MARS SURFACE AND GROUND WATER

By: Devin Devine, Steve Brockman,
Julie Gall, Justin Harris, and Alex Mclane

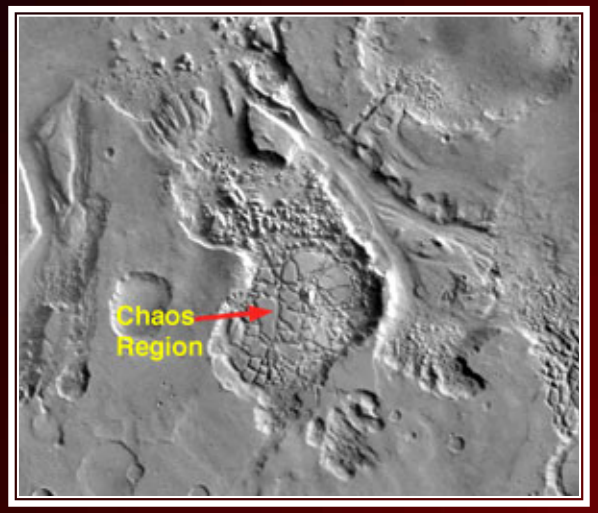
Slide By: Julie Gall

Outline

- Intro to Topics
- Early History and Climate of Mars
  - Missions and what they discovered
- Ground Water and Ice Reservoirs
  - Missions and what they discovered
- Outflow Channels
- Valley Networks and Dendritic Patterns

Slide By: Julie Gall

Chaotic Terrain



- Chaotic terrain on Mars refers to regions that show a complex, jumbled morphology. It is thought they are created when underlying material is removed.

Image 1 and Information: http://www.phy229.group.shef.ac.uk/wiki/index.php/Evidence_for_water_on_Mars
Image 2 http://www.dlr.de/mars/en/desktopdefault.aspx/tabid-4547/421_read-3951/gallery-1/gallery_read-Image.8.2020/

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Chaotic Terrain

- Channels scoured by ancient outbursts of flood waters are seen in these orbital views from Mars Odyssey's Thermal Emission Imaging System. The features are billions of years old.

Image 1: http://www.physorg.com/news176721098.html
Image 2 and Information: http://www.cosmosmagazine.com/news/2094/mars-baked-different-ingredients-earth

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Outflow Channels

- Outflow channels appear to have formed as a result of huge floods. Outflow channels typically begin in areas of collapse called chaotic terrain where water burst out from the subsurface quickly carving channel pathways.

Information: http://www.waterencyclopedia.com/La-Mi/Mars-Water-on.html

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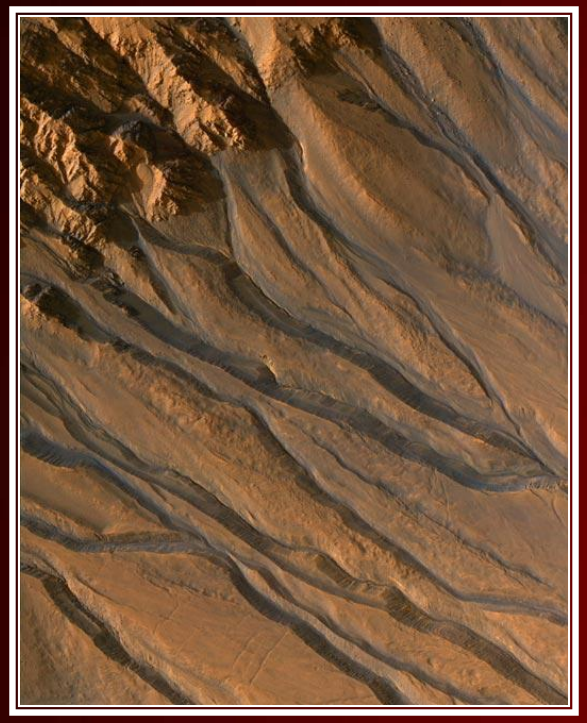
Outflow Channels

- These are pictures of gullies inside a crater that are cut by flowing water that was from melting ice. Left picture is Mars and the two on the right are Earth.



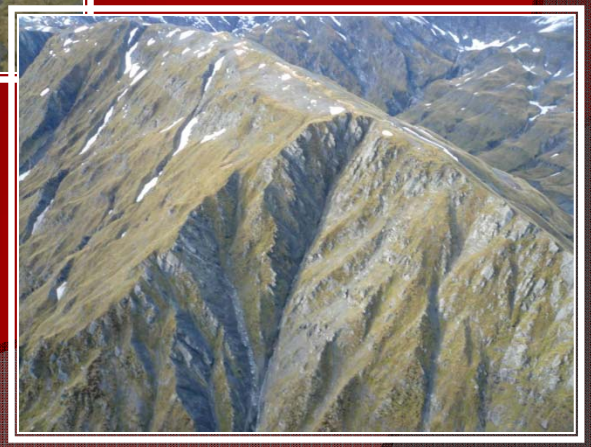


Image 1: http://satftp.soest.hawaii.edu/space/hawaii/vfts/molokai/air9.667x340.jpg
Image 2 and 3: http://www.mountainrec.co.nz/mtnr_news.htm

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Water Valley Networks

- Many valley systems on Mars do not show evidence of catastrophic flooding; instead they show greater resemblance to drainage systems on Earth.
- Although liquid water is unstable on the surface of Mars, it is thought that flowing ground water would be able to form valley networks if the water flowed beneath a protective cover of ice.

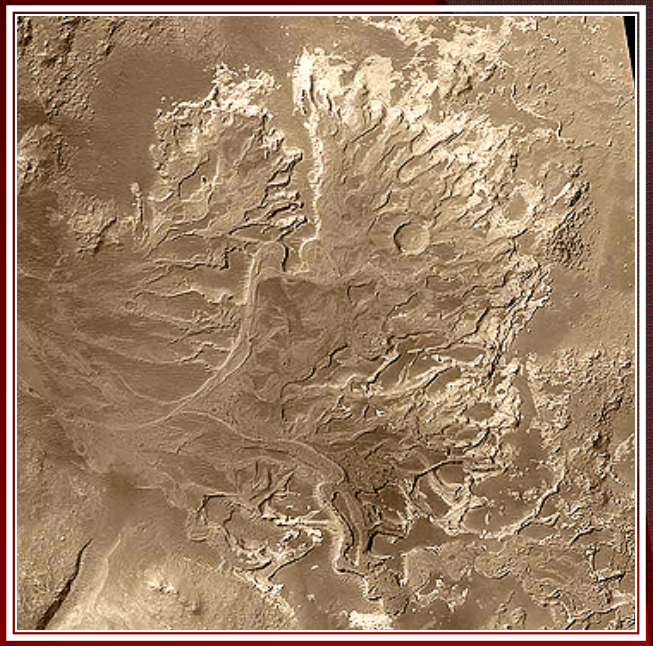

Image 1:http://marinesciencetoday.com/2009/11/09/new-approach-to-clean-the-chesapeake-bay/
Image 2: http://www.phy229.group.shef.ac.uk/wiki/index.php/Evidence_for_water_on_Mars
Information: http://www.lpi.usra.edu/publications/slidesets/redplanet2/slide_26.html

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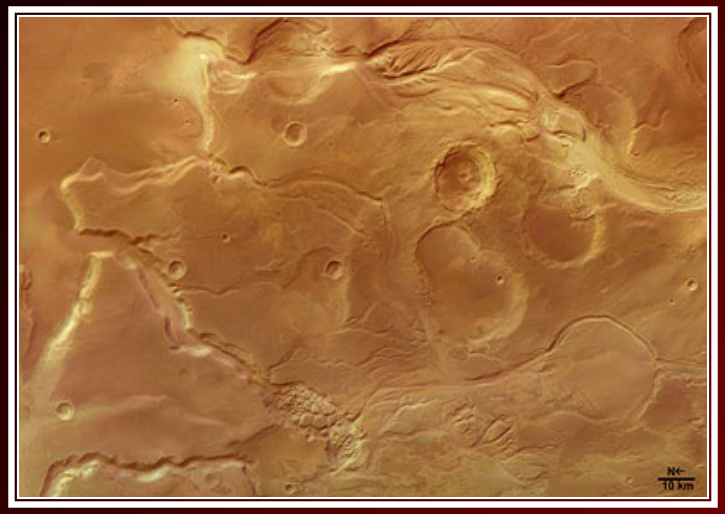
Water Valley Networks



- Water channels cut by flowing water, these are found around the chaotic terrain where the bursts of floor water escape.
- Formed by ground water flow rather than by runoff of rain

Images 1 and 2: http://www.phy229.group.shef.ac.uk/wiki/index.php/Evidence_for_water_on_Mars
Image 3: http://cultofthecarboncow.com/

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Meandering Streams

- For these types of meandering stream remnants to form, usually there would have to be high concentrated vegetation on the banks holding the soil in place.

Image 1 : http://www.stfc.ac.uk/Our%20Research/Aurora/5141.aspx
Image 2: http://www.travelpod.com/travel-blog-entries/richardvanleeuw/1/1277418155/tpod.html
Image 3: http://cdn.physorg.com/newman/gfx/news/hires/2009/themeanderin.jpg
Information: http://www.marsdaily.com/reports/The_Meandering_Channels_Of_Mars_999.html

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Meandering Streams

- Other options that could have caused these formations of river banks are clay sediment forming or chemical hardening of the stream bed. In arid environments minerals deposited in the ground can cement together to form a hard, thin layer.

Information: http://www.marsdaily.com/reports/The_Meandering_Channels_Of_Mars_999.html

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Comparisons

- In order to better understand key points, we will be showing many comparisons between Mars and Earth.

