EXPLORATION OF MARS VIA UNMANNED SPACECRAFT

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BACKGROUND

Past

- Mariner 3 & 4
- Mariner 6 & 7
- Mariner 8 & 9
- Viking 1 & 2
- Mars Observer
- Mars Global Surveyor
- Phoenix
- Mars Polar Lander/Deep Space 2
- Mars

Present

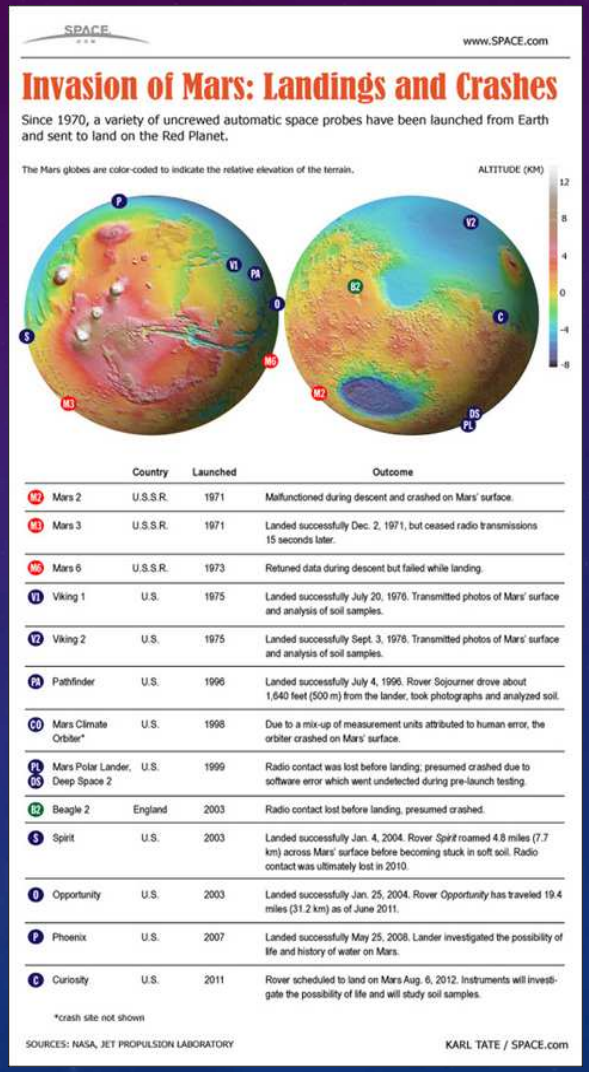
- Mars Odyssey
- Spirit and Opportunity
- Mars Express
- Mars Reconnaissance Orbiter
- Mars Science Laboratory
- MAVEN

Future

- ExoMars/Trace Gas Orbiter
- Mars 2018 Mission
- 2020 Mission Plans
- NASA In 2016 ExoMars Orbiter
- NASA In 2018 ExoMars Rover
- Insight

MISSION TYPES

- Orbiters
- Landers
- Rovers
- Airplanes
- Balloons
- Subsurface Explorers
- Sample Returns



