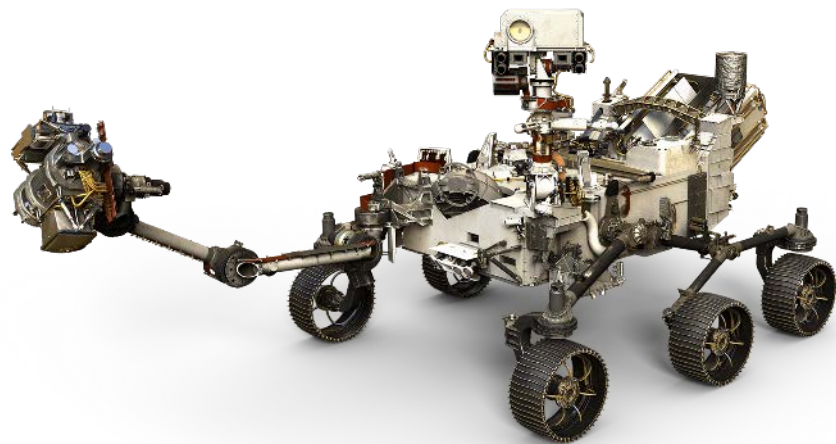


The science case for caching and returning samples from Jezero Crater, Mars

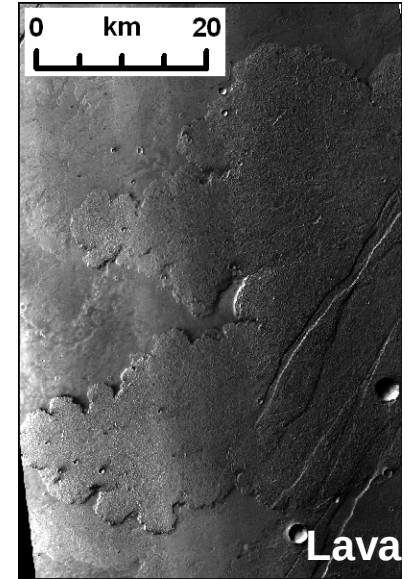
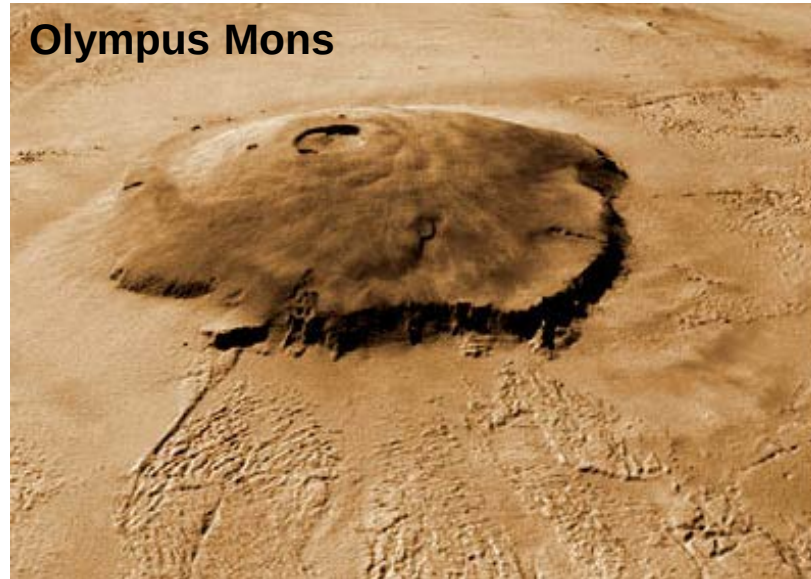
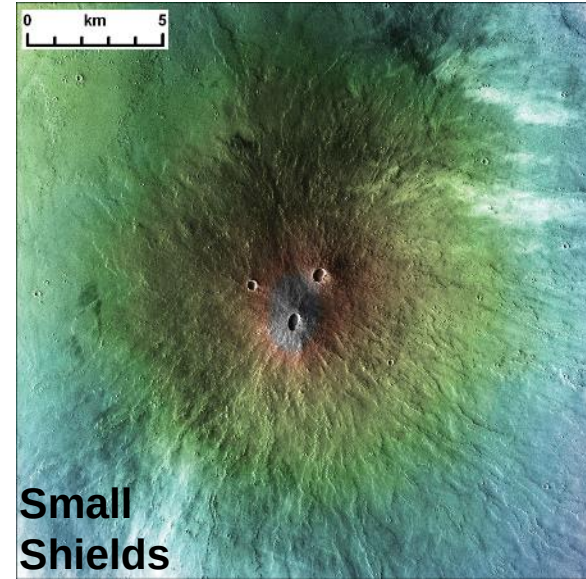
Caleb Fassett

