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

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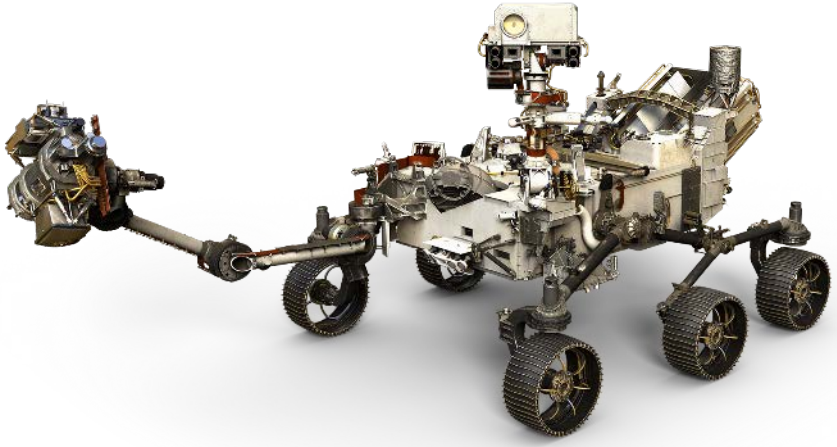
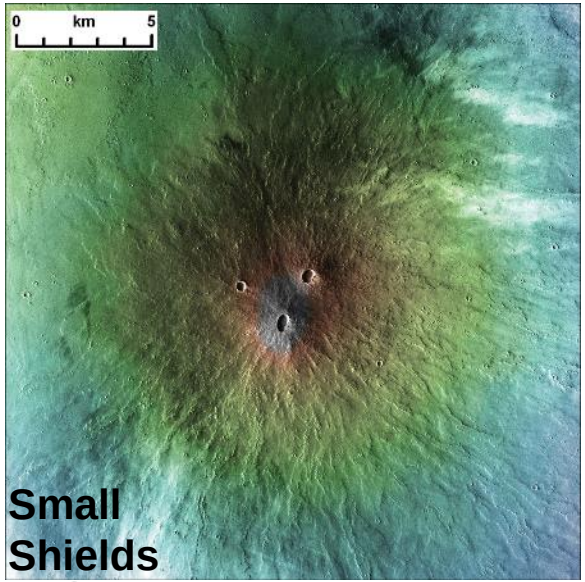
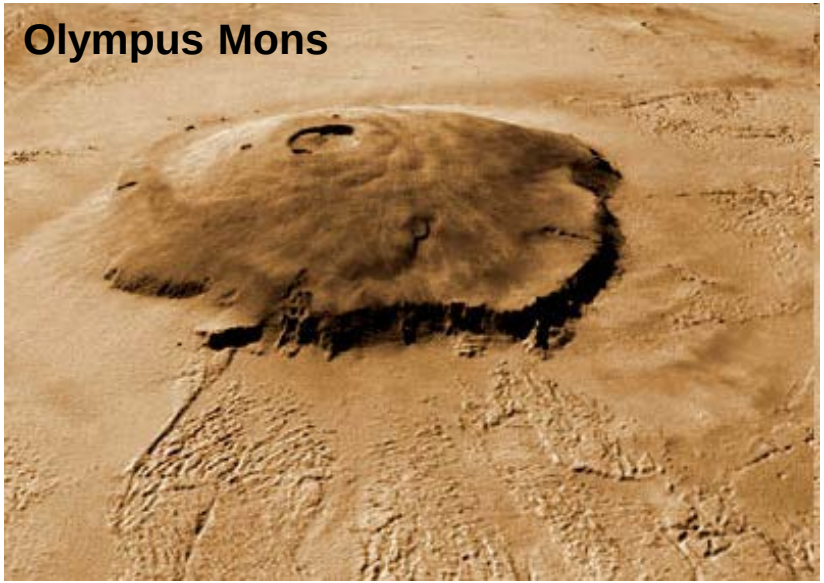
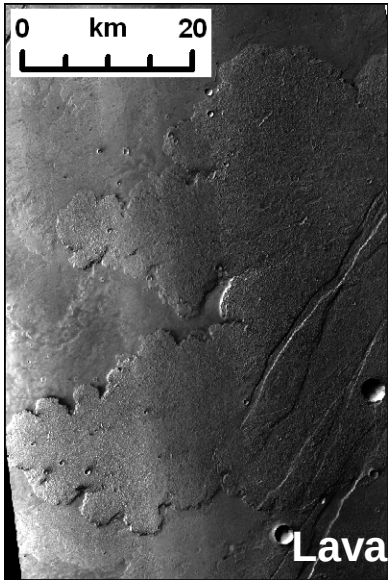
MARSHALL SPACE FLIGHT CENTER



