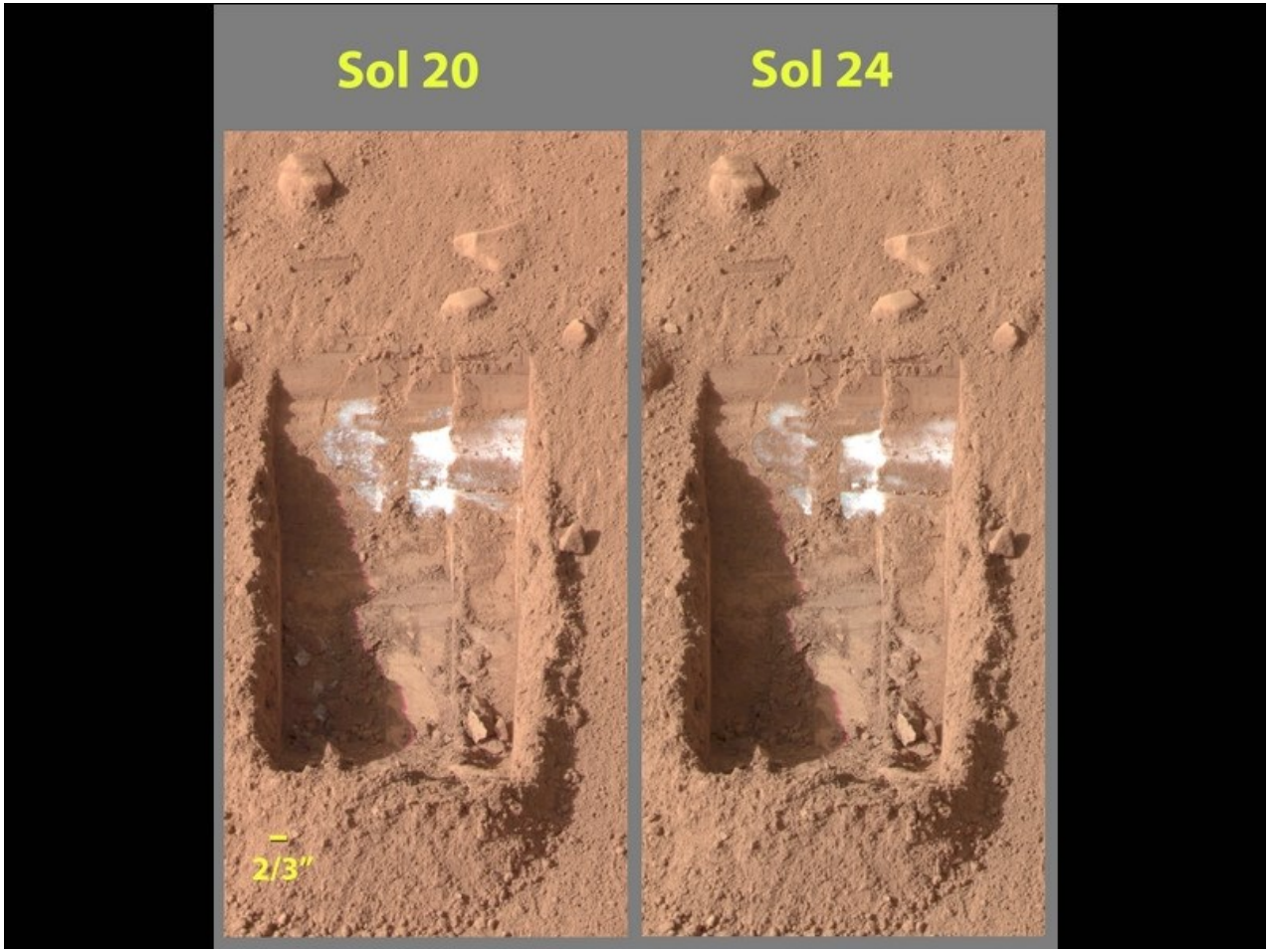


Phoenix lander (2007)



http://upload.wikimedia.org/wikipedia/commons/2/22/PIA13804-MarsPhoenixLander-Panorama-20080525b.jpg

Phoenix lander (2007)