National Aeronautics and
Space Administration



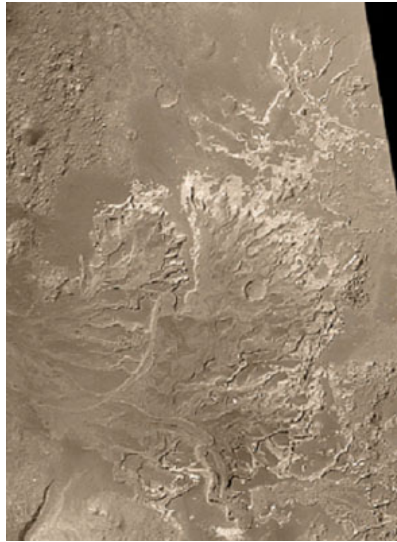
MARSHALL
SPACE FLIGHT CENTER

Mars: Volcanism



Mars Geology 101

Mars: Sedimentary Systems



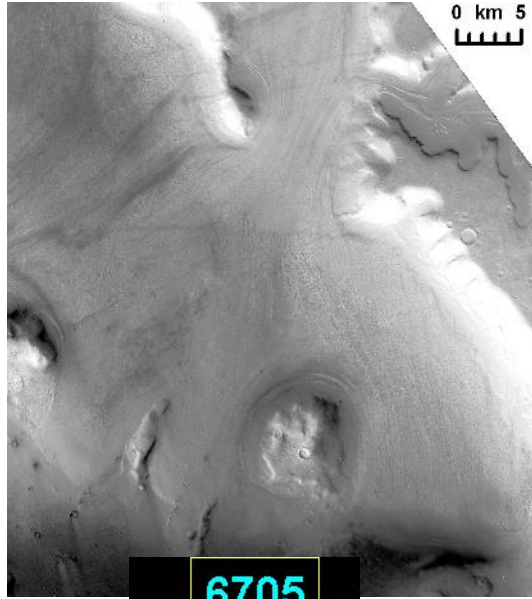
MGS / MOC Camera



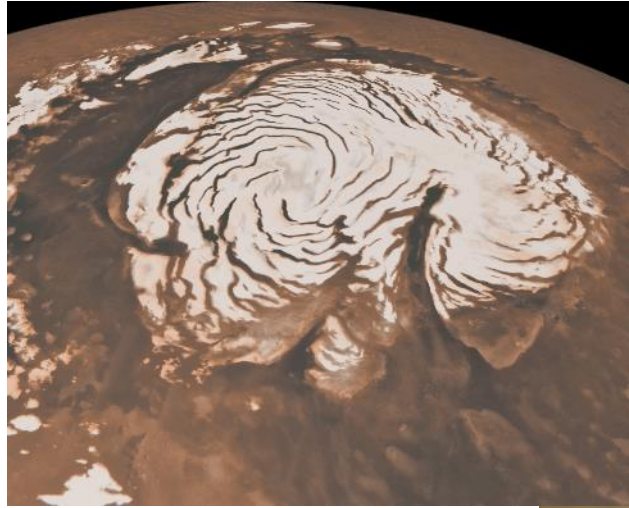
Mars Curiosity Rover

Mars Geology 101

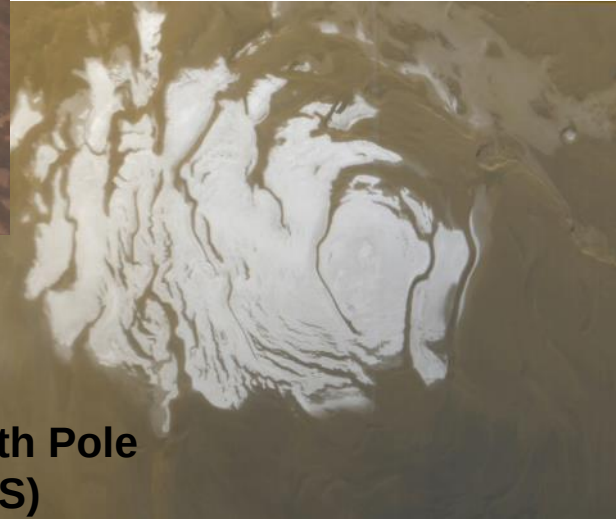
Mars: Ice and Glaciers



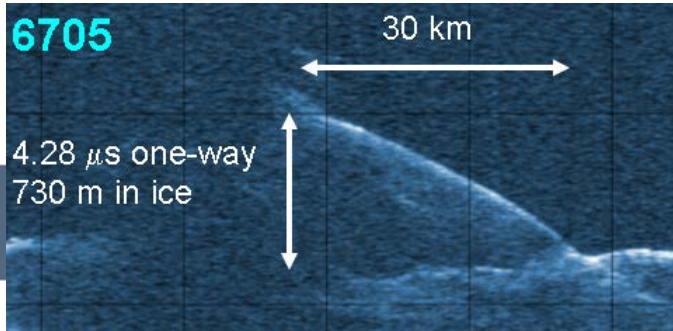
6705



North Pole
(MGS)