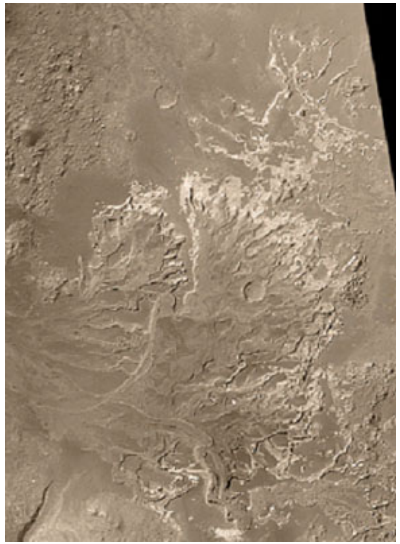
Mars: Volcanism



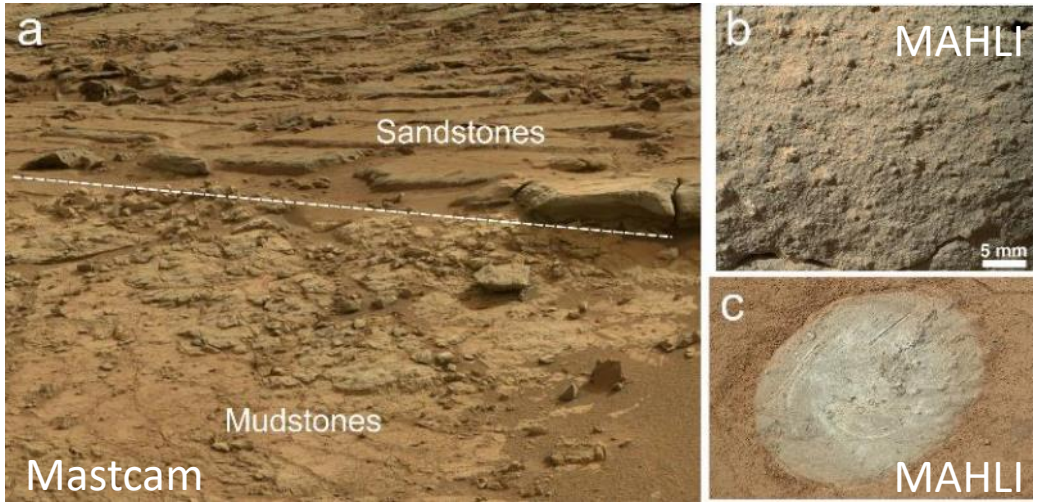




Mars: Sedimentary Systems

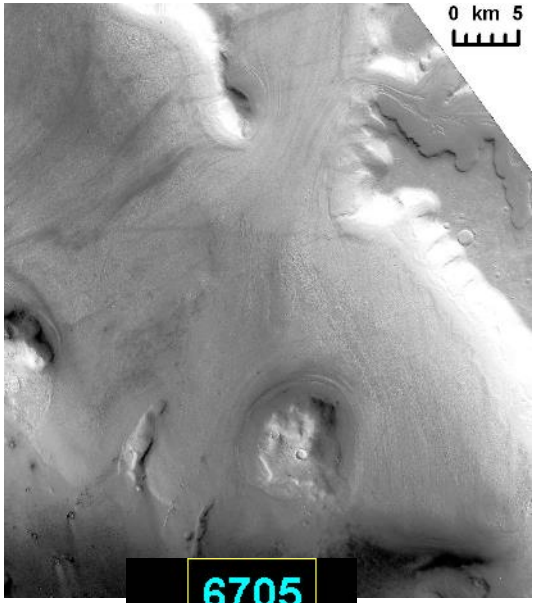


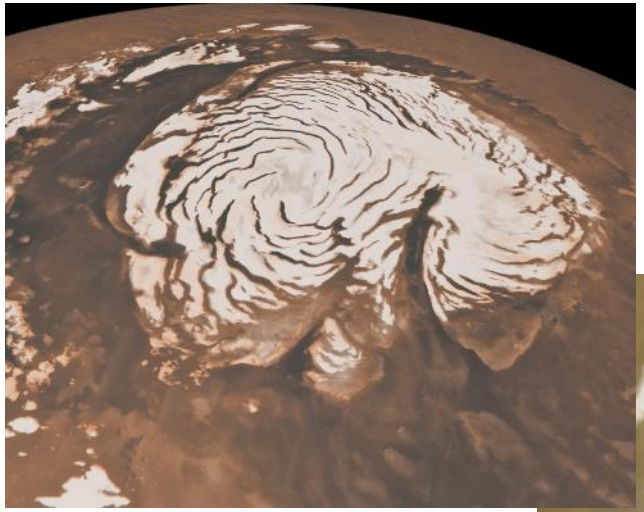