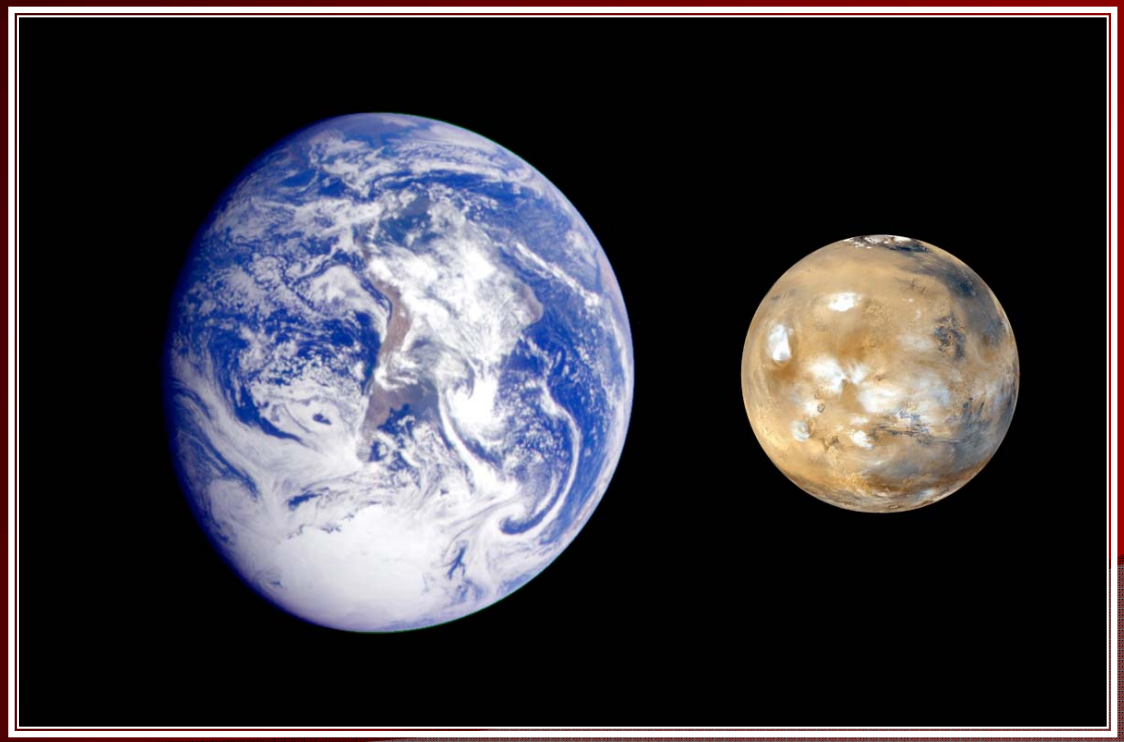

Image 1: http://photojournal.jpl.nasa.gov/catalog/PIA02570

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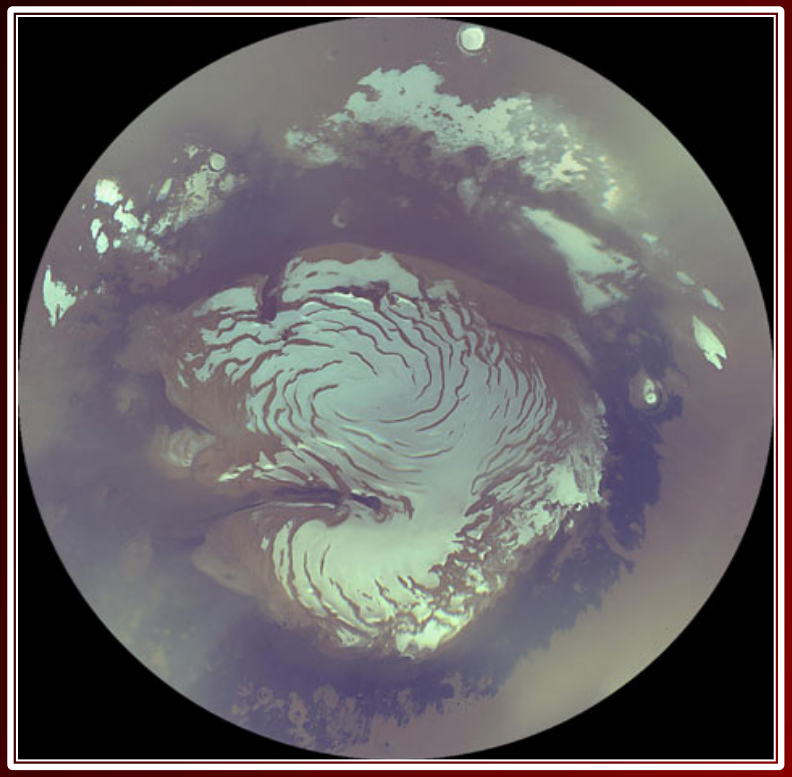
History and Climate of Mars



- Evidence
- Warmth
- Water

Image 1: http://www.dailymail.co.uk/news/article-410901/Amazing-Mars-picture-planets-dramatic-climate-changes.html#ixzz155gPn8rG

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Mars Pathfinder Results

- MPF found rounded pebbles, cobbles, and possible conglomerates at the landing site. The rocks and the soil were suggestive of a catastrophic flood. This in turn suggests more warmth and more water in Mars' past history.

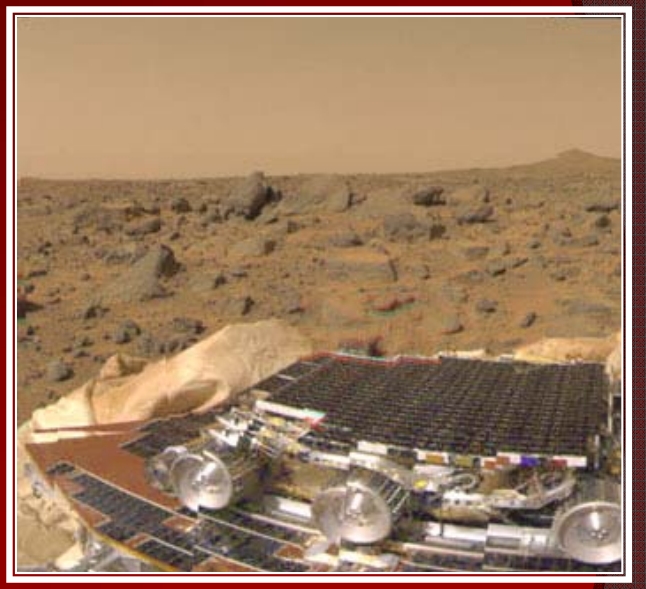

Image 1: http://www.asatro.psu.edu/users/niel/astro1/slideshows/class37/slides-37.html

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Results of Exploration

- Suggestive of liquid water in equilibrium with the atmosphere
- Suggestive of a warmer and wetter Martian past
- Showed a variety of rocks deposited by a catastrophic flood

Information: http://www.asatro.psu.edu/users/niel/astro1/slideshows/class37/slides-37.html

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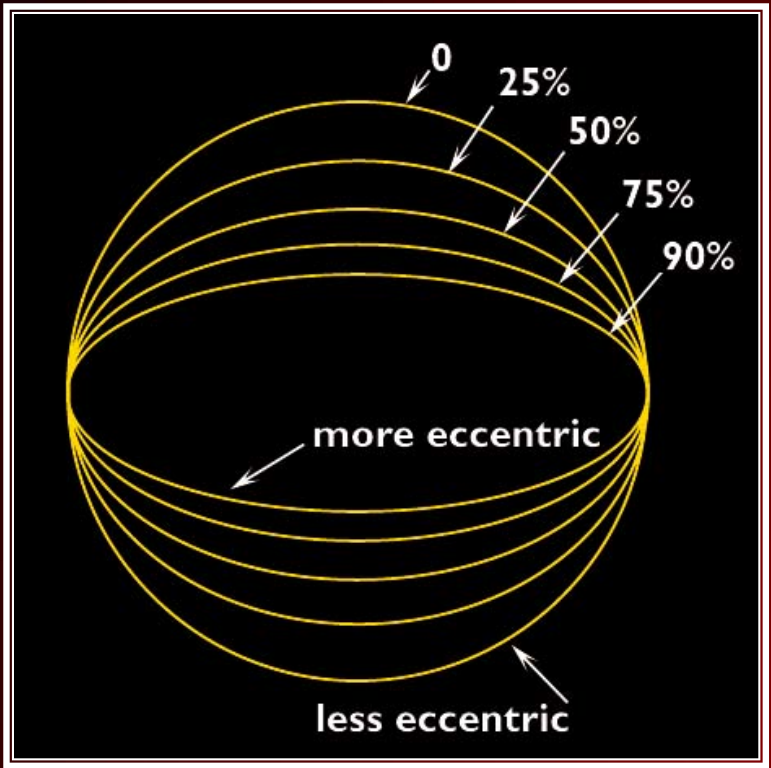
Orbital Eccentricity



- The Martian climate is more influenced by the shape of its orbit than Earth's climate is by the shape of its orbit.
- The orbit of Mars is more elliptical than that of the Earth. The departure from a perfect circle is known as the *eccentricity* of the orbit.

Image and Information: www.windows2universe.org/mars/interior/Martian_orbit_eccentricity.html

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High Inclination of the Axis of Revolution

- Most importantly for the climate of Mars, the inclination of the axis of revolution of Mars is much more extreme than that of the Earth.
- This means that differences between summer and winter on Mars can be more extreme than they are on Earth.

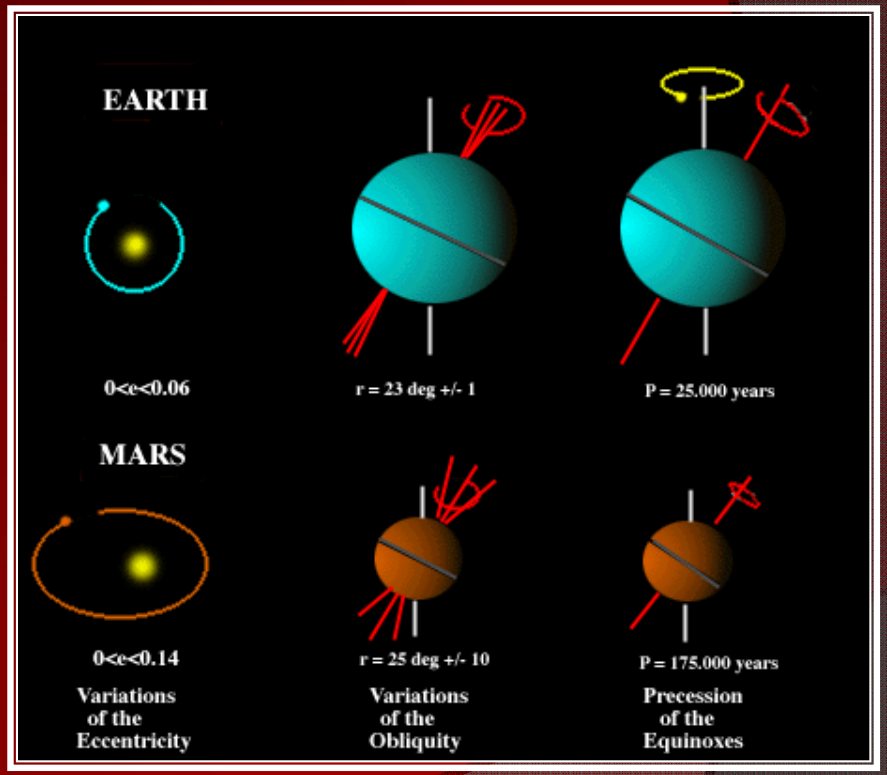

Image and Information: http://cmex.ihmc.us/SiteCat/sitecat2/mars.htm

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What It Means

- The high eccentricity of Mars, combined with the high inclination of the axis of revolution, means that there are times when Mars can experience a lot more warming than normal.
- These large changes in the warming of the surface of Mars mean that Mars has more potential for climate change induced by orbital parameters than does the Earth.