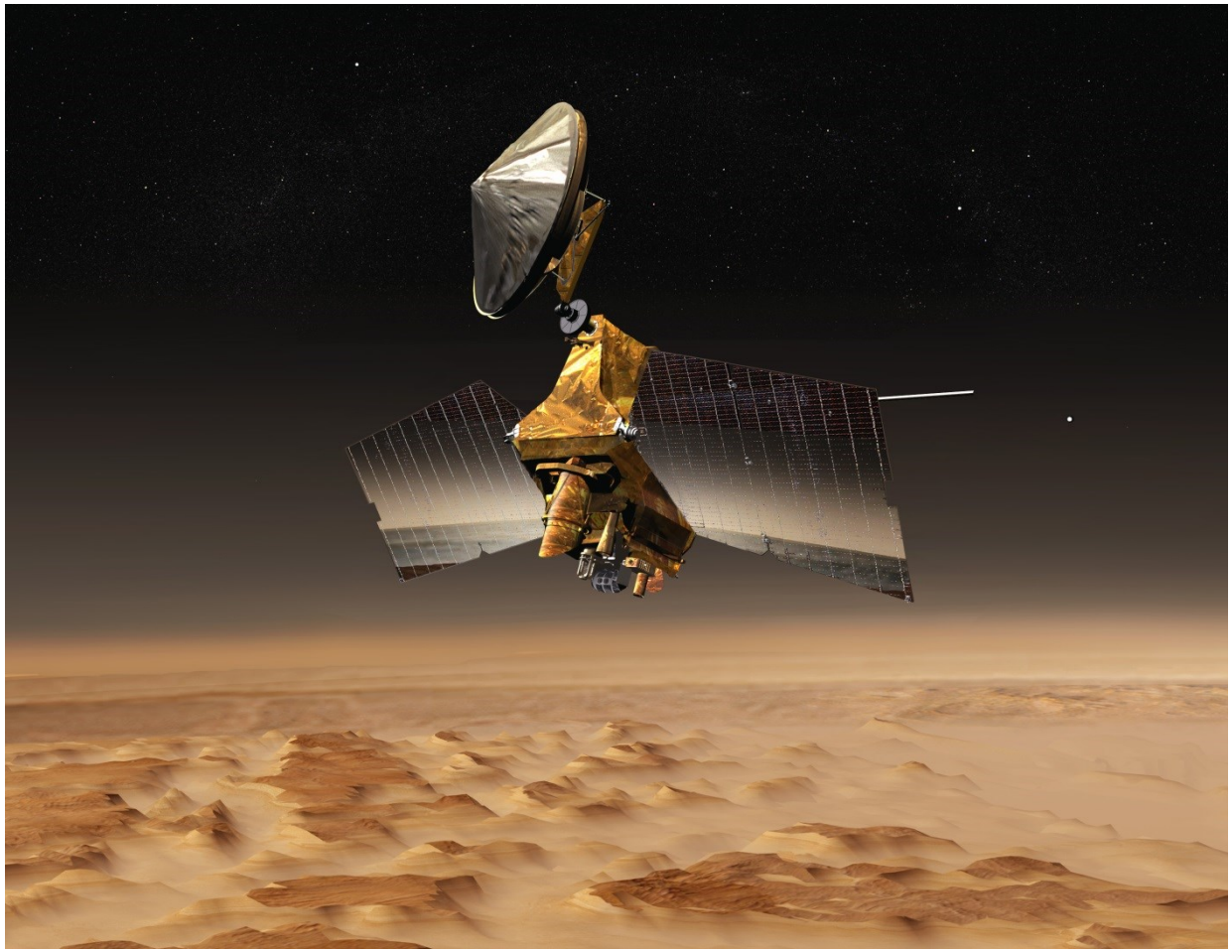


http://www.jpl.nasa.gov/images/phoenix/collection_16/sol_020_024_change_dodo_v3_800-600.jpg

Phoenix lander (2007)