South Pole
(MGS)



Mars Geology 101

Mars: Wind and Weather



MER Spirit



**MER Opportunity
(Endurance Crater)**



**H₂O Clouds
MER Opportunity**

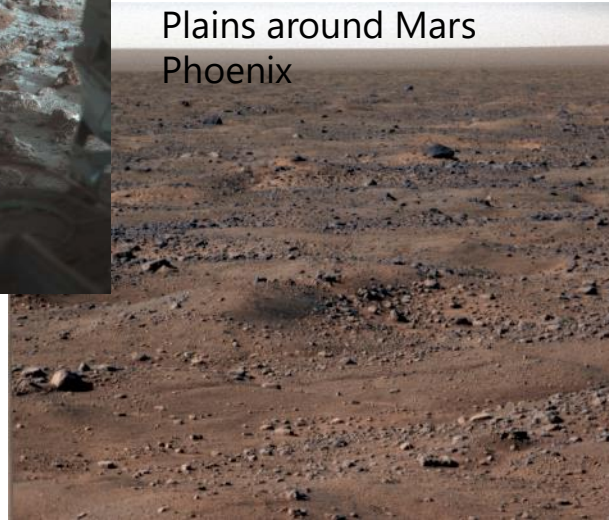


Mars Geology 101

Mars: Environment



H₂O Frost at Viking 2 Site



Plains around Mars Phoenix

- Atmospheric pressure is only 6 mbars, mostly CO₂
- Avg <10 precipitable microns of H₂O in atmosphere
- Avg T=210 K at equator
 - Very large variation: peak daytime, summer temperatures are ~300 K
 - Winter/polar temperatures are pinned at ~145 K: CO₂ frost point

Mars Geology 101

Quick Aside: Mars Meteorites



- Mostly young, volcanic rocks from *unknown* locations.
- Context is important!
- Impacts are a biased delivery mechanism.

Why do we want to return samples?

Objectives	
1	<i>Geological environments</i>
2	<i>Life</i>
3	<i>Geochronology</i>
4	<i>Water</i>
5	<i>Planetary-scale geology</i>
6	<i>Environmental hazards</i>
7	<i>ISRU</i>



Artist's concept of modern / early Mars

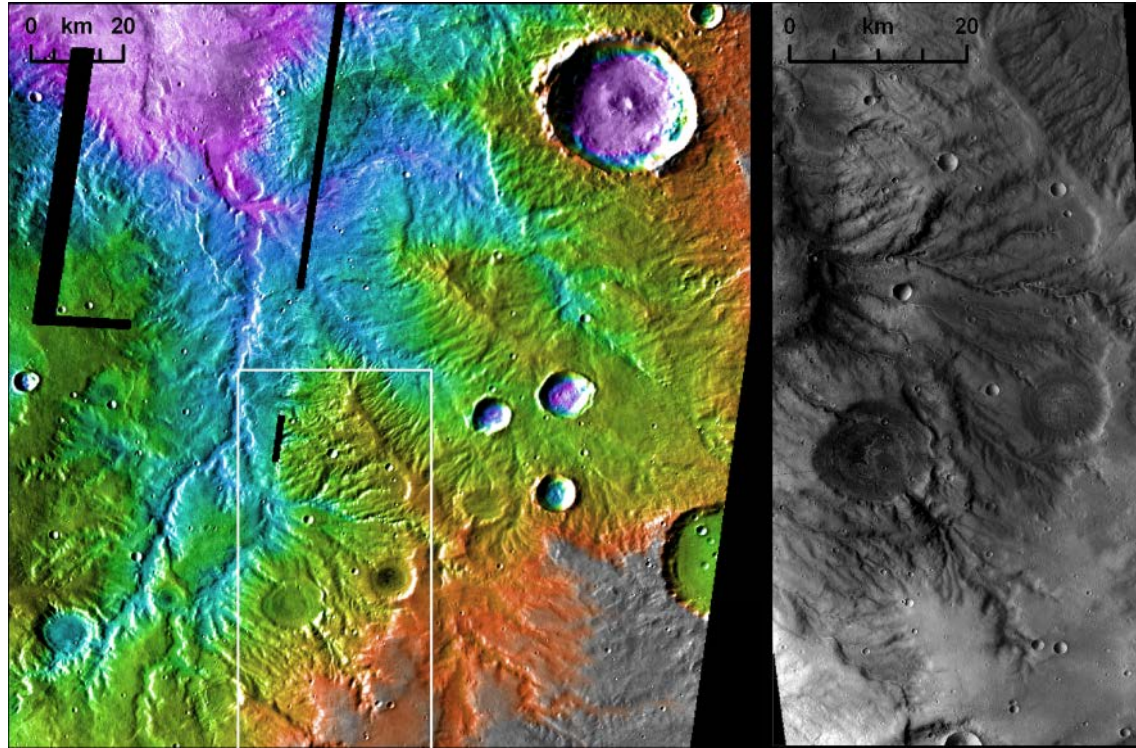
Why do we want to return samples?