Information: http://cmex.ihmc.us/SiteCat/sitecat2/mars.htm

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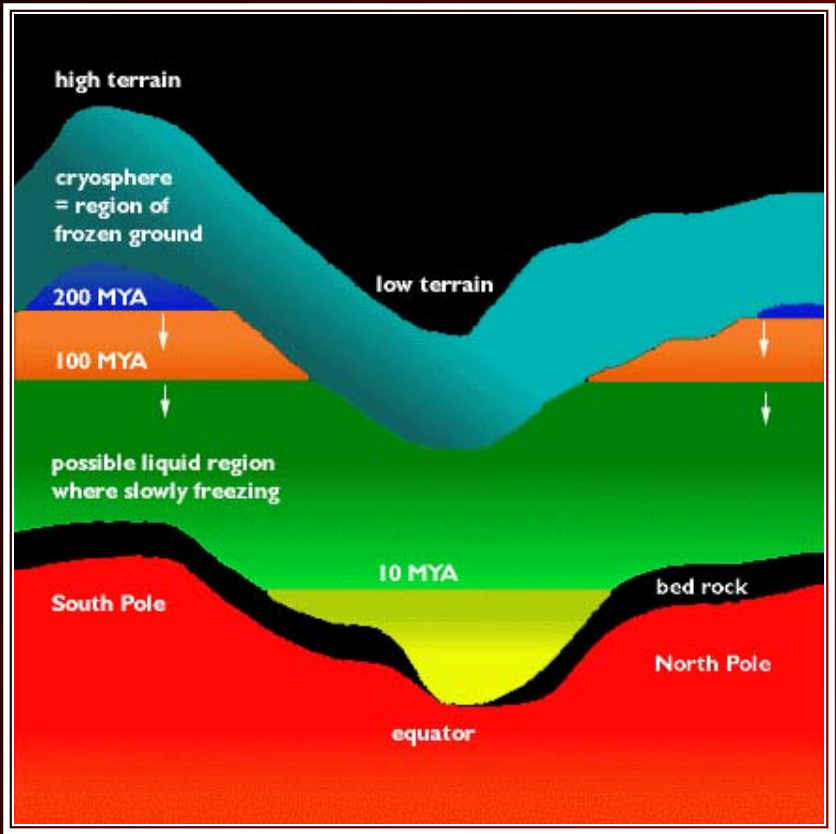
Transfer of Water



- Over the history of Mars, when the climate changes due to the unusual shape of its orbit, water, which has been stored frozen underground, turns to running water and is transferred from regions near the poles to regions near the equator.

Image and Information: http://www.windows2universe.org/mars/interior/Mars_water_drawdown.html

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Water in Clouds

- This graph, taken by Mars Global Surveyor, shows proof that the clouds of Mars are made of water. The sequence shows actual water clouds moving across the face of Mars.

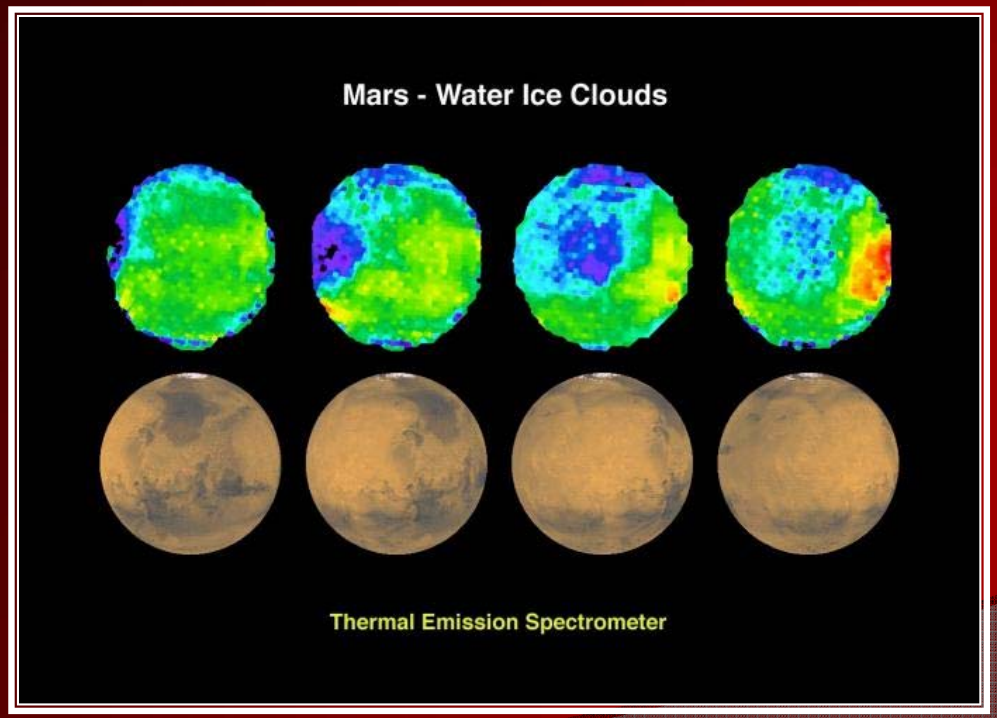

Image and Information: http://www.windows2universe.org/cool_stuff/tour_mars_water_10.html&edu=high

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Water in the Atmosphere

- There is evidence of water in Mars' atmosphere. The atmosphere of Mars is thin today but it was thicker in the past.
- Though there is little evidence of rain or other forms of precipitation on Mars, the radar image here shows snow precipitating onto the south pole of Mars.

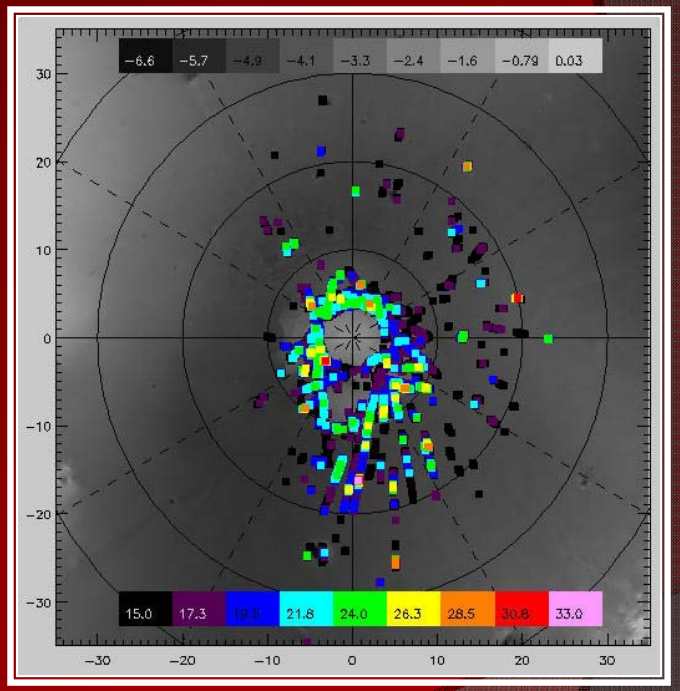

Image and Information: http://www.windows2universe.org/cool_stuff/tour_mars_water_10.html&edu=high

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Searching for Ground Ice and Water on Mars

- Methods
- Vehicles used
- Results
- Locations
- Timelines

Water Ice Polar Cap

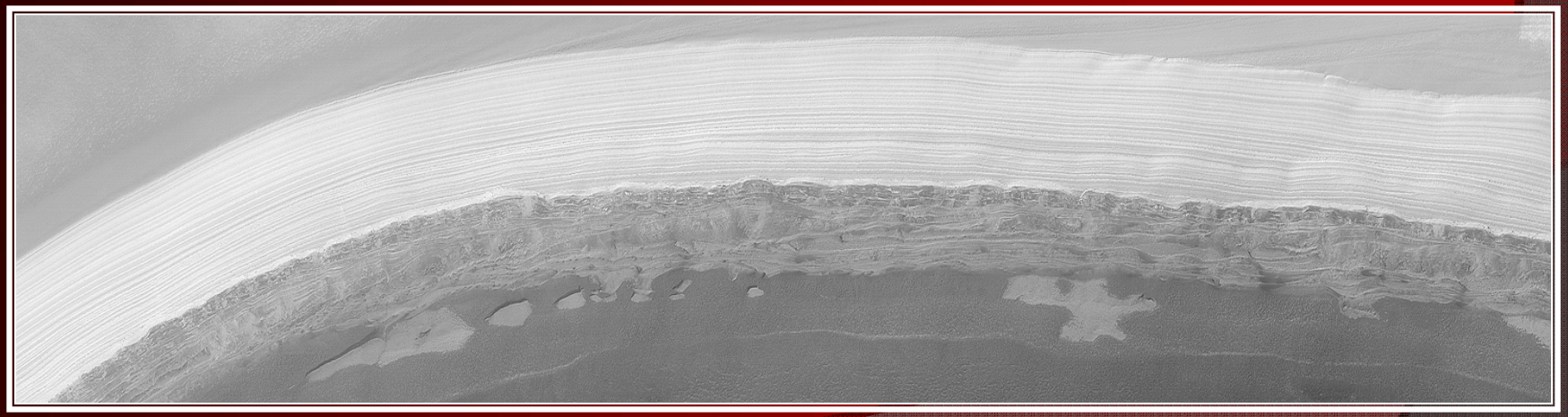

Image 1: http://antwrp.gsfc.nasa.gov/apod/ap020219.html

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2001 Mars Odyssey

Gamma-Ray Spectrometer (GRS)

- Methods
- Reveals what elements are in the soil, detecting telltale signs of water ice in the upper meter of soil, with enough water ice to fill Lake Michigan twice over

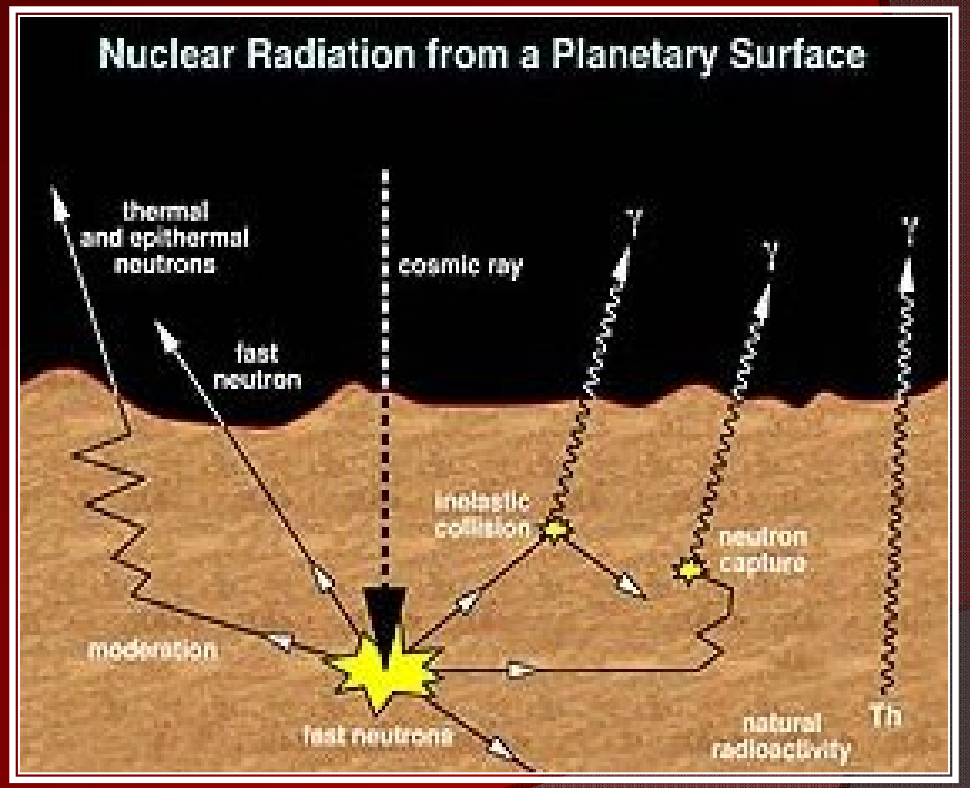

Image and Information: http://science.nasa.gov/science-news/science-at-nasa/2002/28may_marsice/

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Martian Poles

- In these false-color maps of the Martian poles, deep blue indicates soil enriched by hydrogen. The south pole is surrounded by icy terrain. The north pole contains water ice too, but it is hidden for the moment by a wintertime layer of carbon dioxide frost.