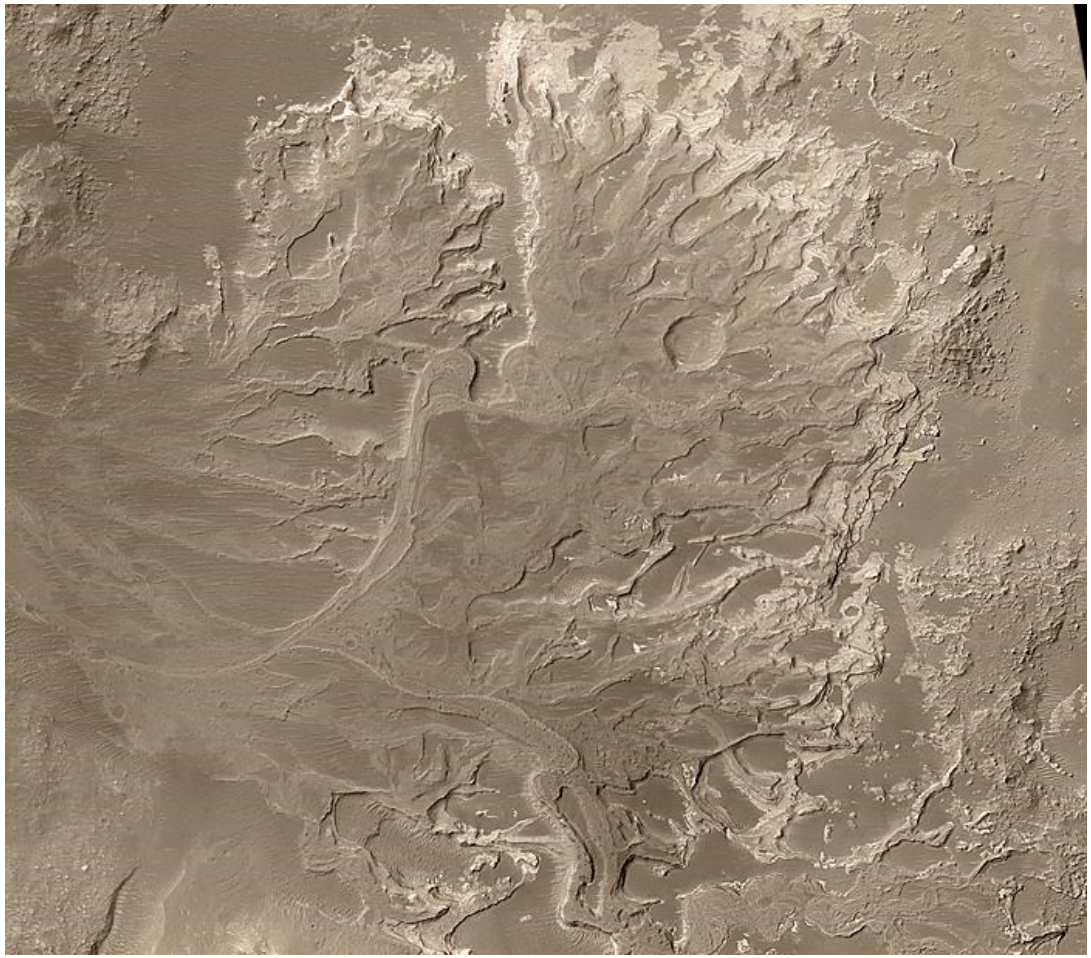
http://surp.jpl.nasa.gov/news/features/index.cfm?FuseAction=ShowNews&NewsID=97

Mars Reconnaissance Orbiter (2005)