SPACE.com www.SPACE.com

Invasion of Mars: Landings and Crashes

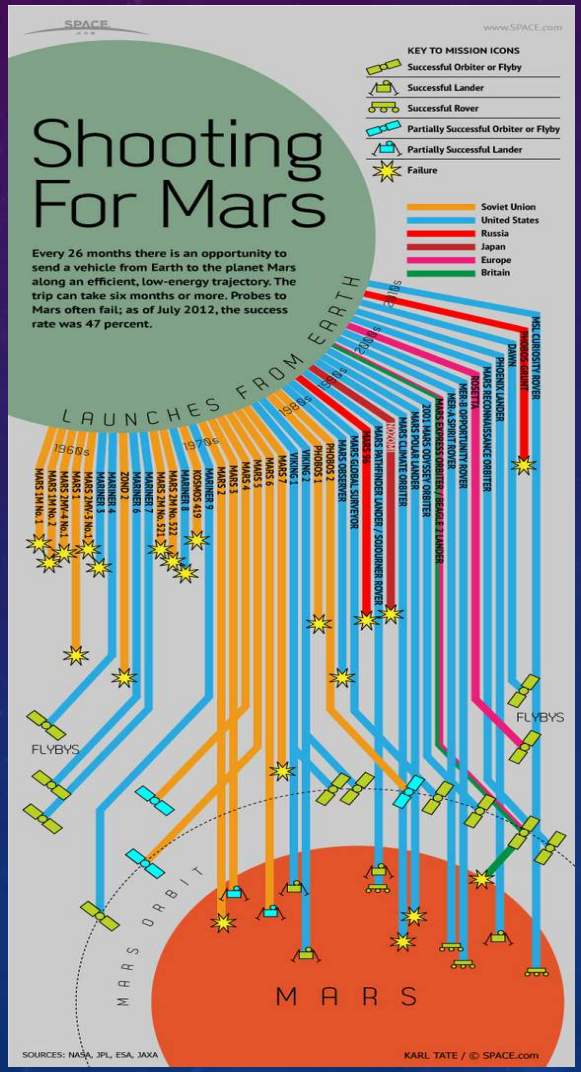
Since 1970, a variety of uncrewed automatic space probes have been launched from Earth and sent to land on the Red Planet.

The Mars globes are color-coded to indicate the relative elevation of the terrain. ALTITUDE (KM) 12 8 4 0 -4 -8

	Country	Launched	Outcome
M2 Mars 2	U.S.S.R.	1971	Malfunctioned during descent and crashed on Mars' surface.
M3 Mars 3	U.S.S.R.	1971	Landed successfully Dec. 2, 1971, but ceased radio transmissions 15 seconds later.
M6 Mars 6	U.S.S.R.	1973	Returned data during descent but failed while landing.
V1 Viking 1	U.S.	1975	Landed successfully July 20, 1976. Transmitted photos of Mars' surface and analysis of soil samples.
V2 Viking 2	U.S.	1975	Landed successfully Sept. 3, 1976. Transmitted photos of Mars' surface and analysis of soil samples.
PA Pathfinder	U.S.	1996	Landed successfully July 4, 1996. Rover Sojourner drove about 1,640 feet (500 m) from the lander, took photographs and analyzed soil.
CO Mars Climate Orbiter*	U.S.	1998	Due to a mix-up of measurement units attributed to human error, the orbiter crashed on Mars' surface.
PL Mars Polar Lander, DS Deep Space 2	U.S.	1999	Radio contact was lost before landing; presumed crashed due to software error which went undetected during pre-launch testing.
B2 Beagle 2	England	2003	Radio contact lost before landing, presumed crashed.
S Spirit	U.S.	2003	Landed successfully Jan. 4, 2004. Rover *Spirit* roamed 4.8 miles (7.7 km) across Mars' surface before becoming stuck in soft soil. Radio contact was ultimately lost in 2010.
O Opportunity	U.S.	2003	Landed successfully Jan. 25, 2004. Rover *Opportunity* has traveled 19.4 miles (31.2 km) as of June 2011.
P Phoenix	U.S.	2007	Landed successfully May 25, 2008. Lander investigated the possibility of life and history of water on Mars.
C Curiosity	U.S.	2011	Rover scheduled to land on Mars Aug. 6, 2012. Instruments will investigate the possibility of life and will study soil samples.

*crash site not shown

SOURCES: NASA, JET PROPULSION LABORATORY KARL TATE / SPACE.com



MAVEN

Launch: Nov. 18, 2013, 10:28 a.m. PST (1:28 p.m. EST)
Launch Window: Nov. 18-Dec. 7, 2013

MAVEN (Mars Atmospheric and Volatile EvolutioN) is the second mission selected for NASA's Mars Scout program, an initiative for measurements of the Martian atmosphere to help understand dramatic climate change on the red planet over its history

MAVEN will provide information on how and how fast atmospheric gases are being lost to space today, and infer from those detailed studies what happened in the past. Studying how the Martian atmosphere was lost to space can reveal clues about the impact that change had on the martian climate, geologic, and geochemical conditions over time, all of which are important in understanding whether Mars had an environment able to support life