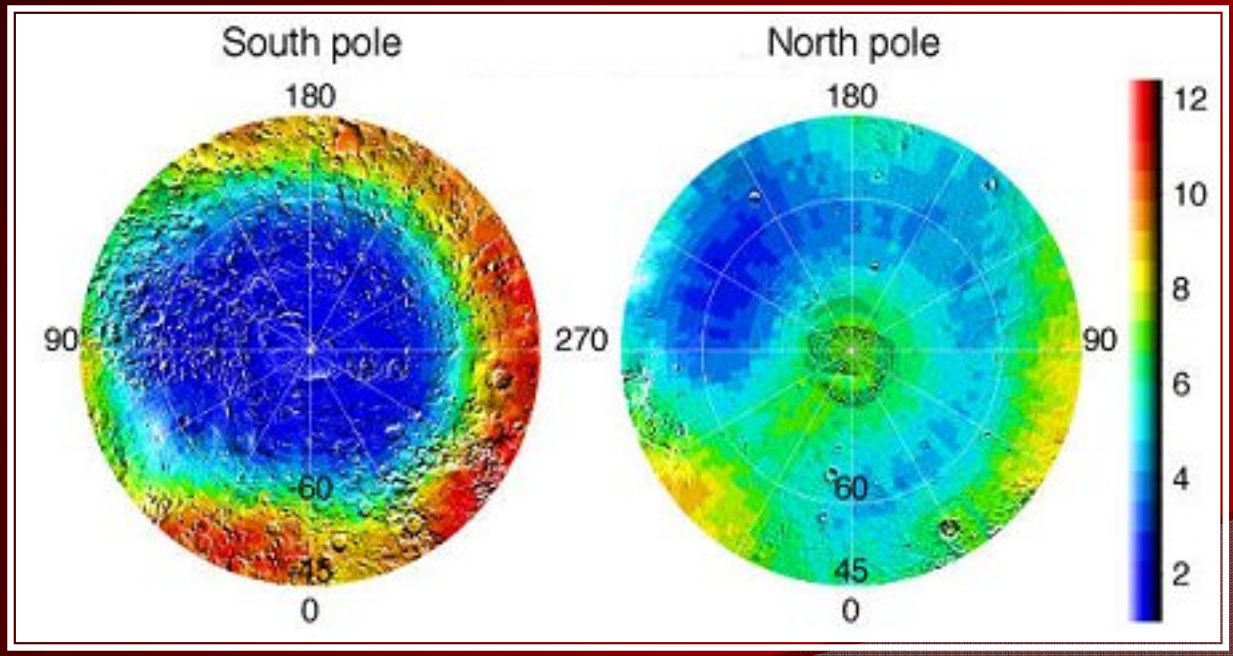

Image and Information: http://science.nasa.gov/science-news/science-at-nasa/2002/28may_marsice/

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Thermal Emission Imaging System (THEMIS)

- The left image is a daytime infrared view. The same image, color-coded by temperature, is on the right. Green indicates water ice (I), S is dry soil, C is CO2 ice, and D is a warm, dark, dusty layered unit cutting into the polar cap. Areas 1 and 2 were regions studied for seasonal changes.

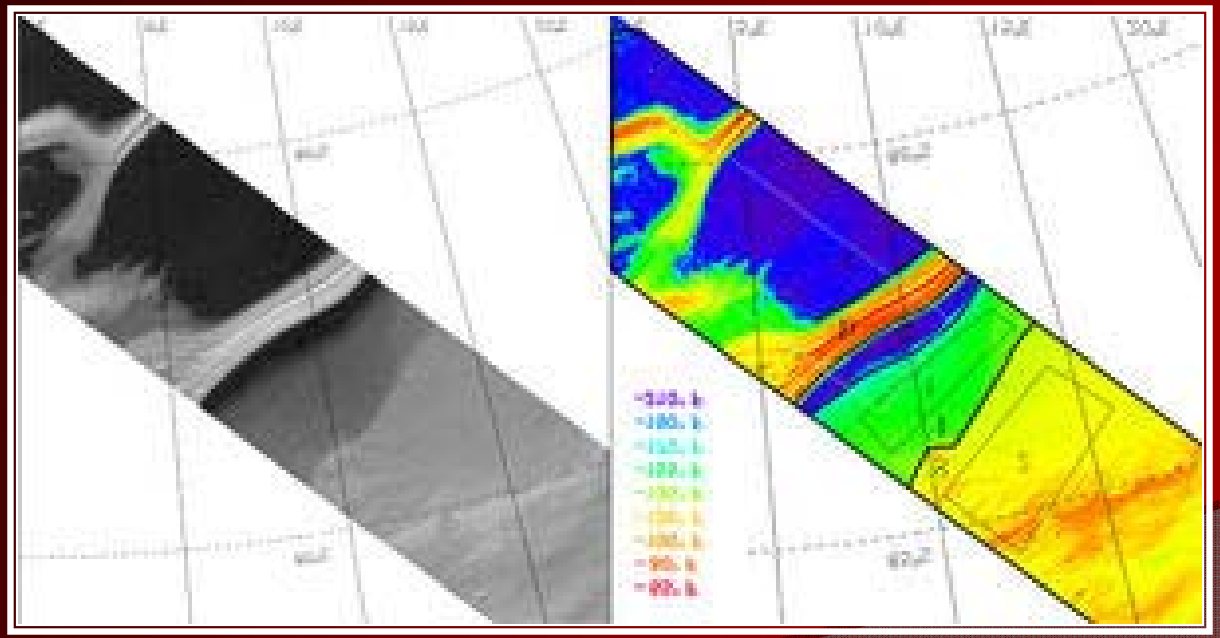

Image and Information: http://themis.asu.edu/node/5392

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European Space Agency Mars Express

(MARSIS) Mars Advanced Radar for Subsurface and Ionospheric Sounding

- MARSIS should reveal much about the composition of the top 5 kilometers (about 3 miles) of crust.

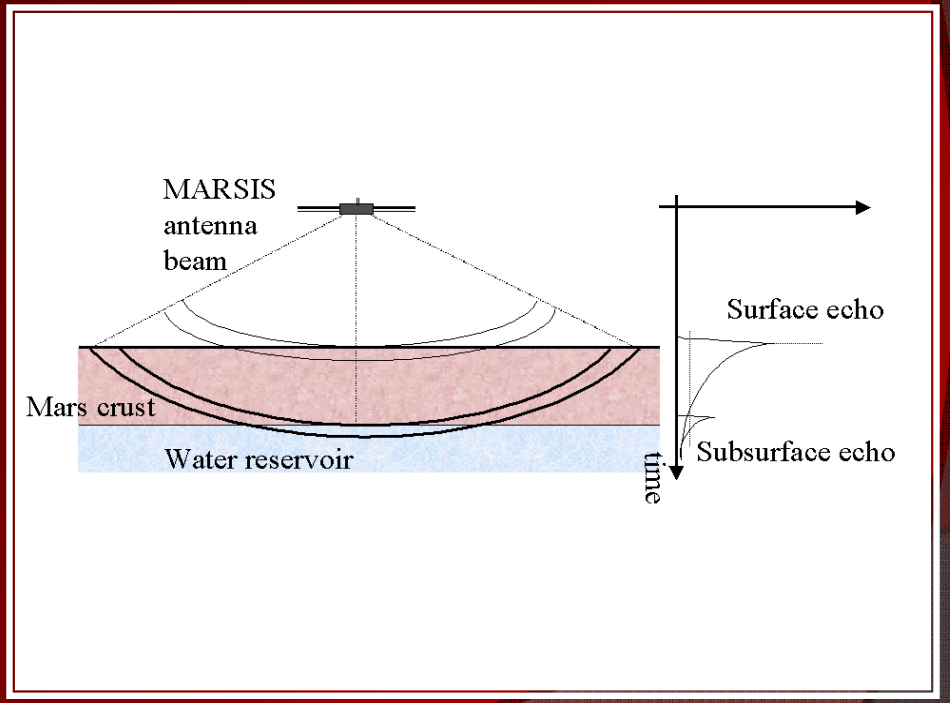

Image 1: http://www.nasa.gov/mission_pages/mars/images/pia09224.html

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Mars South Polar Region

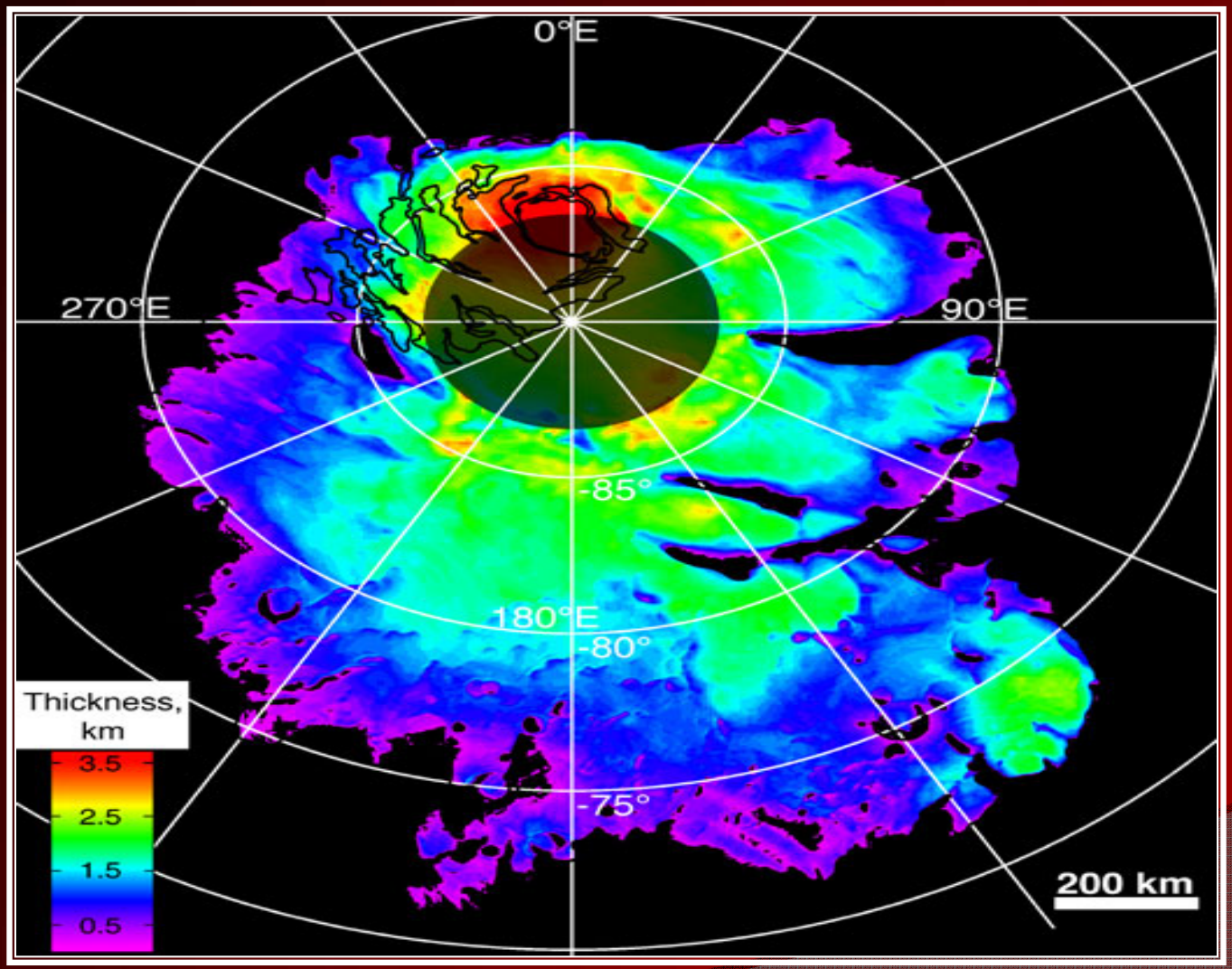

Image 1: http://www.nasa.gov/mission_pages/mars/images/pia09224.html

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Mars Reconnaissance Orbiter

- Discovers new category of minerals

Image 1: http://www.jpl.nasa.gov/news/news.cfm?release=2008-198

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Mars Phoenix Lander

- Meteor strikes on Mars have uncovered pure water ice and maybe liquid water on the red planet's relatively balmy mid-latitudes.