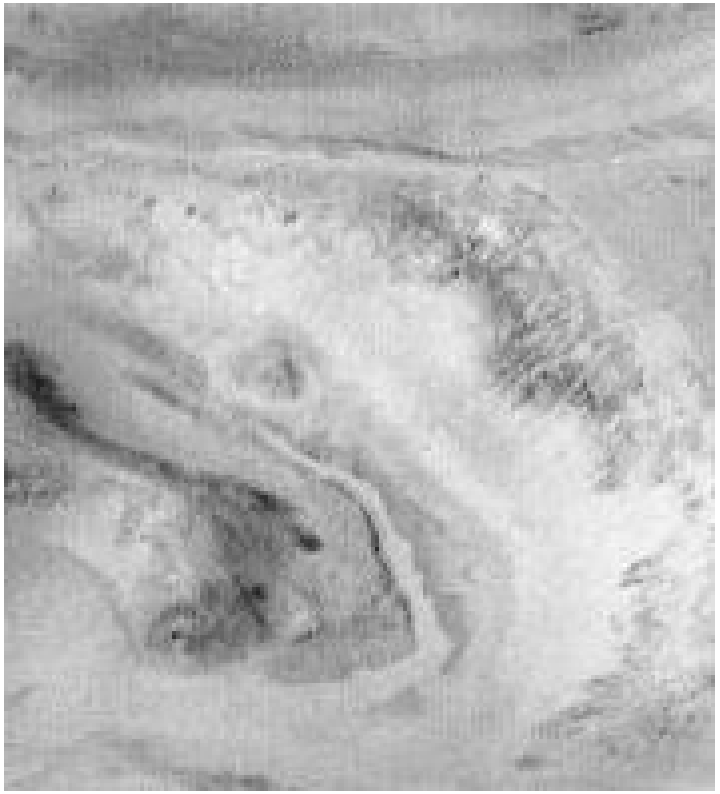
http://upload.wikimedia.org/wikipedia/commons/b/bd/Mars_Reconnaissance_Orbiter.jpg