Mars Orbit Insertion: Sept. 21, 2014, 7:24 p.m. PDT (10:24 p.m. EDT)

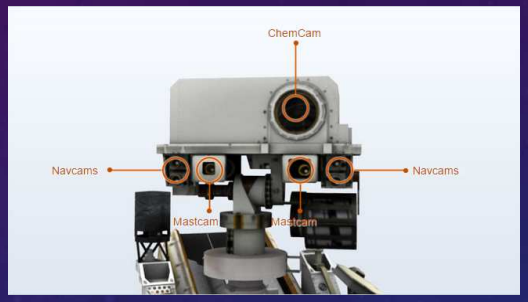
CURIOSITY

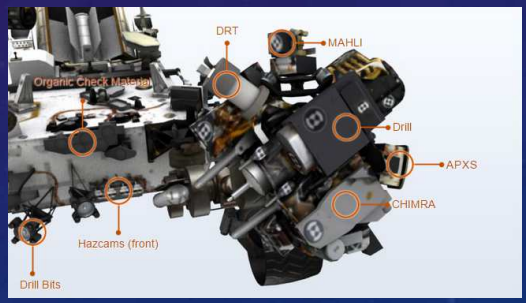
Curiosity was designed to assess whether Mars ever had an environment able to support small life forms called microbes. In other words, its mission is to determine the planet's "habitability."

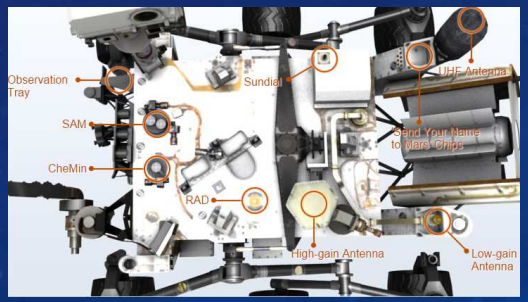
The rover carries the biggest, most advanced suite of instruments for scientific studies ever sent to the Martian surface

The rover will be able to roll over obstacles up to 75 centimeters (29 inches) high and travel up to 90 meters (295 feet) per hour. On average, the rover is expected to travel about 30 meters (98 feet) per hour, based on power levels, slippage, steepness of the terrain, visibility, and other variables.

Mission name: Mars Science Laboratory
Rover name: Curiosity rover
Size: About the size of a small SUV -- 10 feet long
(not including the arm), 9 feet wide and 7 feet tall
(about 3 meters long (not including the arm), 2.7 meters wide,
and 2.2 meters tall), or about the height of a basketball player.
Arm Reach: About 7 feet (2.2 meters)
Weight: 900 kilograms (2,000 pounds)
Features: Geology lab, rocker-bogie suspension,
rock-vaporizing laser and lots of cameras



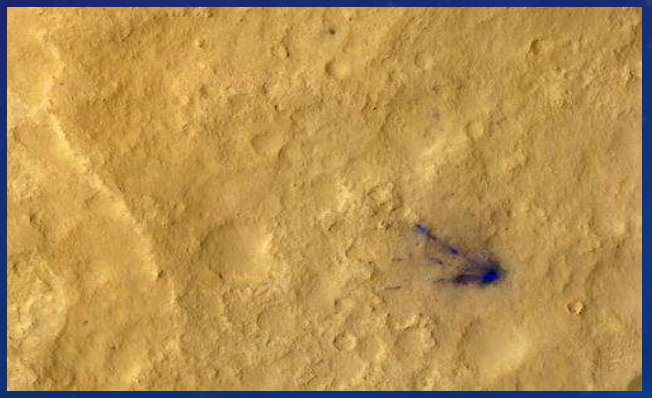




CURIOSITY

In a maneuver that had never been tried before on another planet, a rocket-powered sky crane lowered Curiosity to the Martian surface on cables, then flew off and crash-landed intentionally a safe distance away. NASA officials say this technique should help land other big payloads in the future, helping pave the way for human outposts on the Red Planet.