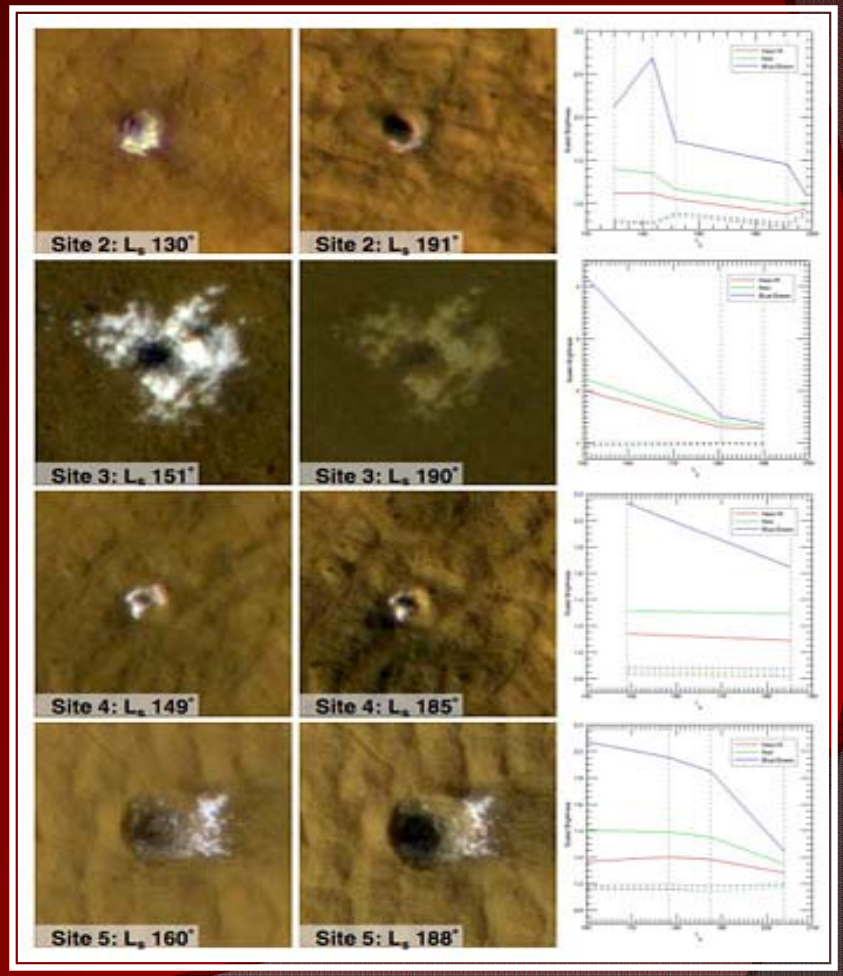

Image and Information: http://news.nationalgeographic.com/news/2009/09/090924-mars-ice-picture.html

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Types of Outflow Channels on Mars

According to a NASA website there are three main types of outflow channels recognized on the Martian surface:

1. **Runoff channels that appear to be dendritic networks or arrays of relatively small channels or valleys located mainly in the old, densely cratered terrain.**

2. **Outflow channels that appear to have large scale tributaries**

3. **Fretted channels appear as long, relatively wide, fiat-floored valleys that possess tributaries and increase in size downstream**

Information: http://history.nasa.gov/SP-441/ch4.htm

Slide By: Alex Mclane

Outflow Channels

- Outflow channels on Mars are thought to be aqueous in origin given the modern presence of water ice in the polar regions. There are morphological similarities of outflow channels on Mars to terrestrial formations on Earth produced from catastrophic floods. Outflow channels typically begin in areas of collapse called chaotic terrain where water burst out from the subsurface quickly carving channel pathways. The channels would rapidly boil and evaporate given the low atmospheric pressure on Mars today. Other explanations for the existence of outflow channels include models with atmospheric and planetary conditions that are much different than there are on Mars today.

Information: http://www.waterencyclopedia.com/La-Mi/Mars-Water-on.html

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Chryse Planitia

Chryse Planitia is a circular plain in the northern equatorial region of Mars. The area shows evidence of water erosion located at the bottom end of perceived outflow channels originating in the higher elevation equatorial region. The Valles Marineris (largest canyon on Mars) in the equatorial region of the image is considered to be one of those outflow channel sources. The image on the right shows what the Chryse Planitia might have looked like on Mars 3.5 billion years ago.

Image 1: http://legacy.signonsandiego.com/news/science/20040526-9999-lz1c26water.html

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Martian Channel

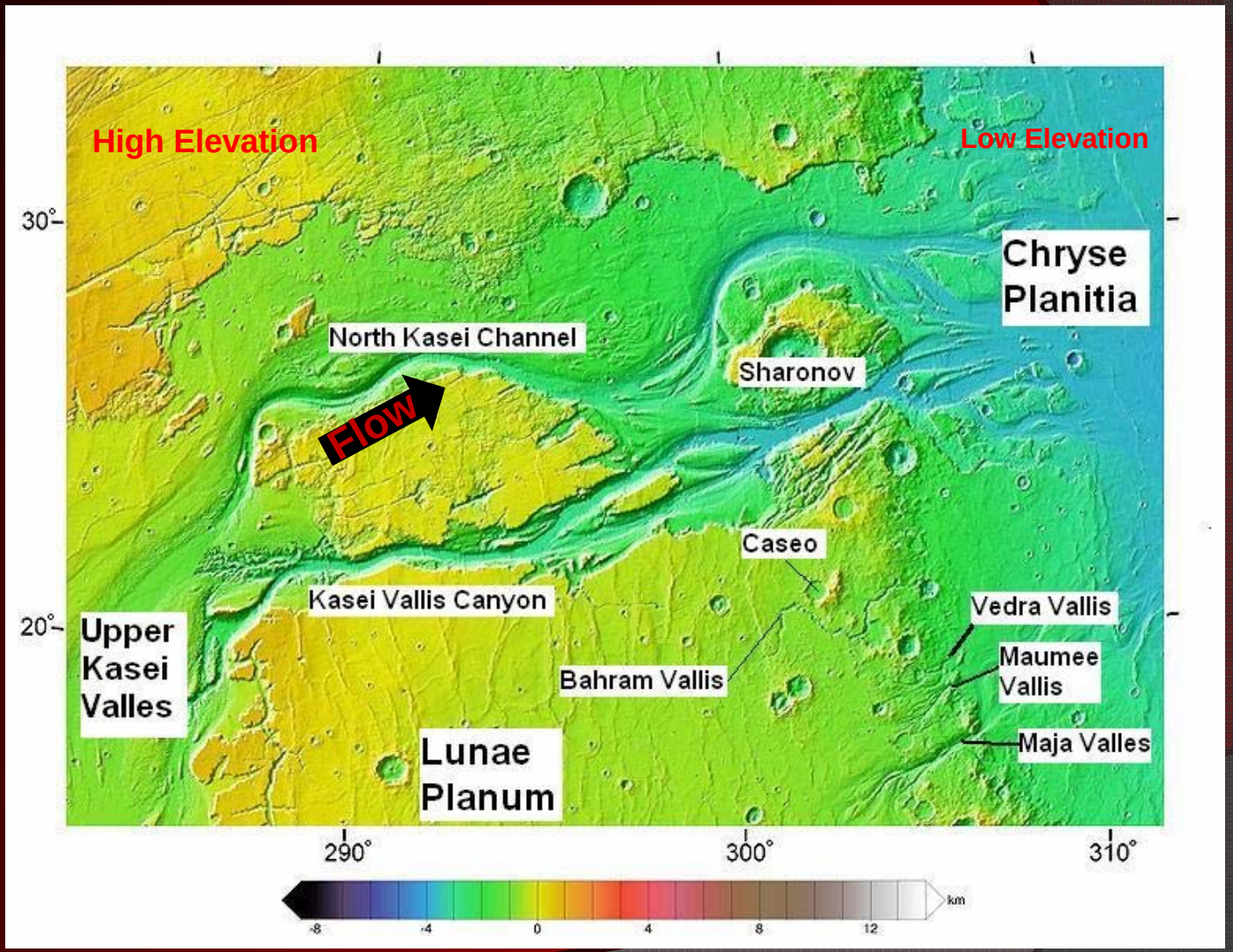

Image 1: http://en.wikipedia.org/wiki/File:Kasei_Valles_topolabled.JPG

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Missoula Floods c. 12,000 BCE

Both Missoula Flood and the Martian channels event are moving channels from high elevations to low elevations with relatively few tributaries being evidence of a catastrophic event rather than an established water system.

Slide By: Alex Mclane

Outflow Channels

- Similarities between Martian outflow channels and the Missoula floods include calculated similarities in channel slopes, velocities, and amount of discharge. Also the channels show anastomosing (or braided) appearance with teardrop islands, and long linear grooves (or ripple marks). Some Martian outflow channels also show a lack of pronounced meandering and few to any tributaries.