Mars Reconnaissance Orbiter (2005)



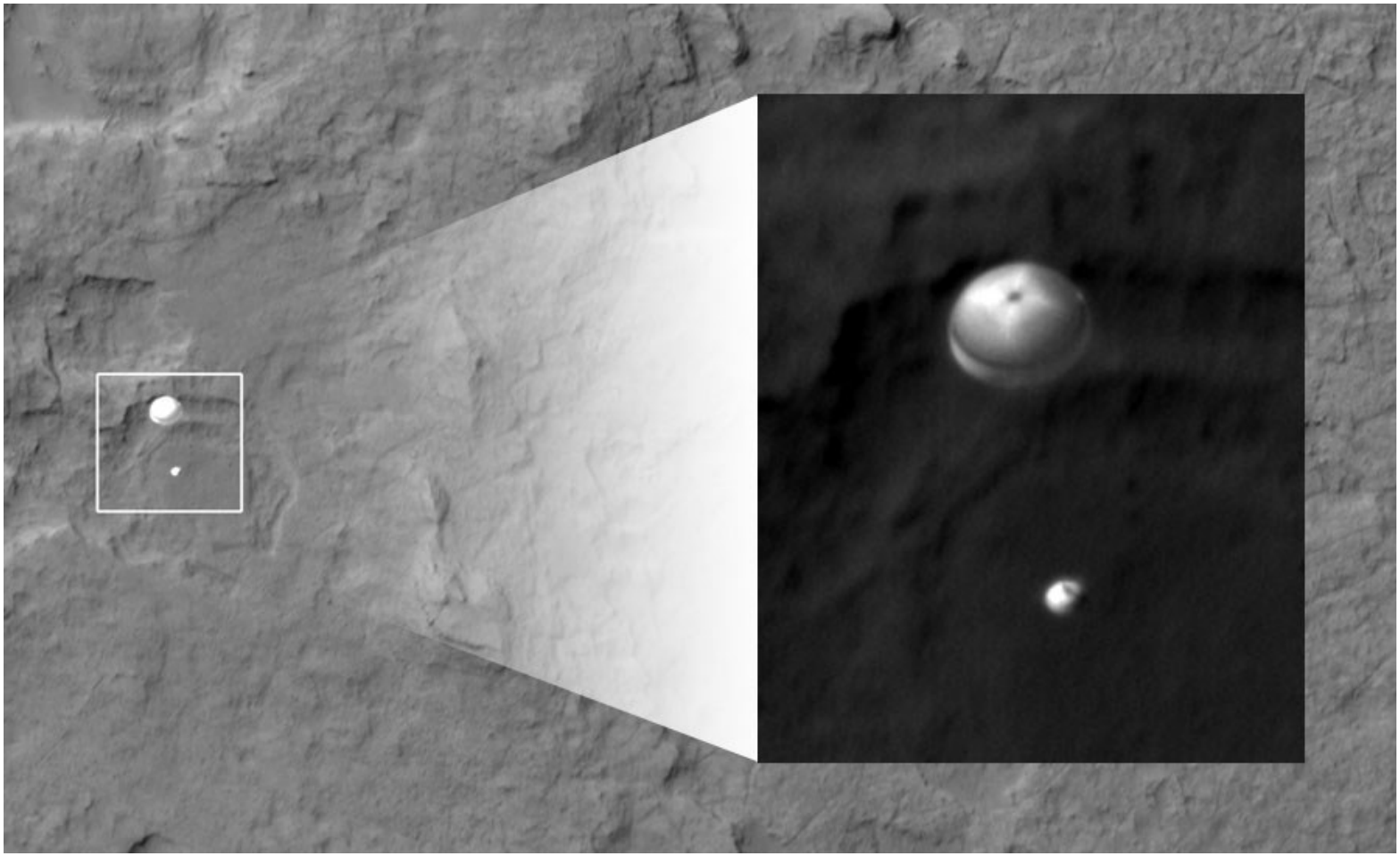
http://upload.wikimedia.org/wikipedia/commons/4/42/Distributary_fan-delta.jpg