MGS / MOC Camera



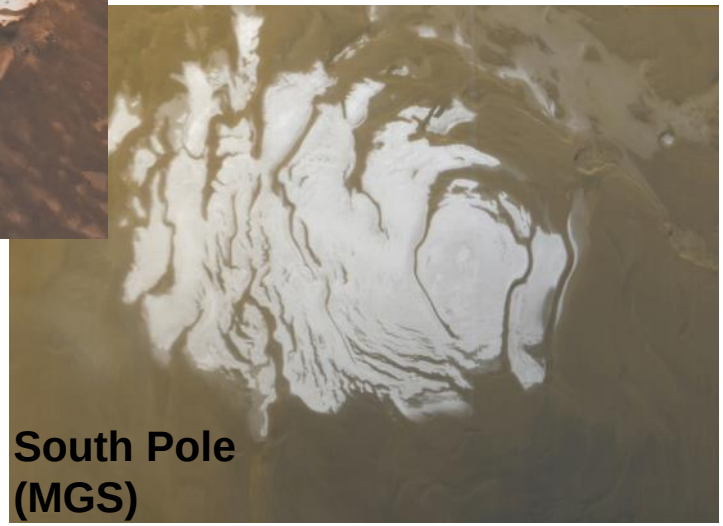
Mars Curiosity Rover

Mars: Ice and Glaciers

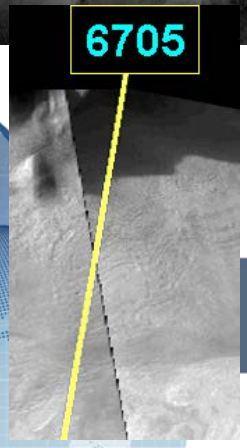


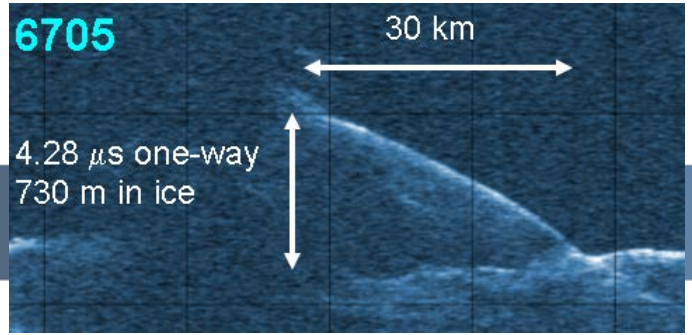


North Pole
(MGS)