Information: http://history.nasa.gov/SP-441/p39.htm
Komar, Paul. (1979) "Comparisons of the Hydroulics of Water Flows in Martian Outflow Channels with Flows of Similar Scale on Earth" *Icarus* 37, 156-181

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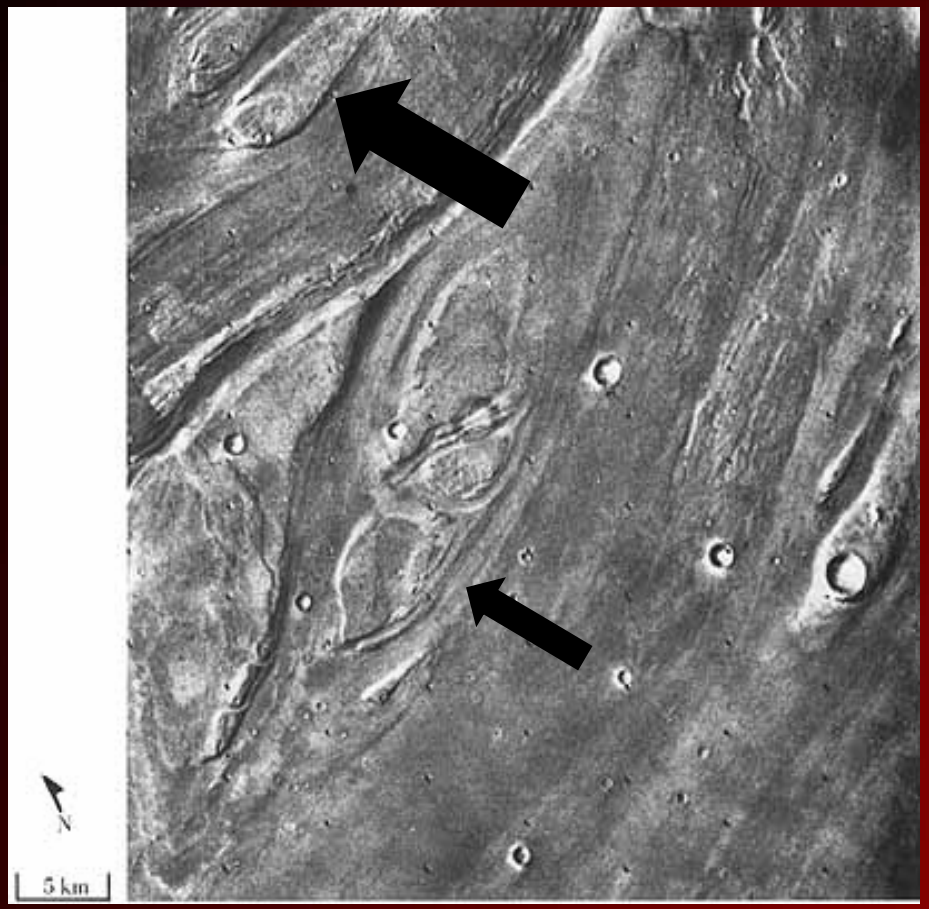
Teardrop Islands



Long Linear Grooves

Image 1 and 2: http://history.nasa.gov/SP-441/p39.htm

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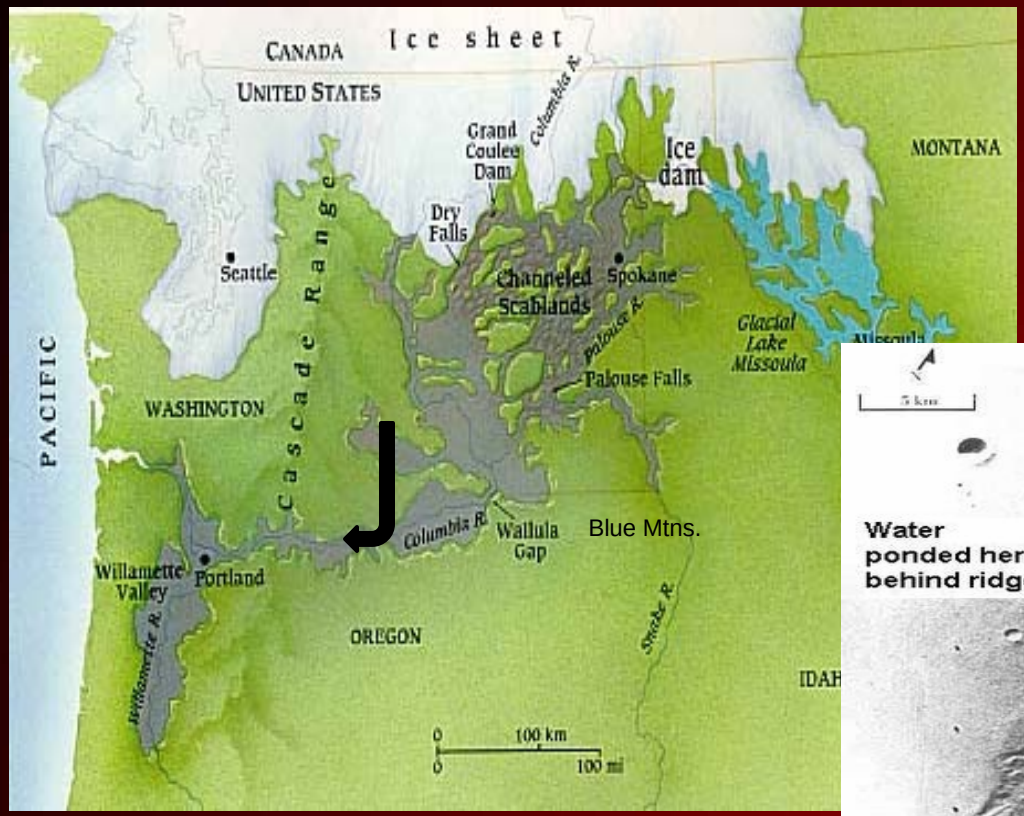
Outflow Channels

- **Evidence of water pooling from catastrophic floods and cutting water gaps as it flowed over low points of the obstructing ridges can be seen on both Earth and Mars. This is evident on Mars near the Dromore Crater of the Chryse Planitia where there appears to be outflow channels proceeding around Dromore Crater and then cutting across Mare Ridge. There is also evidence of this water behavior occurring during the Missoula Floods on Earth where the Glacial Lake Missoula waters pooled in the Scablands of Eastern Washington and proceeded around the Blue Mountains then cut a water gap through the Cascade Ridge.**

Information: Komar, Paul. (1979) "Comparisons of the Hydroulics of Water Flows in Martian Outflow Channels with Flows of Similar Scale on Earth" *Icarus* 37, 156-181

Slide By: Alex Mclane

Missoula Floods



Mars

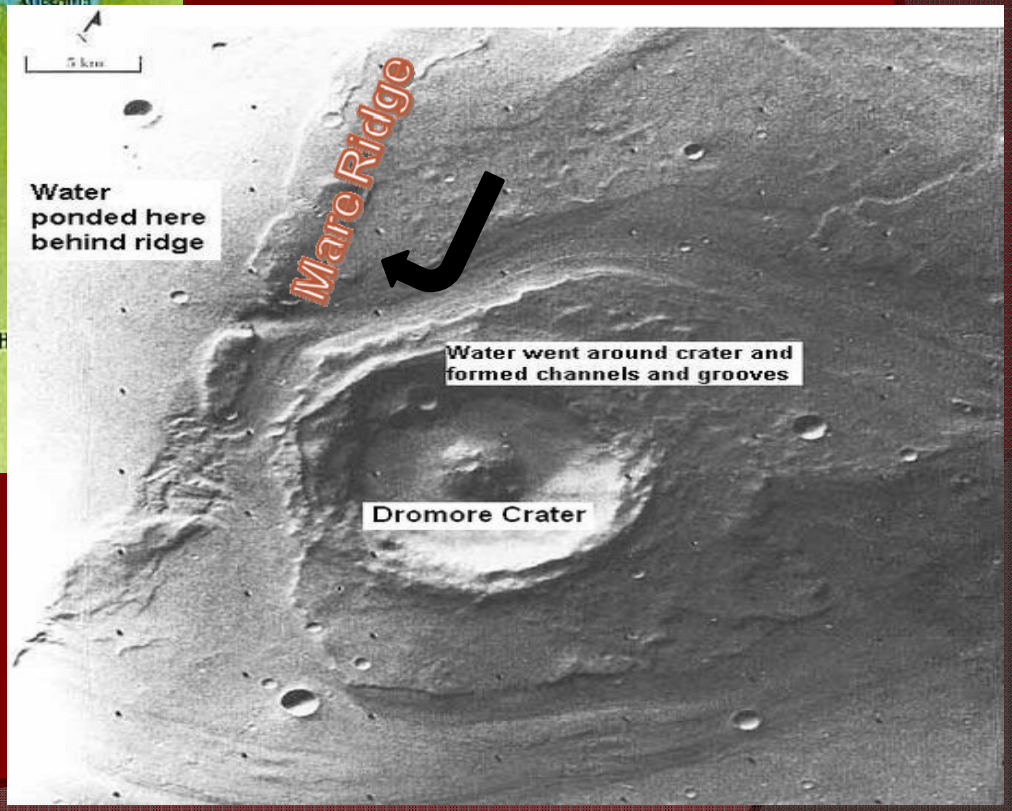


Image 1: **http://www.nwcreation.net/articles/missoulaflood.htm**
Image 2: **http://history.nasa.gov/SP-441/p41.htm**

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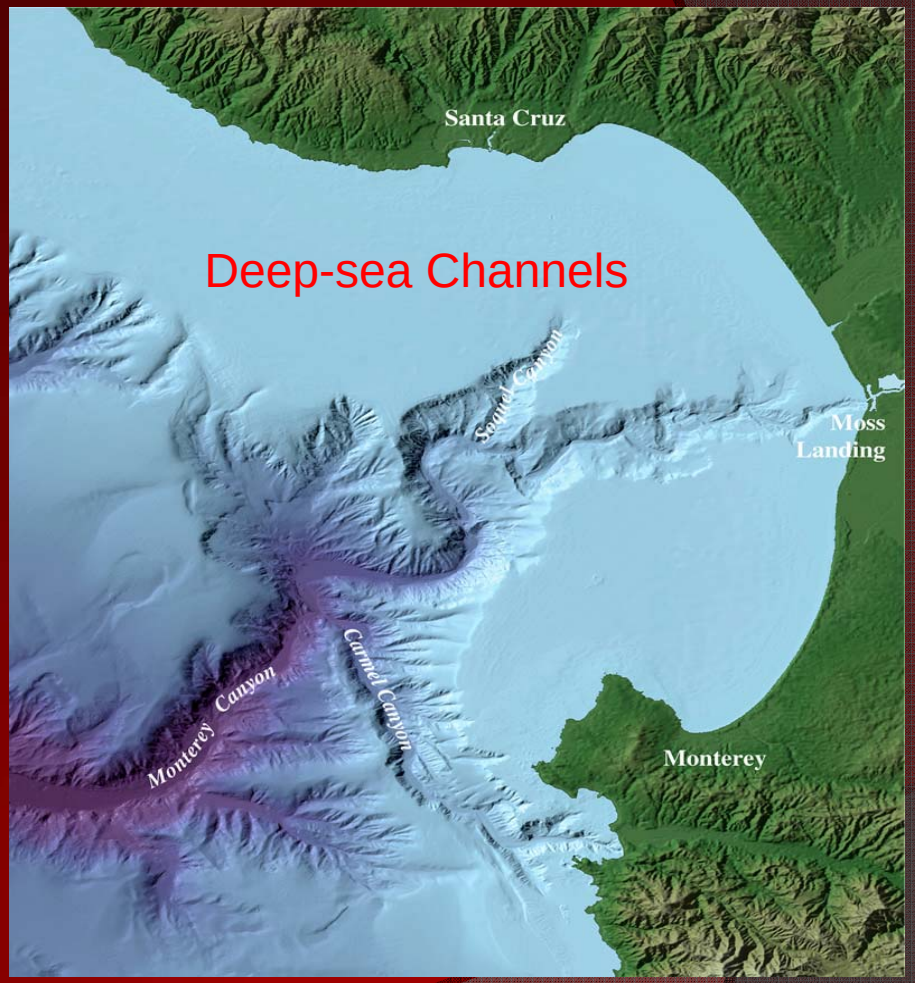
Other Possibilities for Outflow Channels

If the atmospheric and planetary conditions were much different than they are today, which is hypothesized because of the amount of degassing occurring on Mars than models such as deep-sea channels formed by catastrophic turbidity currents can be possible. Estimates of the quantity of water once available might have reached high enough to cover the planet 9 meters thick of water. In this scenario both the Martian outflow channels and deep-sea channels on Earth have one pronounced channel, a lack numerous tributaries, and have little flow meandering. Calculated dimensions of bottom slope, velocity, and discharge are similar between the two as well.