Geologic Environments

- Rivers & lakes existed on Mars.
- Big questions remain:
 - **What was the climate?**
[Climate models have major challenges making Mars wet.]
 - **Which environments were *habitable*?**
 - ***Were any inhabited?***

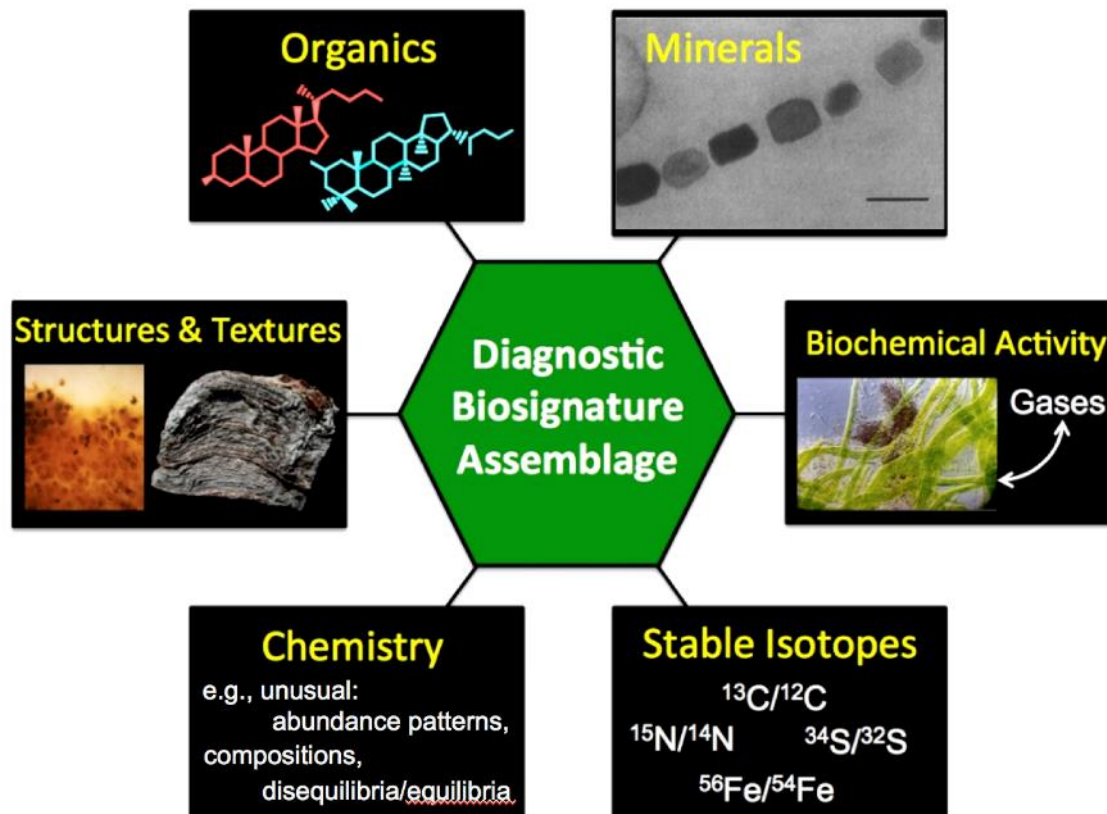
Objectives	
1	Geological environments
2	Life
3	Geochronology
4	Water
5	Planetary-scale geology
6	Environmental hazards
7	ISRU

Left: MOLA Topo on THEMIS mosaic: White high, Purple Low
Right: CTX image (~6 m/px)



Why do we want to return samples?