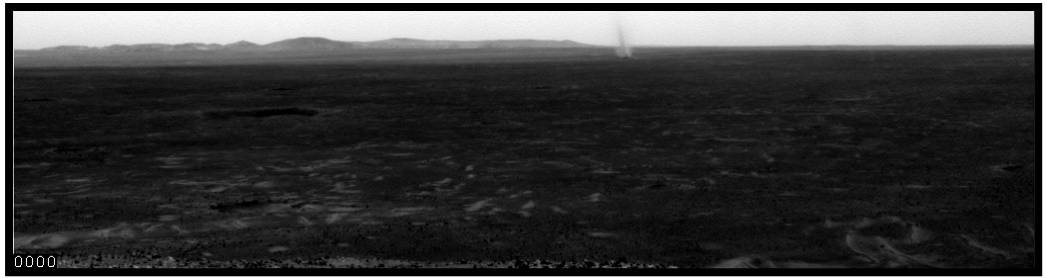
South Pole
(MGS)





Mars Geology 101

Mars: Wind and Weather

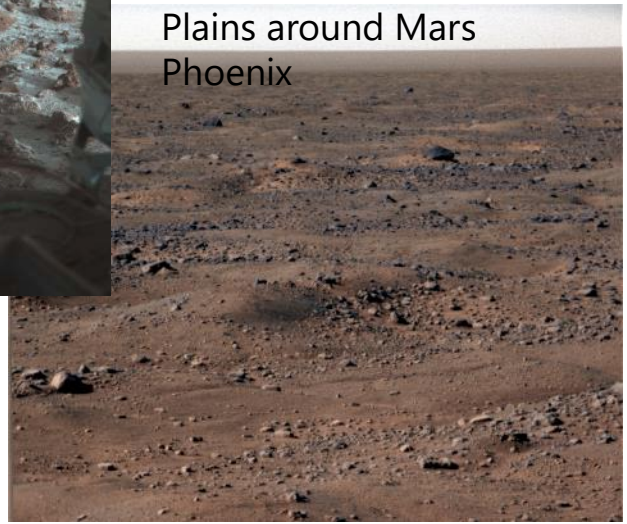


MER Spirit

MER Opportunity
(Endurance Crater)

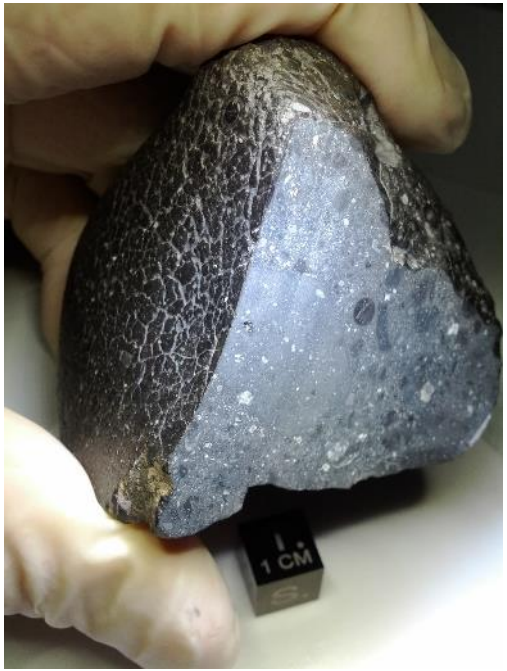
H_2O Clouds
MER Opportunity

Mars: Environment



- Atmospheric pressure is only 6 mbars, mostly CO_2
- Avg <10 precipitable microns of H_2O 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: CO_2 frost point