The benefit of looking at deep-sea channels is that they have a gravity field different than terrestrial events on the earth surface. The effective gravity on Mars would be somewhere in between an Earth terrestrial environment and deep-sea channels in the Earth's oceans.

Nearly all the deep-sea channels on Earth originate from submarine canyons at the edges of the continental shelves. Martian outflow channels also have a single source in chaotic terrain.

A problem with deep-sea turbidity currents is that they have only been shown to transport cobbles. At those depths in the oceanic environment there is rarely any larger material available for transport in the currents. On the contrary large blocks of rock which were shown to be transported by the Lake Missoula floods and have been calculated to be transported by Martian channelized flows as well.



Monterey Canyon in the Pacific Ocean off of California has no associated river attached to the channel an example of a submarine channel.

Image 1: http://mbari2010interns.wordpress.com/about/

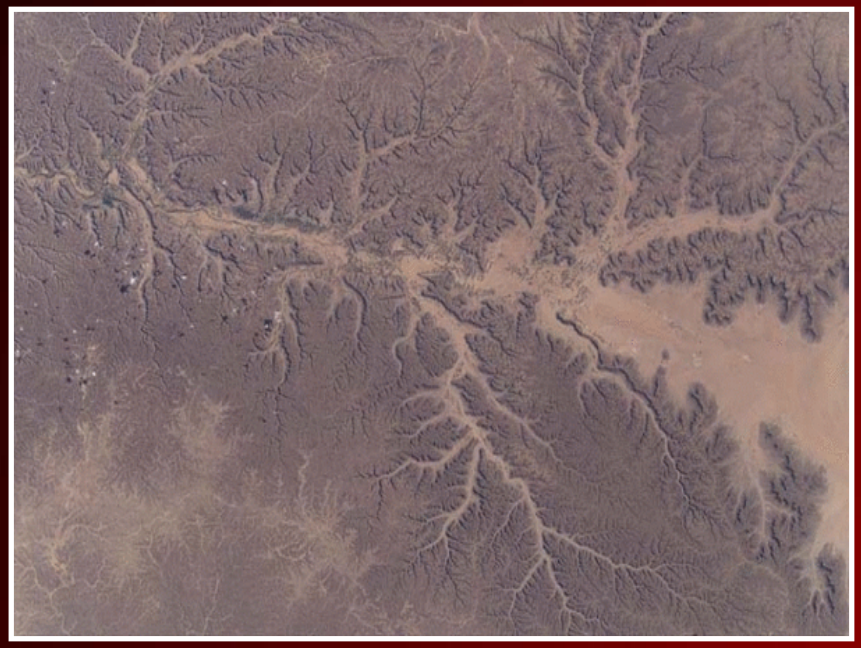
Information: Komar, Paul. (1979) "Comparisons of the Hydroulics of Water Flows in Martian Outflow Channels with Flows of Similar Scale on Earth" *Icarus* 37, 174

Slide By: Alex Mclane

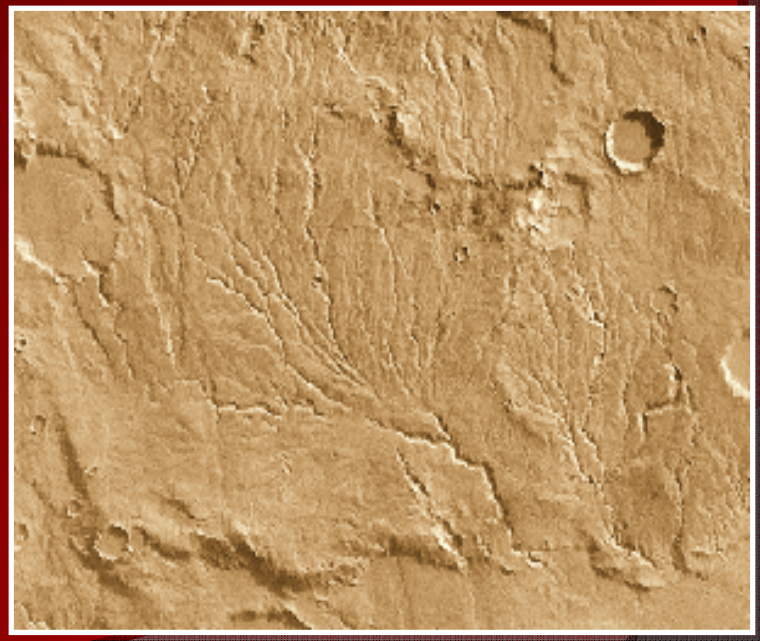
Valley Networks and Dendritic Patterns

(Comparison of Earth and Mars)

Fossil dendritic drainage pattern
in the Republic of South Yemen



Drainage patterns on Mars



Images and Information: http://europlanet.dlr.de/node/index.php?id=124

Slide By: Justin Harris

Channels and Valley Networks

Both Mars and Earth have valley networks. They are one of the oldest channels on Mars. They are thought to be carved by liquid water and are said to be around 3.8 billion years old or older. The branching patterns are similar to river systems on earth and many scientists believe that the valleys formed along ancient systems of Martian rivers.

Image and Information: http://crism.jhuapl.edu/science/marsGeo.php#Channels

Slide By: Justin Harris

Dendritic Patterns

These are the patterns formed by streams, rivers, and lakes in a basin.

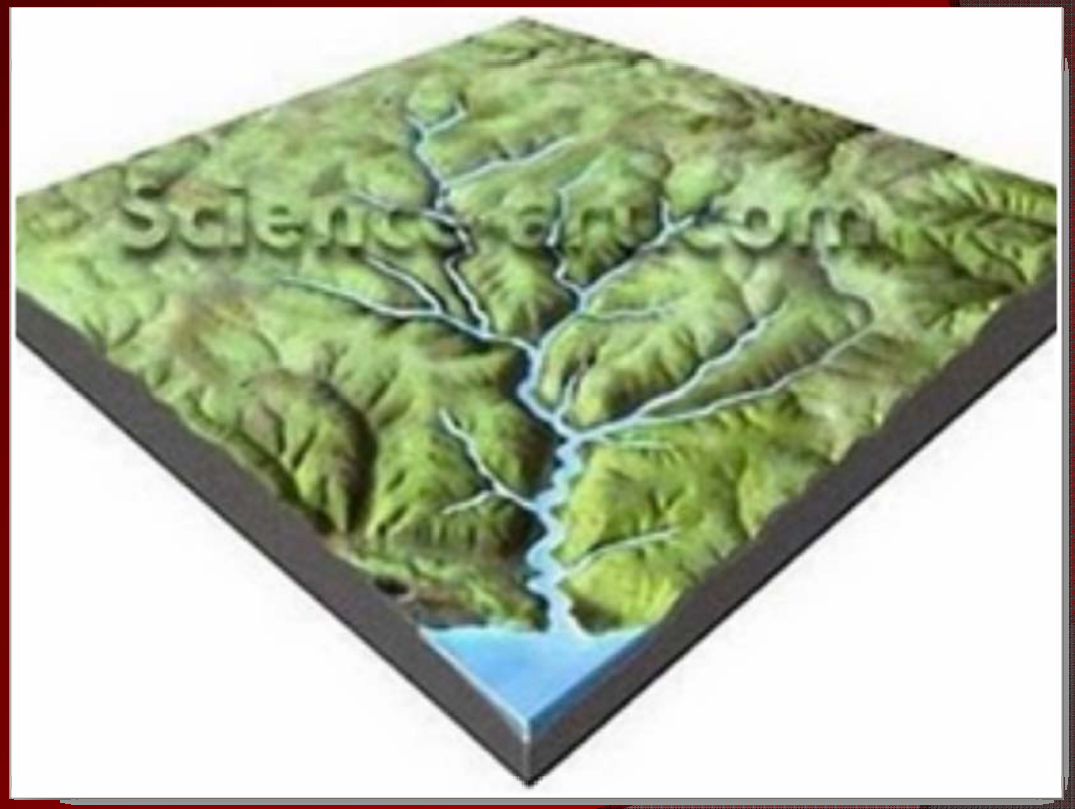
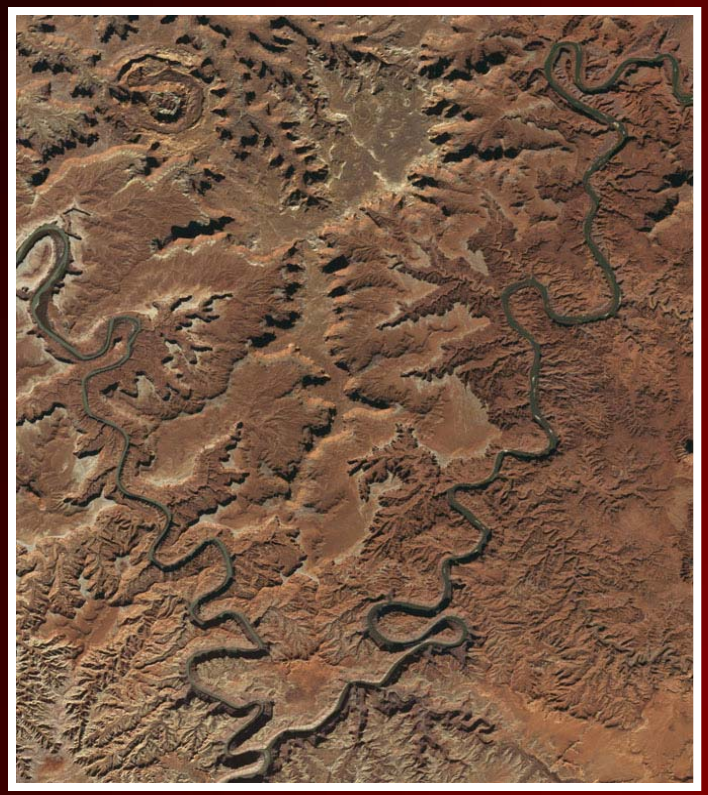