Mars Reconnaissance Orbiter (2005)



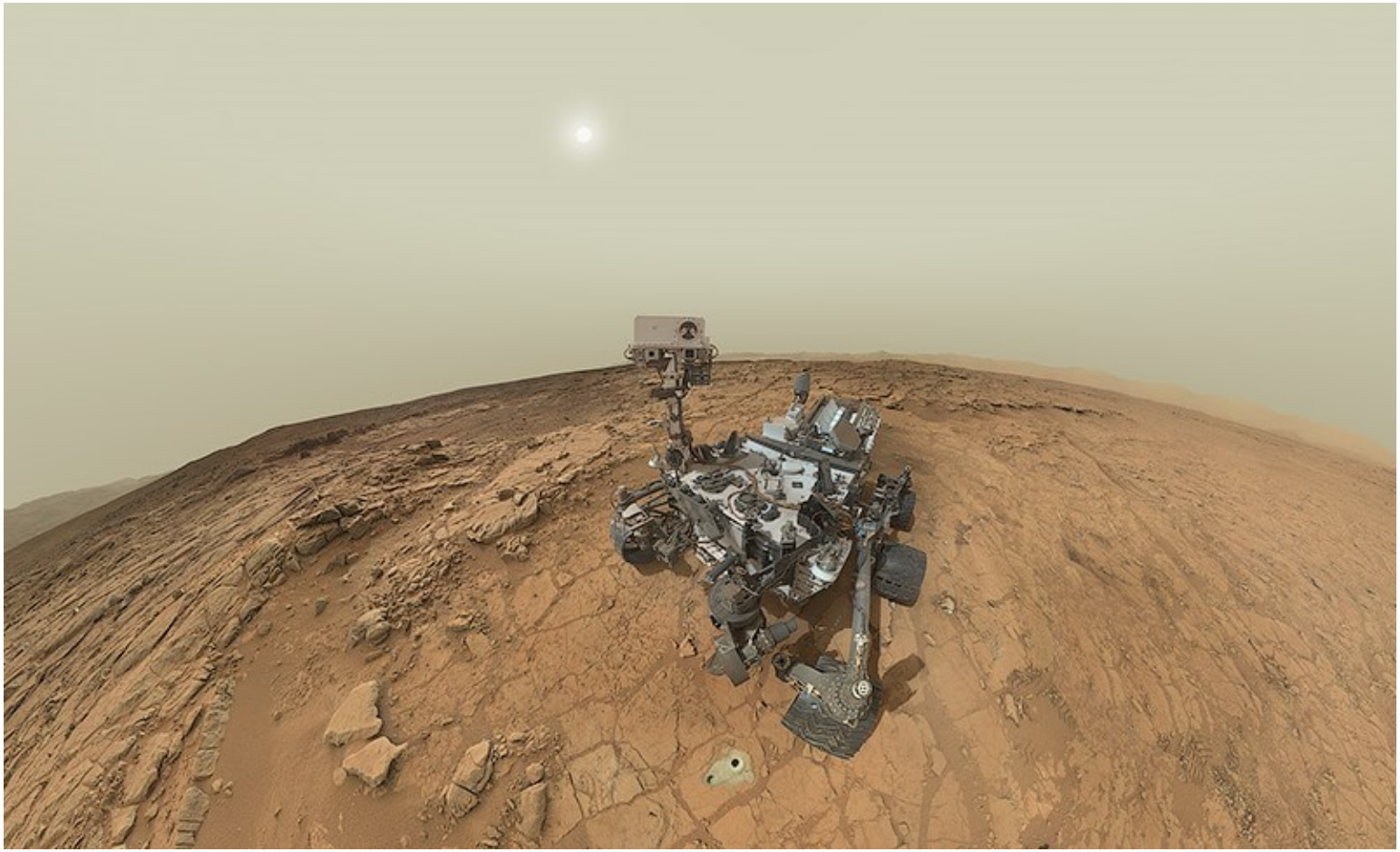
http://upload.wikimedia.org/wikipedia/commons/8/84/Nanedi_channel.JPG