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

Artist's concept of modern / early Mars

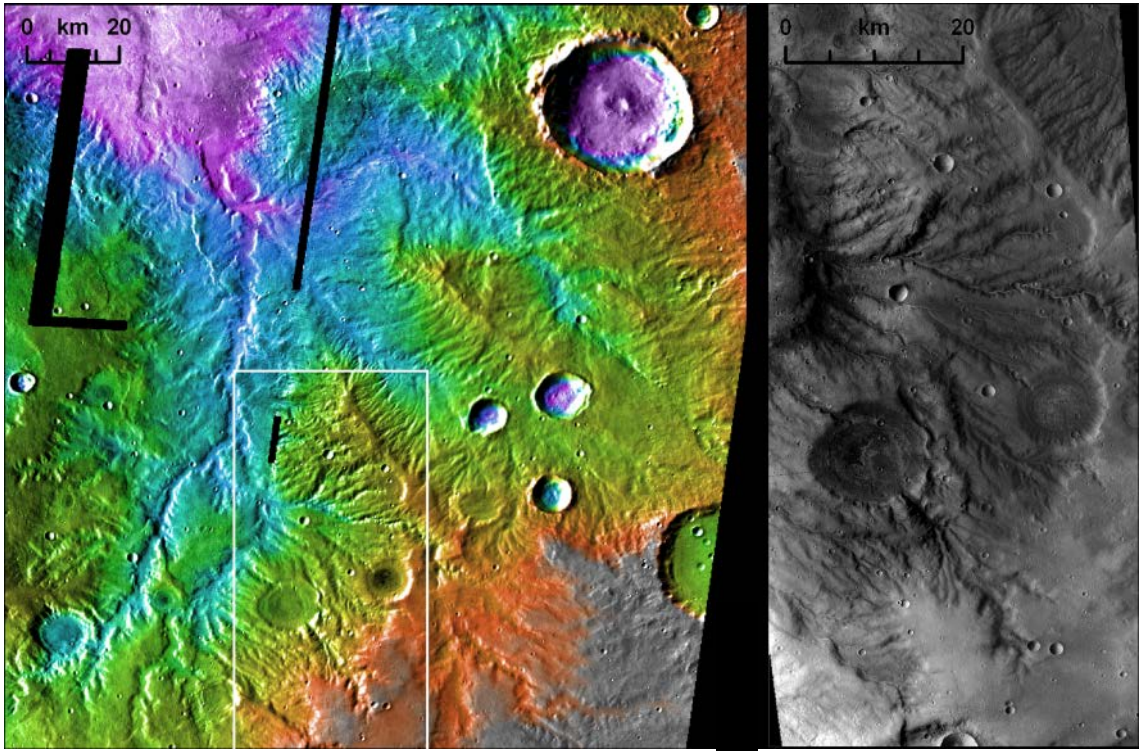
Why do we want to return samples?