Image 1: http://brhectorsgeoworld.blogspot.com/2009_06_01_archive.html

Slide By: Justin Harris

River Valleys of Earth Compared to the Ancient Valleys of Mars

Colorado and Green Rivers, Utah



Large channels Kasei Valleys, Mars

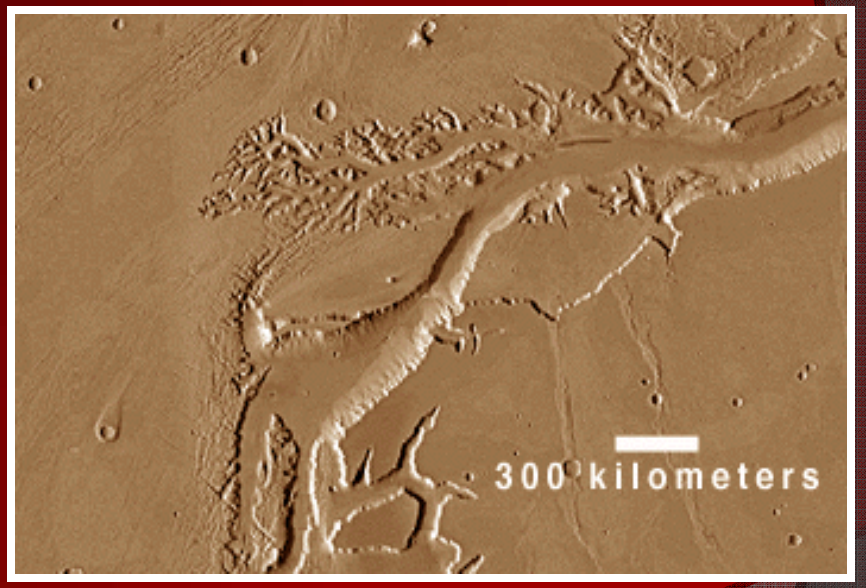


Image 1: http://www.wired.com/wiredscience/2010/03/gallery-rivers/7/
Image 2: http://www.psrd.hawaii.edu/Oct96/AncientMars.html

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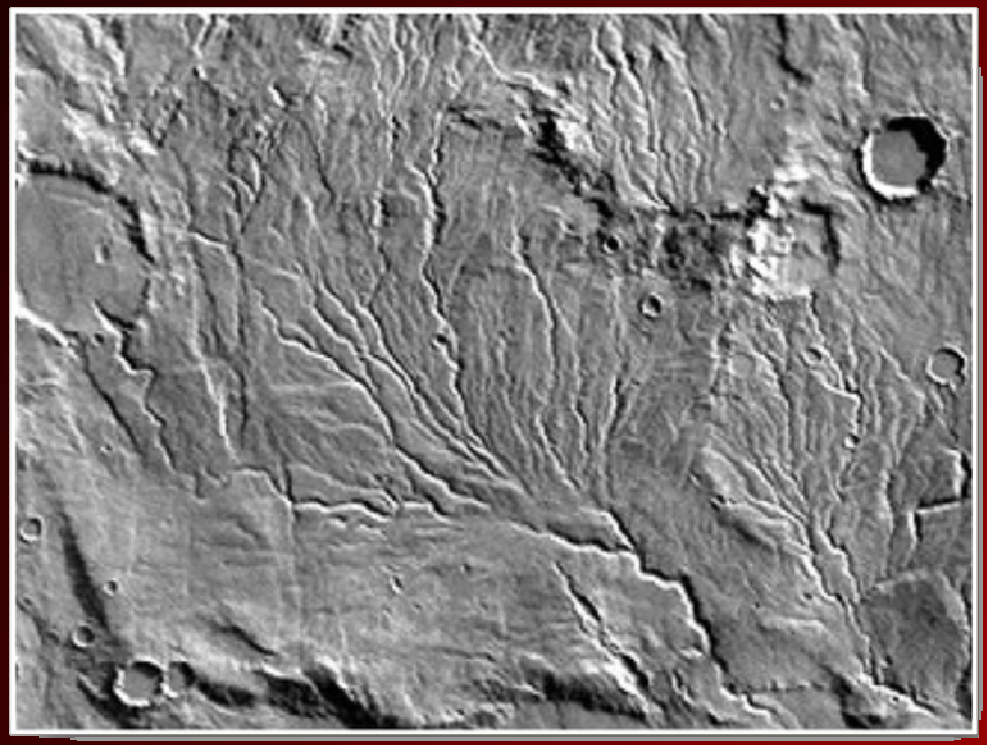
Southern Highlands of Mars dendritic patterns



Streams erode the edges of some of the older, larger craters. These are similar dendritic patterns to earth. This is a major indicator of flow water

Image and Information: http://www.lpi.usra.edu/education/explore/mars/background/

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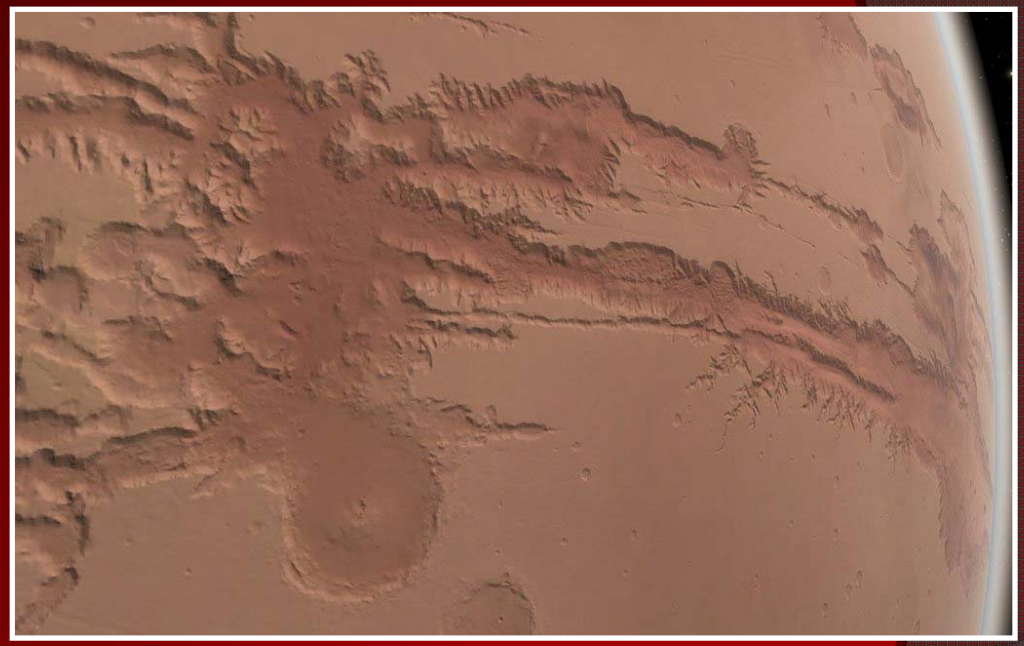
Valles Marineris

The Valles Marineris is a large rift system that is more than 4000km long, 200km wide, and 7km deep. It is the largest canyon in the solar system. Valles Marineris is a large crack in the Martian crust but certain areas on the eastern flank indicate some channels may have been formed by flowing water. Dendritic patterns can be seen on the plateau and canyon edges and were identified by thermal images. Their geomorphic characteristics and high degree of branching indicate atmospheric precipitation. The branched networks lead some to believe that fluid flows over long geological periods occurred some 2.9 to 3.4 billion years ago.



Information: http://en.wikipedia.org/wiki/Valles_Marineris
Image 1: http://fisica.cab.cnea.gov.ar/estadistica/abramson/celestia/gallery/slides/Valles%20Marineris.html

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Newton Valley System

This image is from the Mars Global Surveyor Mars Orbiter Camera. It is of a valley found in the Newton Crater. This valley could have been formed by liquid water.

Image and Information: http://www.spaceref.com/news/viewsr.html?pid=9742

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Reull Vallis of the Hellas Basin

Mars express recorded this photo of a 62 mile wide swath that may have been carved by flowing water.

Image and Information: http://www.spacetoday.org/SolSys/Mars/MarsThePlanet/MarsWater.html

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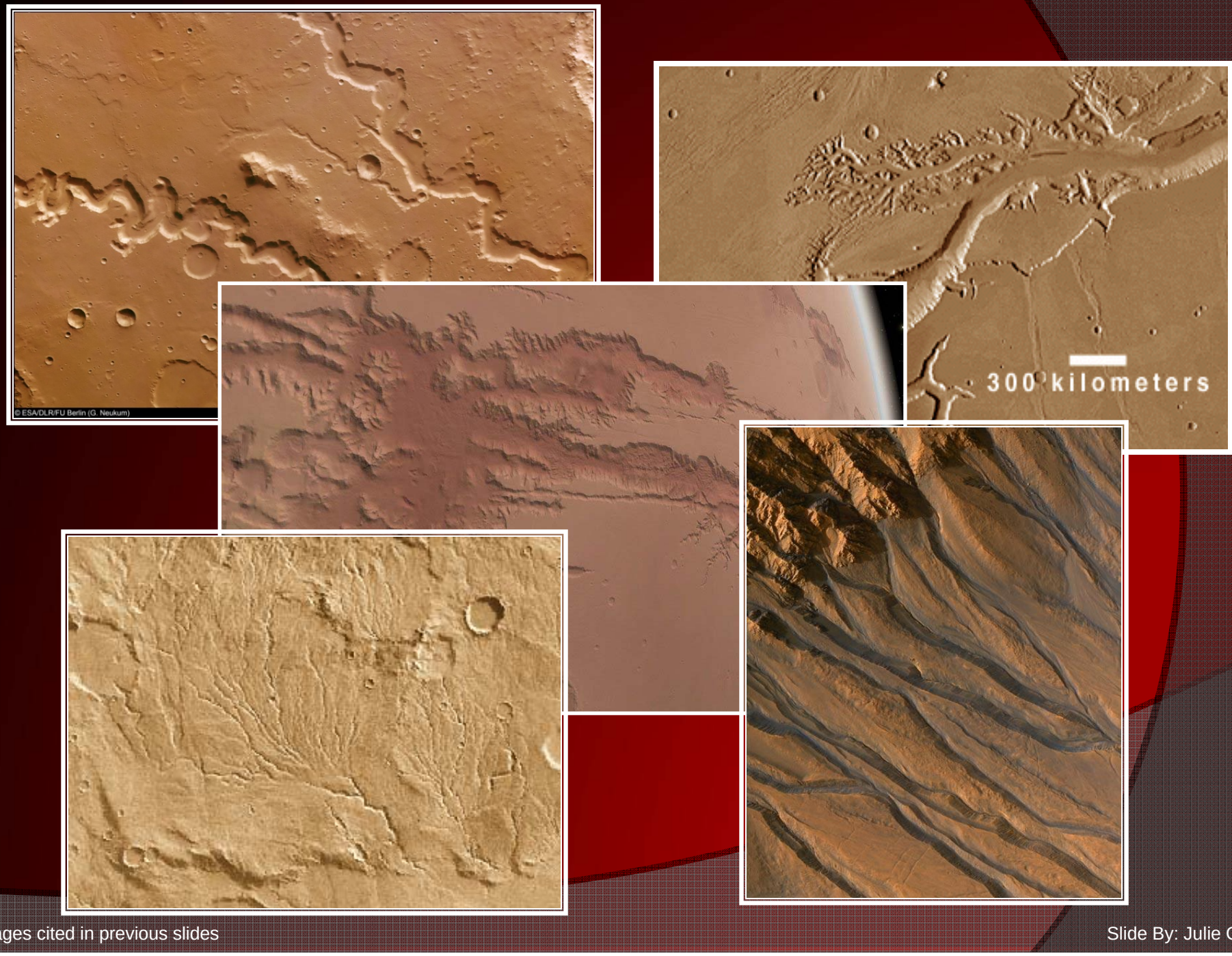

Images cited in previous slides

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Conclusion

- In Mars 4 Billion year history it had been warmer and wetter then it is today.
- A great deal of evidence for water on Mars has been found
- Three geomorphic features explained above (valleys, channels and gullies) provided for a reasonably direct attribution of the cause of erosion due to water on Mars.

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Thank You

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