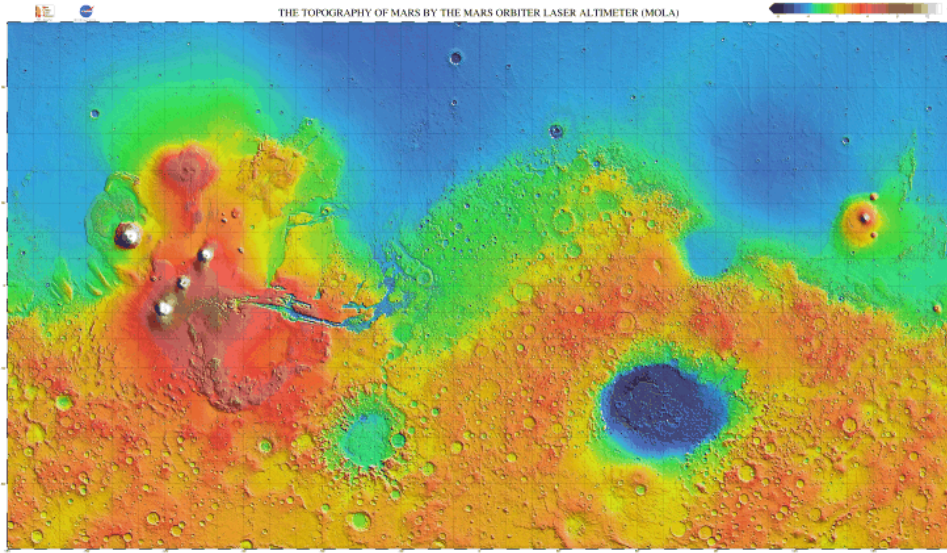
Life and Biosignatures



Objectives	
1	Geological environments
2	Life
3	Geochronology
4	Water
5	Planetary-scale geology
6	Environmental hazards
7	ISRU

Why do we want to return samples?

Geochronology & planetary evolution



Low Ridge, Gusev, MER Spirit

Objectives	
1	Geological environments
2	Life
3	Geochronology
4	Water
5	Planetary-scale geology
6	Environmental hazards
7	ISRU

Why do we want to return samples?



Water

Objectives	
1	Geological environments
2	Life
3	Geochronology
4	Water
5	Planetary-scale geology
6	Environmental hazards
7	ISRU

Planetary-Scale Geology



Characterize the intensity and timing of the Martian dynamo.



Characterize the dynamo reversal frequency and conduct magnetostratigraphy.



Test the hypotheses that Mars experienced plate tectonics and true polar wander.



Determine the major mineral carriers of Martian crustal magnetization

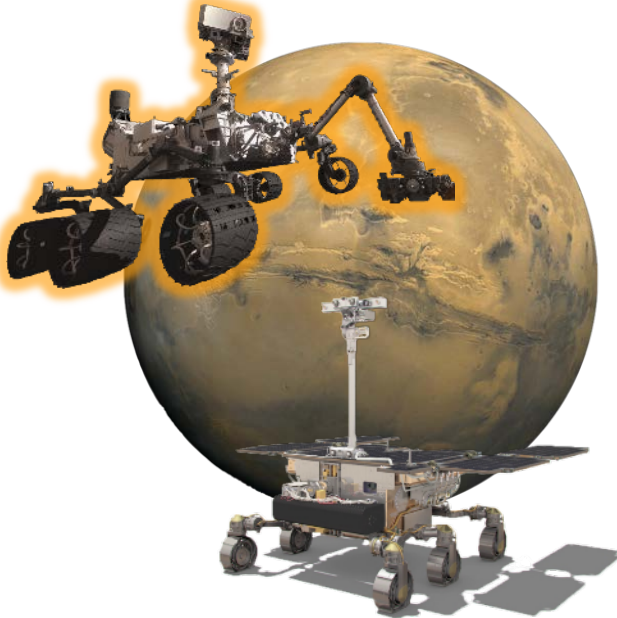
Hazards



In-situ Resource Utilization (ISRU)

Why do we want to return samples?

*Large amounts of sample but
limited instruments*



- Analyses using protocols prescribed far in advance.
- Instruments limited by flight requirements.
- Important preliminary organic characterization steps.

*Small amounts of sample but
unlimited instruments*



Sample Return



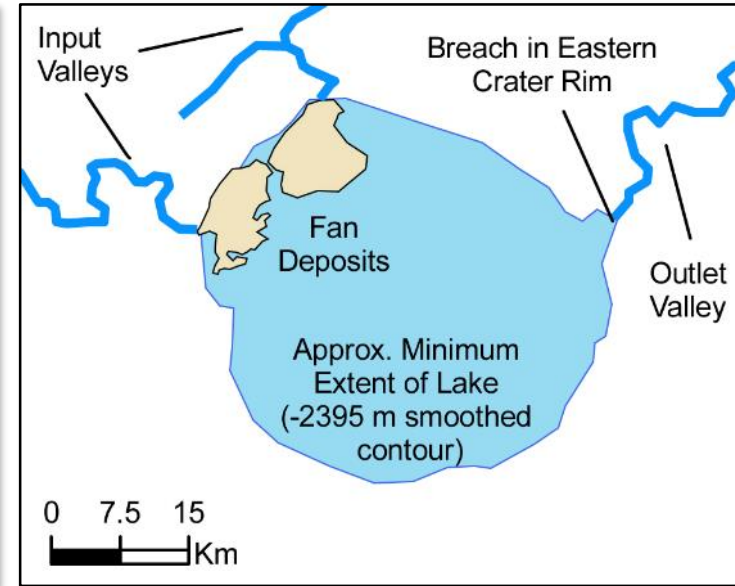
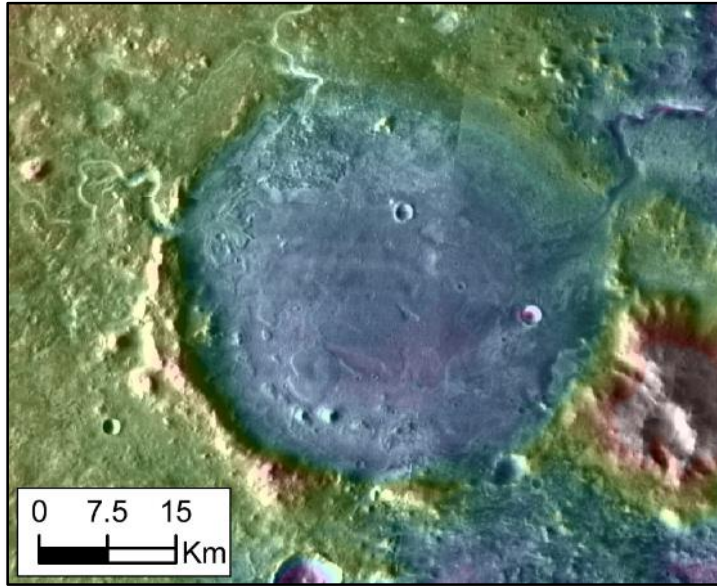
- Analytical flexibility.
- Comprehensive and state of the art measurement.