Curiosity also landed with unprecedented precision, thanks to a new guided entry system that will aid future missions as well. The rover touched down within a target ellipse that measured just 12 miles long by 4 miles wide (20 by 7 kilometers) — a huge improvement from the 2004 landing of NASA's twin Spirit and Opportunity rovers, whose ellipses spanned 93 miles by 12 miles (150 by 20 km).



FINDINGS

- Tilt of Mars Rotation Axis
  - Climate change
    - Orbital Eccentricity varies between 1.36 - 1.64 AU over a year
  - Ice age
  - Ice migration at various changes of tilt
  - Atmosphere/Magnetosphere
  - Pressure Variation at various changes of tilt
  - Rock Layering possible correlation

- Water
  - Ancient Lakes/Rivers
  - Polar ice caps hold water ice too as much as Lake Ontario

TILT OF MARS ROTATION AXIS

- Tilt of Mars Rotation Axis
  - 0° - 60° over just a few million years
    - High tilt angle = Polar ice caps melt
    - Low tilt angle = Atmosphere may freeze
  - Earths Large moon keeps this extreme tilt fluctuations from occurring

- Climate change
  - Ice age
  - Ice migration at various changes of tilt
  - Atmosphere/Magnetosphere
  - Pressure Variation at various changes of tilt
  - Rock Layering possible correlation

TILT OF MARS ROTATION AXIS

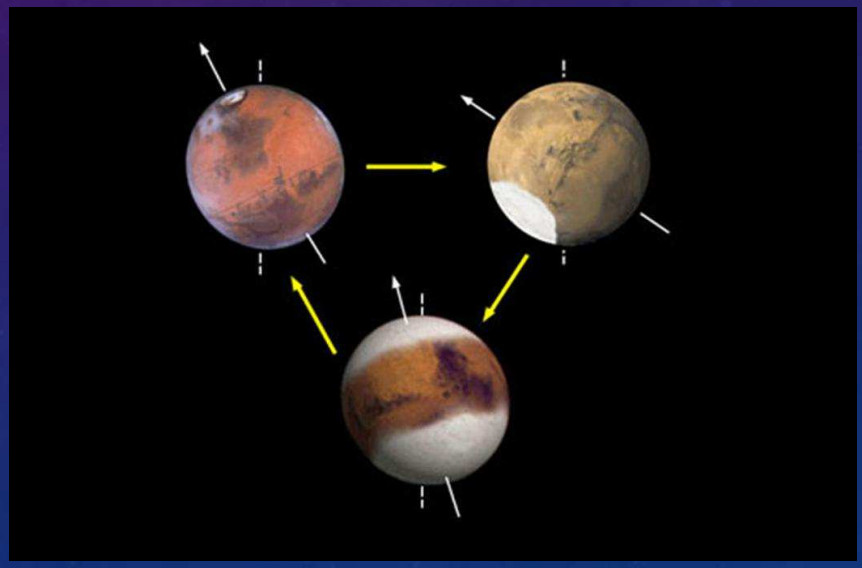
- Ice Age
  - NASA's Mars Global Surveyor and Mars Odyssey missions have provided evidence of a relatively recent ice age on Mars
  - Martian ice age waxes when the poles warm, and water vapor is transported toward lower latitudes
  - Martian ice ages wane when the poles cool and lock water into polar icecaps
  - Estimated the most recent ice age occurred just 400 thousand to 2.1 million years ago
  - During a Martian ice age:
    - polar warming drives water vapor from polar ice into the atmosphere
    - The water comes back to ground at lower latitudes as deposits of frost or snow mixed generously with dust
    - This ice-rich mantle, a few meters thick, smoothes the contours of the land
    - When ice at the top of the mantling layer sublimes back into the atmosphere, it leaves behind dust which forms an insulating layer over remaining ice

TILT OF MARS ROTATION AXIS

- Climate change
  - Rotation Axis Tilt Variation 0° - 60°
  - Rotation speed is largest at aphelion (1.64 AU) and smallest (1.36 AU) at perihelion
    - Causes Variance in seasonal durations