For More: See, iMOST: International MSR Objectives and Samples Team

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?***

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



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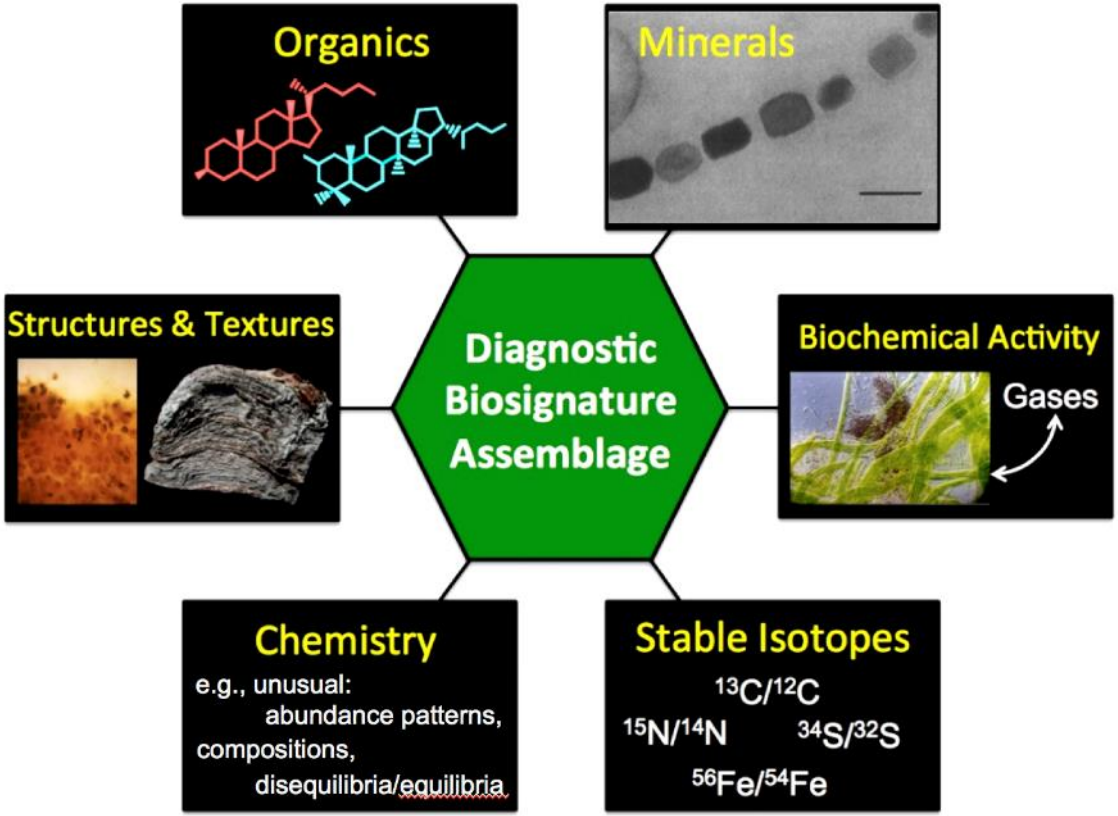
Why do we want to return samples?

Life and Biosignatures



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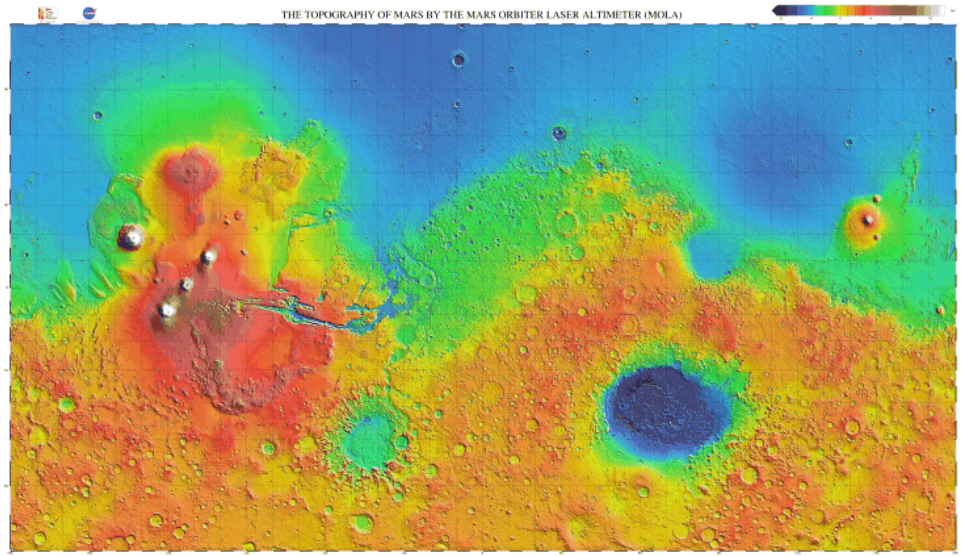
Why do we want to return samples?

Geochronology & planetary evolution



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Low Ridge, Gusev, MER Spirit

Why do we want to return samples?