Why do we want to return samples?

Data used for
Jezero's
discovery, 2004

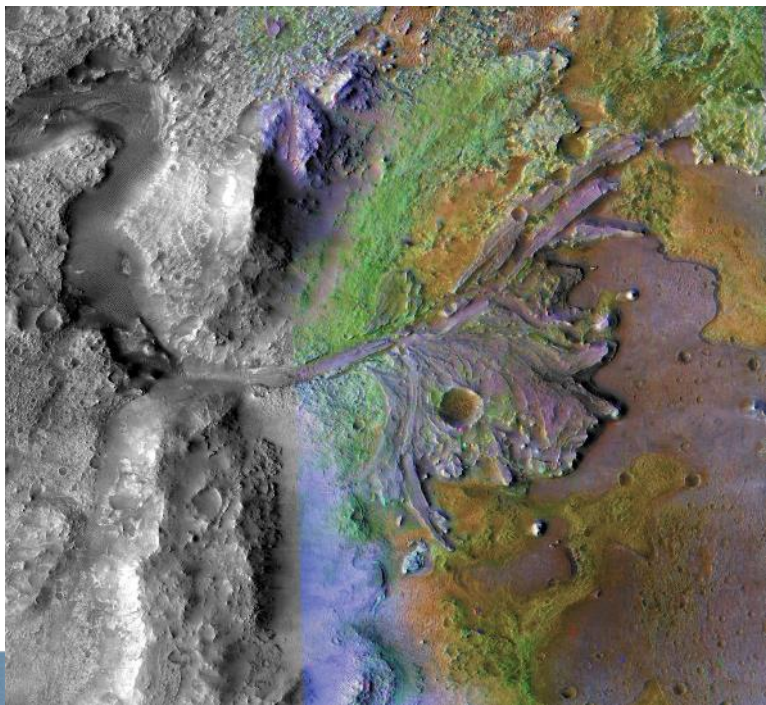
MOLA Topography
(MGS)

THEMIS IR
(Mars Odyssey)



Fassett & Head, 2005

First step towards Mars Sample Return: Jezero Crater Lake



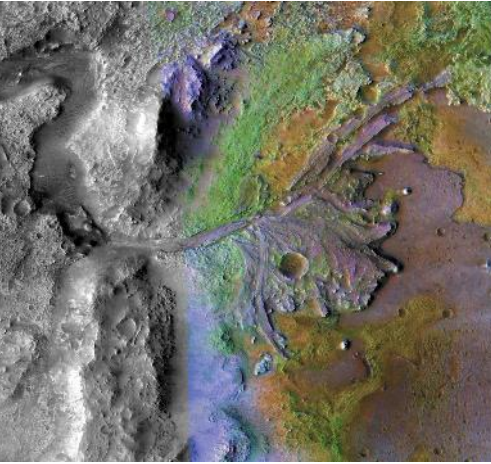
False color CRISM on CTX (MRO)
NASA/JPL/JHUAPL/MSSS/Brown U.

We are going to Jezero to address the Mars 2020 science objectives:

- A. **Geology:** Characterize geologic history of site with “astrobiologically-relevant ancient environment and geologic diversity”.
- B. **Astrobiology:** Assess habitability/“potential evidence of past life” in units with “high biosignature preservation potential”.
- C. **Sample Caching:** Cache scientifically compelling samples for potential return to Earth.
- D. **Preparation for Humans:** Demonstrate ISRU, gather critical engineering data for future human exploration.