TILT OF MARS ROTATION AXIS

- Ice migration at various changes of tilt
  - Very Low Obliquities 0° - 20° = poles grow larger at (BOTTOM)
  - Average Obliquities 25° (present) = ice is present in relatively modest quantities at the north and south poles (TOP LEFT)
  - High Obliquities 30° - 60° = This schematic shows that ice builds up near the equator at (TOP RIGHT)



TILT OF MARS ROTATION AXIS

- Atmosphere
  - The thin atmosphere on Mars does not allow liquid water to exist at the surface for long
  - Thin atmosphere provides not protection to cosmic radiation and isn't thick enough to hold in the gasses which are necessary to support life although there is evidence that they were present in the past
  - Composed of 95% Carbon Dioxide
  - Water on surface as well as in the atmosphere would have been absorbed by the Carbon Dioxide forming Carbonate Rocks
  - Atmosphere must be dense to have a Greenhouse effect which has any influence on the equilibrium temp of Mars
  - **Greenhouse effect dimished + Equillibrium temp dropped + Remaining water froze = Uninhabitable Mars**

TILT OF MARS ROTATION AXIS

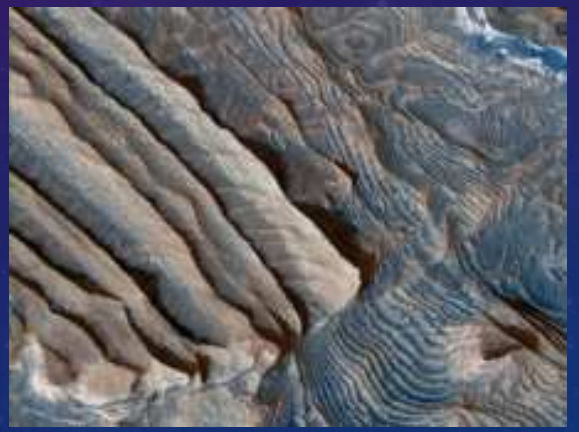
- Magnetosphere
  - Evidence collected by the Mars Global Surveyor (MGS) indicates that the planet may have once had a global magnetic field
    - Generated by an internal dynamo which faded over time
  - The planet's magnetic field reversed direction, or flipped, several times in its early days as conditions in the mantle and core of the planet changed
  - Scientists continue to explore these processes on Mars and how they relate to magnetic processes on Earth
  - Earth's magnetic field is:
    - Clearly identifiable field lines
    - Magnetic lines of force that define an intangible bubble of electromagnetic energy around the planet
  - The magnetic signature that defines the field around Earth acts like a protective shield from harmful solar and cosmic radiation
  - NASA's Mars Global Surveyor orbiter found that areas of the Martian crust in the southern hemisphere are highly magnetized, indicating traces of a magnetic field from 4 billion years ago that remain

TILT OF MARS ROTATION AXIS

- Pressure Variation
  - Seasons change roughly every seven months:
    - Spring beginning around the end of May
    - Summer beginning around the middle of December
    - Fall beginning in June
    - Winter beginning in November
  - Summer
    - During winter the global atmospheric pressure on Mars is 25% lower than during summer.
      - This happens because of the eccentricity of Mars's orbit and a complex exchange of carbon dioxide between the Martian dry-ice polar caps and its CO2 atmosphere.
    - Around the winter solstice when the North Pole is tilted away from the Sun, the northern polar cap expands as carbon dioxide in the polar atmosphere freezes.
    - At the other end of the planet the southern polar cap melts, giving CO2 back to the atmosphere.
    - Process reverses half a year later at the summer solstice.
  - Winter
    - Mars is 10% closer to the Sun in winter than it is in summer.
    - At the time of the winter solstice the northern polar cap absorbs more CO2 than the southern polar cap absorbs half a year later.
      - The difference is so great that the Martian atmosphere is noticeably thinner during winter.