Curiosity rover (2011)



http://upload.wikimedia.org/wikipedia/commons/d/d2/MRO_sees_Curiosity_landing.jpg

Curiosity rover (2011)



http://apod.nasa.gov/apod/image/1302/curiosity_sol-177bodrov600.jpg

Curiosity rover (2011)

http://photojournal.jpl.nasa.gov/figures/PIA16156_fig1.jpg

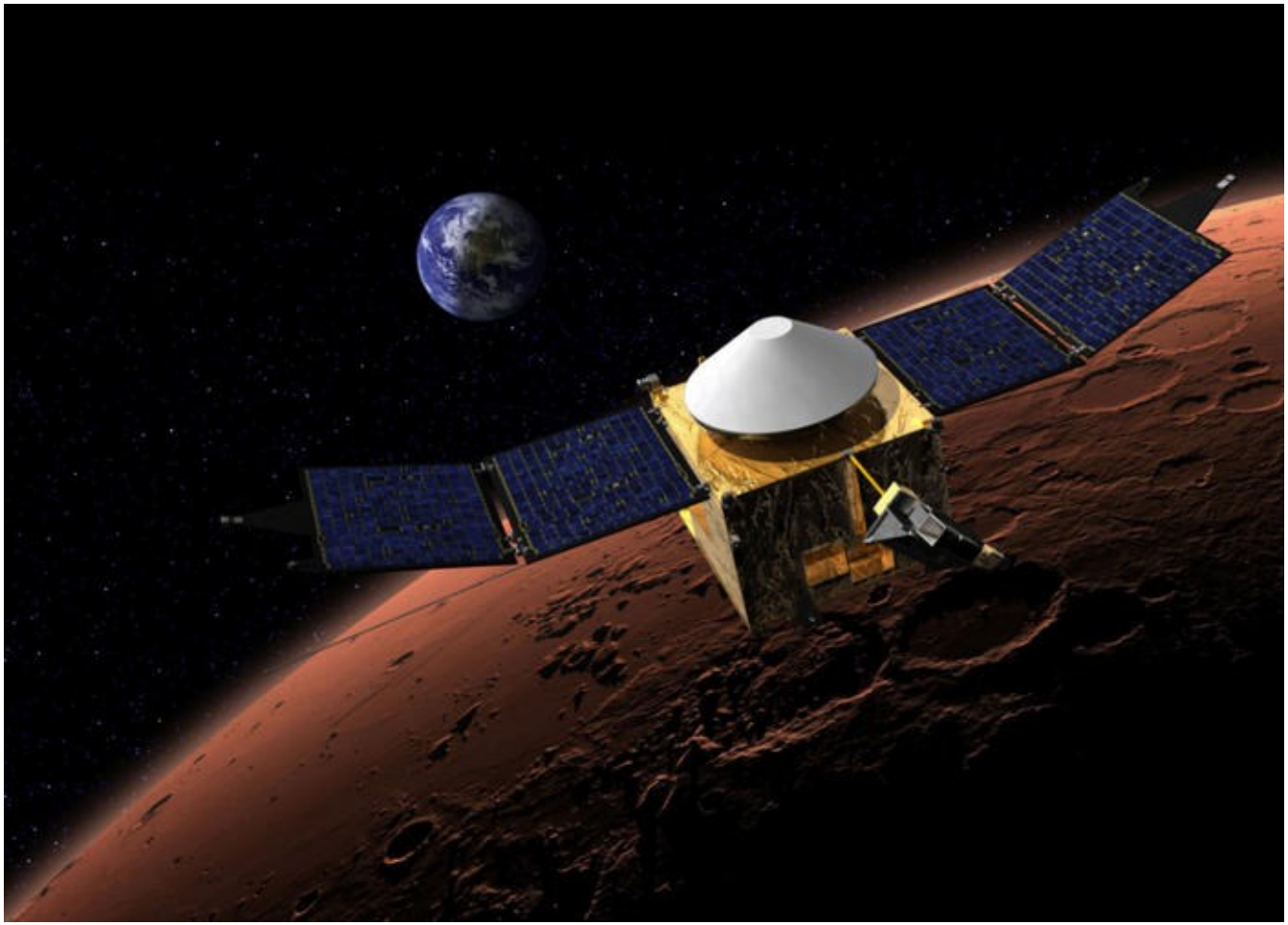
Successful missions

- Mariner 4, 6, and 7 (flyby)
- Mariner 9, Viking 1 and 2, Phobos (Russia), Mars Global Surveyor, Mars Odyssey, Mars Express (Europe), Mars Reconnaissance Orbiter (orbiters)
- Viking 1 and 2, Pathfinder, Spirit, Opportunity, Phoenix, Curiosity (landers and rovers)

- All the missions in the last 20 years have looked at water below the surface, at the surface, and in the lower atmosphere
- It is time to look at the other piece of the puzzle
  - The escape of water and other atmospheric constituents out into space

It is time for MAVEN

MAVEN orbiter (2014)



http://mars.nasa.gov/images/maven/maven_image_gallery.jpg

MAVEN orbiter (2014)

What is the purpose of MAVEN?

MAVEN is the first spacecraft to focus primarily on the state of the upper atmosphere of Mars, the processes that control it, and the overall atmospheric loss that is currently occurring. Specifically, MAVEN is exploring the processes through which the top of the Martian atmosphere can be lost to space. Scientists think that this loss could be important in explaining the changes in the climate of Mars that have occurred over the last four billion years.

MAVEN orbiter (2014)

http://lasp.colorado.edu/home/maven/files/2011/03/MAVEN_fairing_encapsulation.jpg

MAVEN orbiter (2014)

http://lasp.colorado.edu/home/maven/files/2011/03/MAVEN_fairing_lg.jpg

MAVEN orbiter (2014)

http://lasp.colorado.edu/home/maven/files/2013/11/MAVEN_on_rail.jpg

http://lasp.colorado.edu/home/maven/files/2011/03/MAVEN_on_pad41.jpg

MAVEN orbiter (2014)

MAVEN orbiter (2014)