Mars Sample Return: Mars 2020

Jezero crater hosted a **lake**, integrating sediment from a diverse watershed. Basin and surroundings have numerous targets:

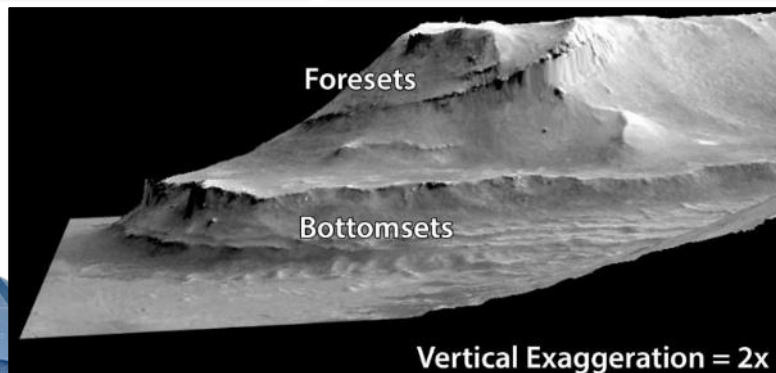
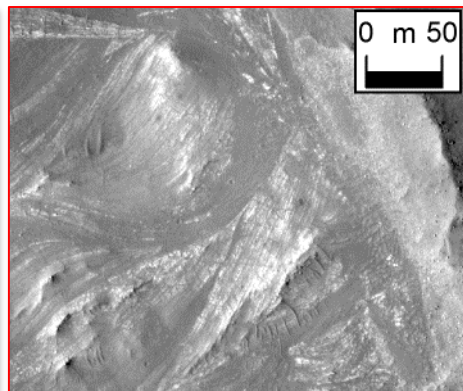
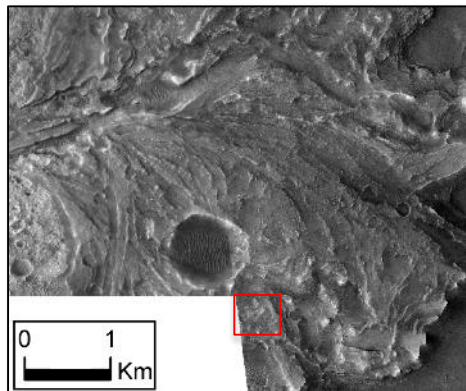


False color CRISM on CTX (MRO)
NASA/JPL/JHUAPL/MSSS/Brown U.

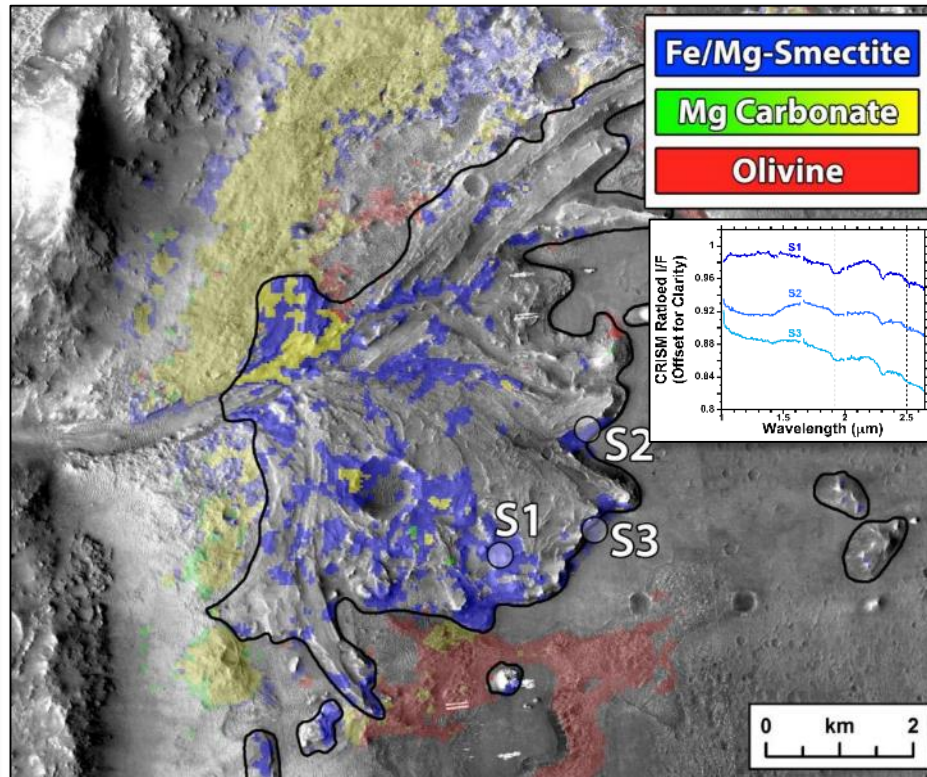
1. Delta deposits record environmental conditions during valley/lake phase. Deltas **accumulate & preserve organic material**.
2. Basin fill, basin marginal deposits with **carbonates**.
3. Floor Unit – potentially **datable** with sample return.
4. Ancient **impact crater materials** on Jezero rim.
5. Highly promising **extended mission** (potential for a mega-mission traverse to another potentially habitable environment).