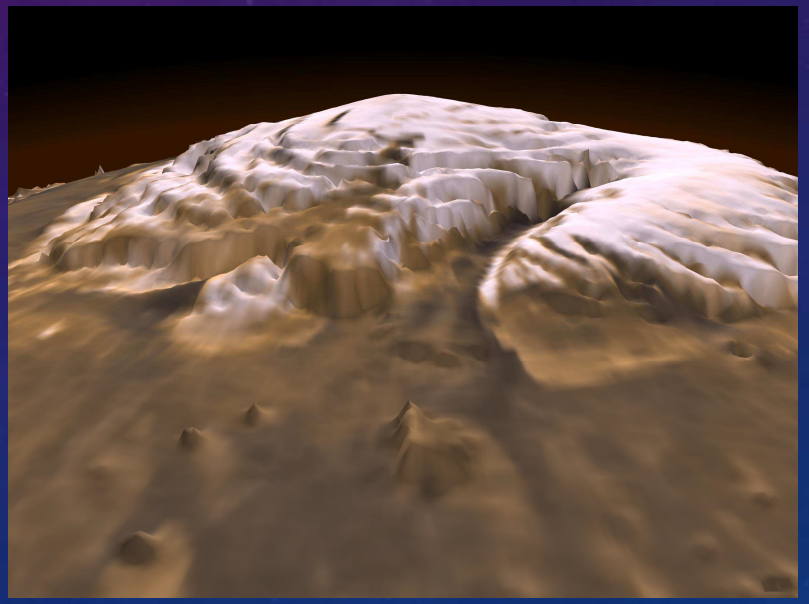
TILT OF MARS ROTATION AXIS

- Rock Layering
  - High Resolution Imaging Science Experiment camera
  - May rekindle debates about some patterns of rock layering on Earth.
  - Layers of similar thickness repeat dozens to hundreds of times in rocks exposed
  - Bundles of a 10-layer pattern repeat at least 10 times, which could correspond to a known 10-to-one pattern of changes in the tilt of the planet's rotation axis.



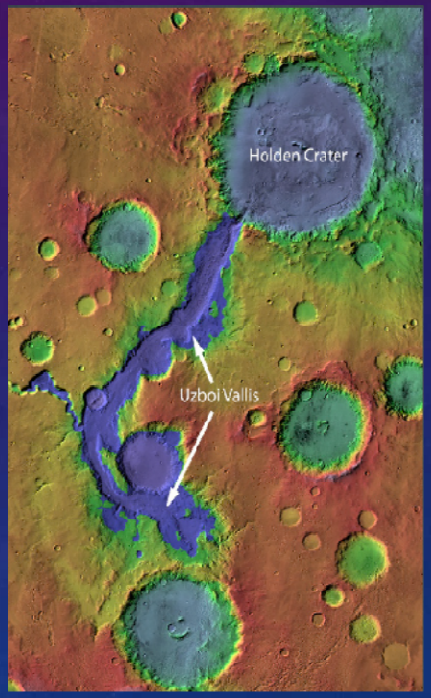
WATER

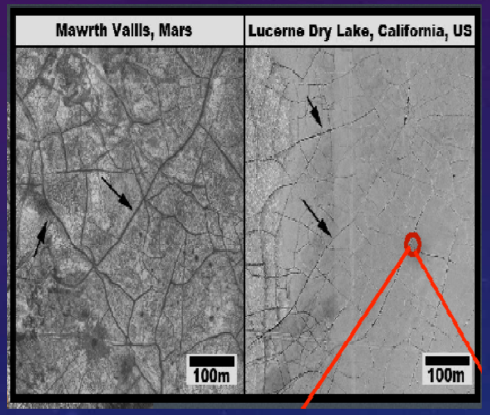
- Main Water Topics
  - Ancient Lakes/Rivers
  - Polar Ice Caps hold Water