Water

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)

	Objectives
1	*Geological environments*
2	*Life*
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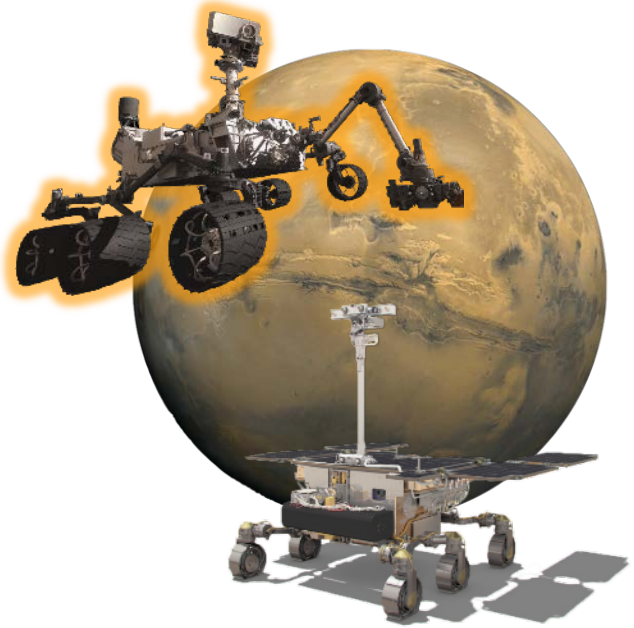
Why do we want to return samples?

Large amounts of sample but limited instruments



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

Sample Return

Small amounts of sample but unlimited instruments

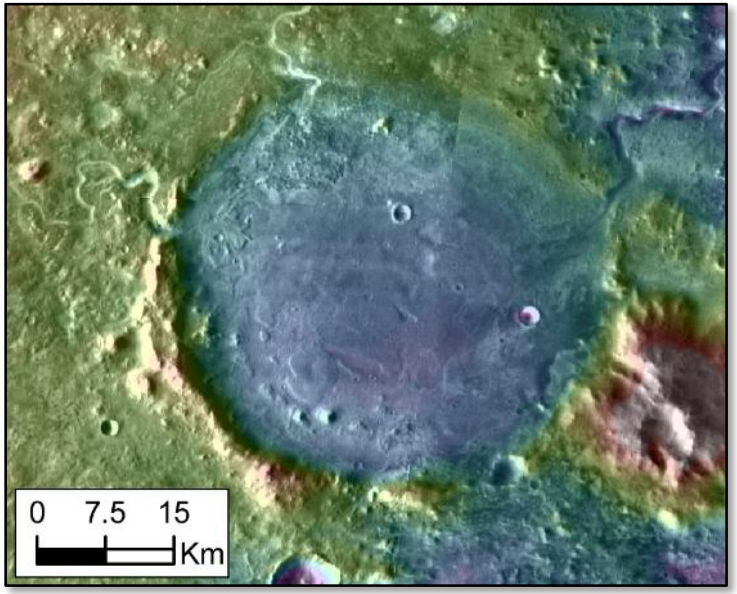
- Analytical flexibility.
- Comprehensive and state of the art measurement.

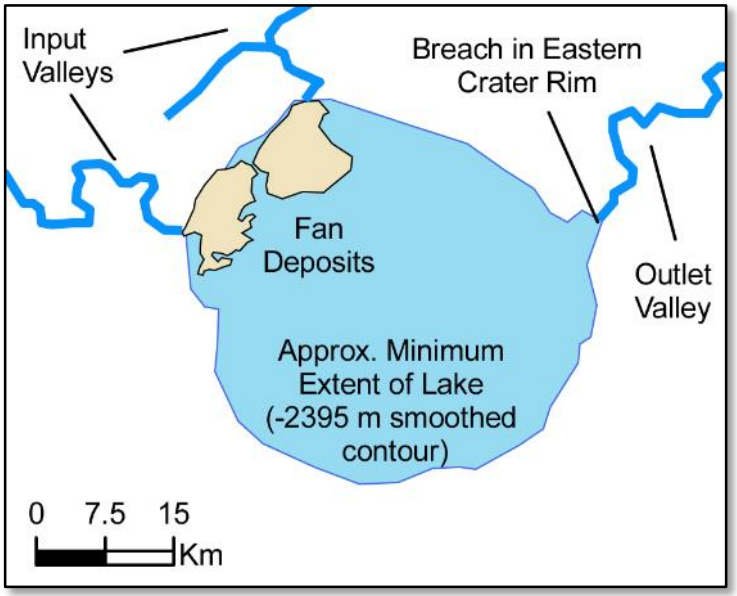
Why do we want to return samples?