Mars Sample Return: Mars 2020 Targets

High Resolution Imaging (MOC + HiRISE)

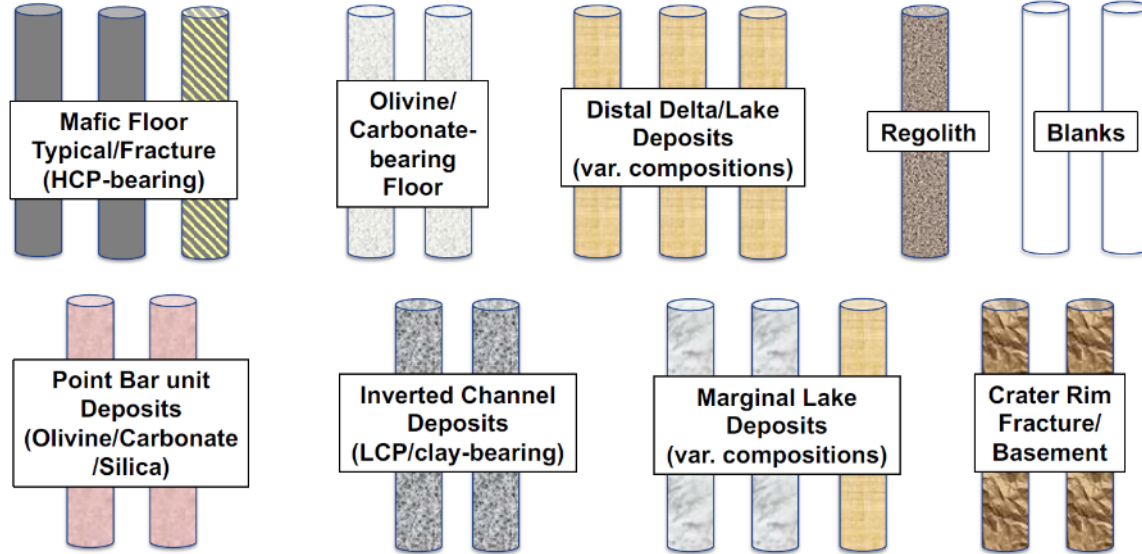
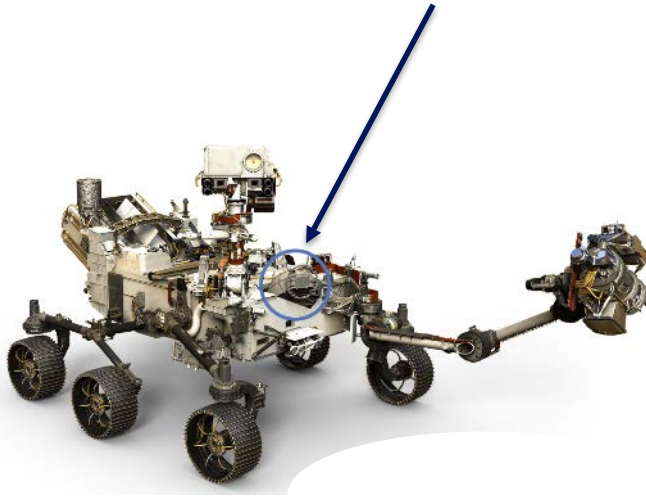


Imaging Spectroscopy (CRISM, MRO)



Mars Sample Return: Mars 2020 Targets

Sample Handling



NOTIONAL Sample collection (by LSWG/ led by Sanjeev Gupta + Briony Horgan)

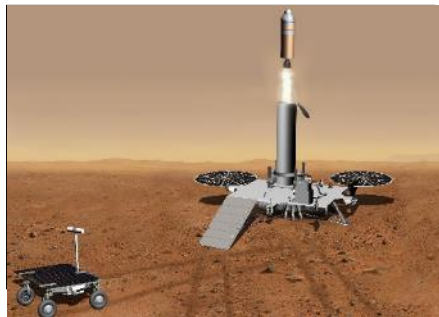
Mars Sample Return: What might we find at Jezero?

SCIENCE



- *Science samples that transcend generations: samples are the gift that keeps on giving.*

ENGINEERING



- *Unique technical challenges of sample return will drive innovation.*
- *Advances will benefit future robotic and human missions.*

PREPARATION



- *Prepare for human exploration of Mars.*
- *Inform planetary protection policies to enable future missions.*

INSPIRATION



- *Inspire and train the next explorers.*

Mars Sample Return