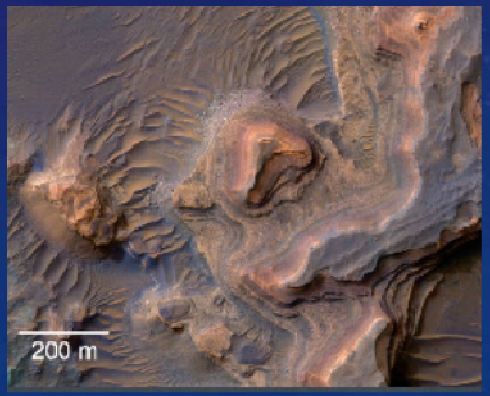


WATER

- Ancient Lakes/Rivers
  - Mud cracks
    - provide evidence of a past body of water
  - Origin and Flow
    - Formed by Craters impacts and other naturally occurring processes
    - River broke through the Holden crater wall and resultantly lowered the water level in the ancient river (evident from erosion layering)



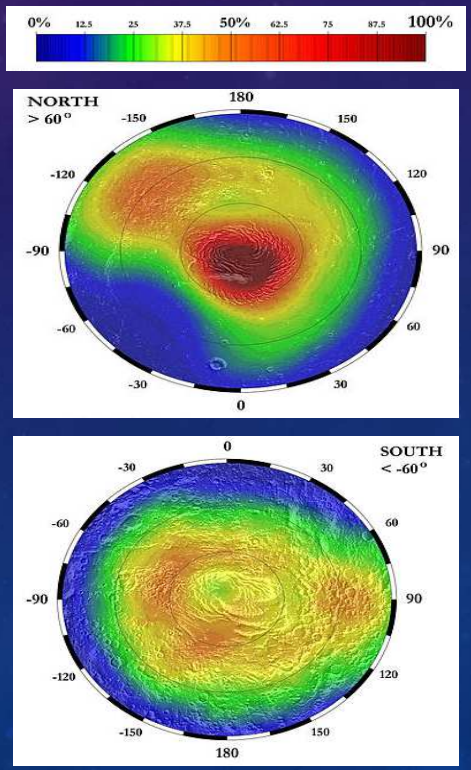




WATER

- Polar Ice Caps hold Water
  - Northern Ice Cap is mostly frozen water
  - Southern Ice Cap is frozen water and carbon dioxide
  - Northern Ice Cap extends over a sizeable portion of the planet's pole similar to Earths
    - Non-seasonally affected size is several times greater than Southern Ice Cap
  - Mars currently contains as much as water as Lake Ontario in the Northern Polar Ice Cap
  - Martian Summer causes Carbon Dioxide Ice to sublimate uncovering Water Ice
    - Warming of the poles and partial melting of water ice at high altitudes broadens the environments in which life might occur on Mars
- http://www.nasa.gov/mpeg/55074main_PolarCaps.mpeg (comparison)

Water Abundance



REFERENCES

- "HiRISE Onboard Reconnaissance." *HiRISE*. N.p., n.d. Web. 07 Dec. 2014. <http://www.uahirise.org/>.
- "HiRISE | Science Themes: Climate Change." *HiRISE | Science Themes: Climate Change*. N.p., n.d. Web. 10 Dec. 2014. <http://www.uahirise.org/science_themes/climate.php>.
- Dunbar, Brian. "Phoenix Site on Mars May Be in Dry Climate Cycle Phase."*NASA*. NASA, 15 Dec. 2008. Web. 10 Dec. 2014. <http://www.nasa.gov/mission_pages/phoenix/news/phoenix-20081215.html>.
- "NASA Mars Rovers Head for New Sites After Studying Layers." *JPL*. N.p., n.d. Web. 10 Dec. 2014. <http://www.jpl.nasa.gov/news/news.php?release=2006-054>.
- "NASA Orbiter Catches Mars Sand Dunes in Motion." *JPL*. N.p., n.d. Web. 10 Dec. 2014. <http://www.jpl.nasa.gov/news/news.php?release=2011-358>.
- Laskar et al., 2002; Head et al., 2003).

QUESTIONS

QUESTIONS

- Will humans ever have the ability to make Mars Habitable?
  - extract oxygen from the Red Planet's carbon-dioxide atmosphere
- Can we use the water on mars as a backup source if our fresh water supply runs out?
  - Northern and Southern Ice Caps are comprised of Fresh water ice, so I would assume yes if we found a way to do it
- Did mars ever have life?
  - Microbial show good evidence but out chemistry experiments being conducted aren’t conclusive enough yet to know