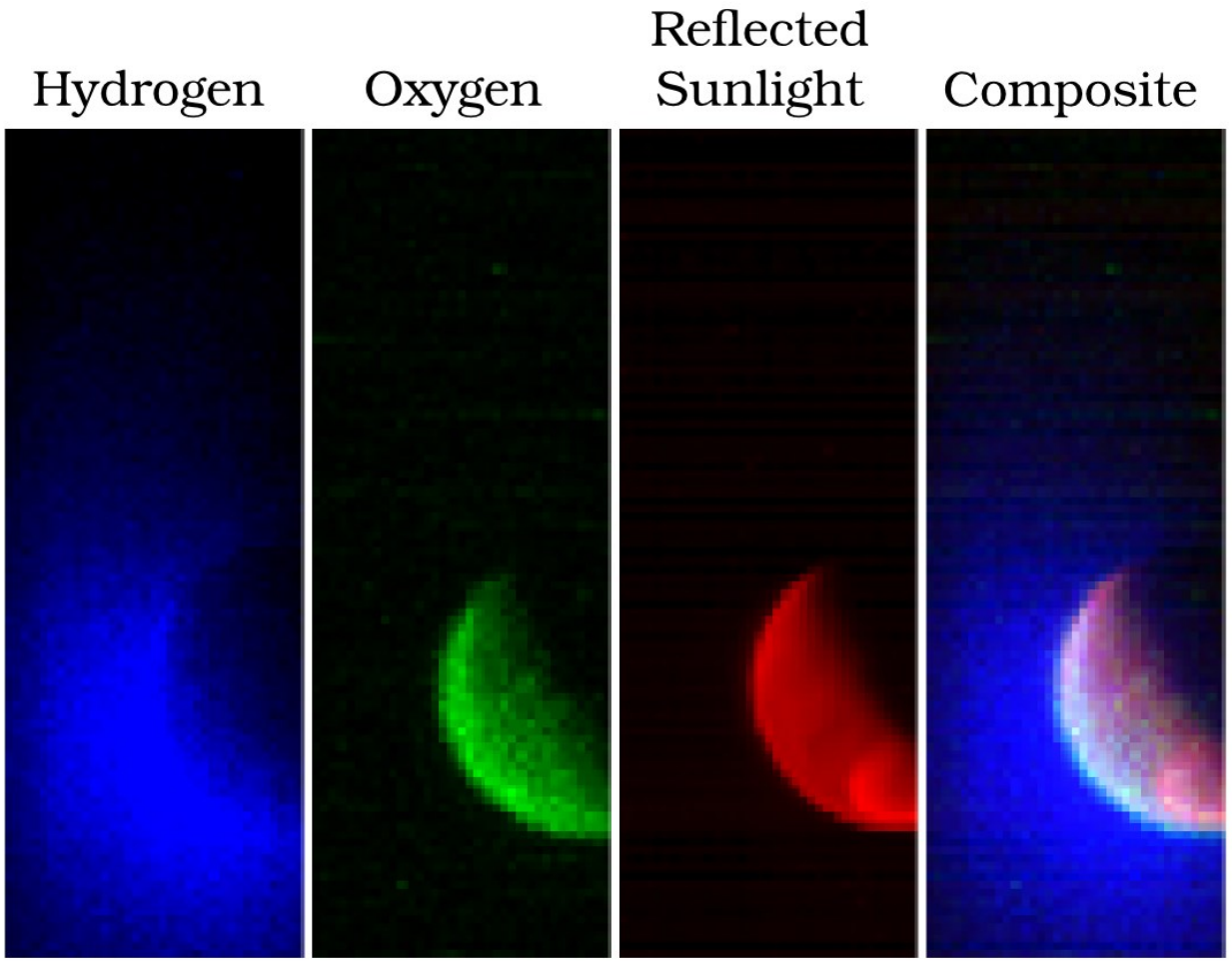
MAVEN orbiter (2014)

MAVEN orbiter (2014)

MAVEN orbiter (2014)

http://media2.s-nbcnews.com/i/MSNBC/Components/Video/__NEW/f_mars_maven_131118.jpg

MAVEN orbiter (2014)



http://lasp.colorado.edu/home/maven/2014/09/24/maven-spacecraft-returns-first-mars-observations/

Conclusions

- Liquid water required for life
- Present-day water exists, but not as liquid
- Lots of liquid water in the past
- “Follow the water”

- MAVEN is about to measure the loss of water from the top of the atmosphere
- From this, the state of the atmosphere, climate, and planetary habitability in the distant past can be estimated

Boston University and MAVEN



Professors John Clarke (left), Michael Mendillo (middle), and Paul Withers (right) lead Boston University's involvement in the MAVEN mission

Science directions

Professor Clarke is using observations by MAVEN's ultraviolet spectrometer to measure hydrogen gas escaping from Mars

Professor Mendillo is using MAVEN measurements of Mars' ionosphere to figure out how it is affected by the changing Sun

Professor Withers is using MAVEN data on the atmosphere and ionosphere to learn how they influence one another

Students

Postdoctoral researchers, graduate students, and undergraduate students in Boston University's Center for Space Physics are also working on MAVEN

They are planning what the spacecraft will look at, calibrating the raw data, and analyzing what MAVEN's measurements reveal about the many interactions between Mars and the space environment that surrounds it

Center for Space Physics

Boston University's Center for Space Physics is a collaboration between science and engineering faculty under a common mission: to advance our understanding of the atmospheres, magnetospheres, and plasma environments of our solar system

Spirit and Opportunity, rovers (2003)