Data used for Jezero's discovery, 2004

MOLA Topography (MGS)

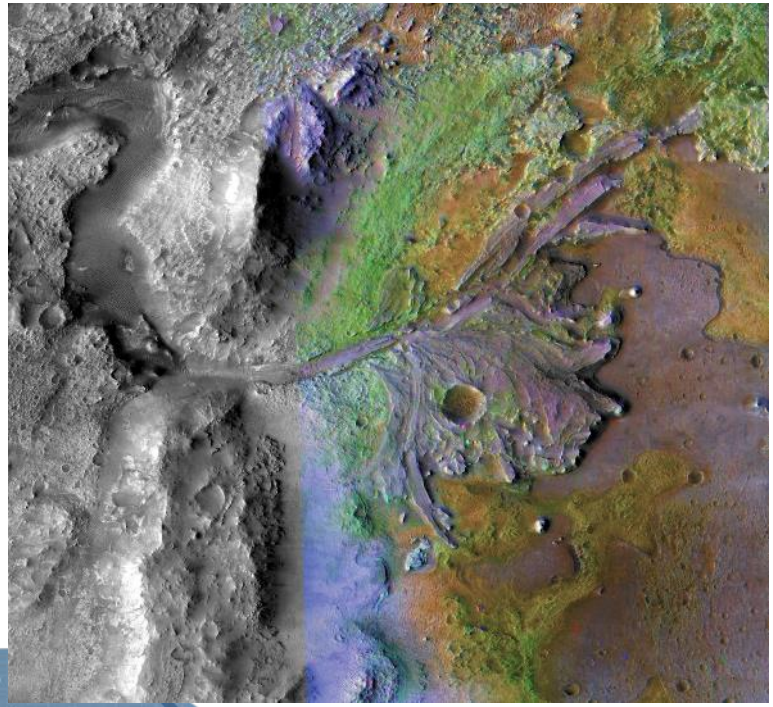
THEMIS IR (Mars Odyssey)





Fassett & Head, 2005

First step towards Mars Sample Return: Jezero Crater Lake



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

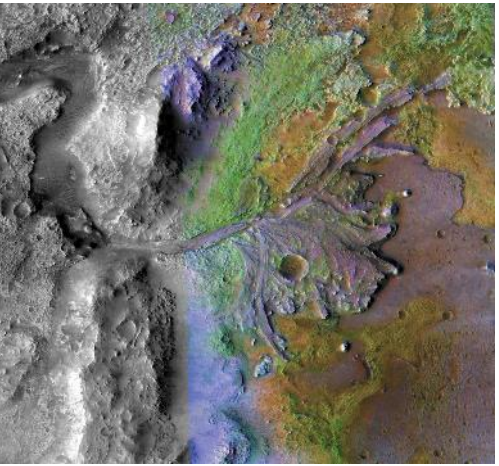
We are going to Jezero to address the Mars 2020 science objectives:

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.



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

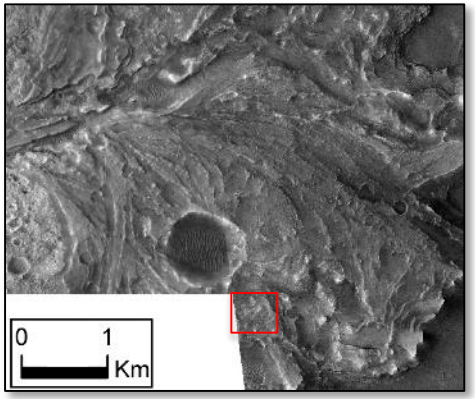
Jezero crater hosted a **lake,** integrating sediment from a diverse watershed. Basin and surroundings have numerous targets:

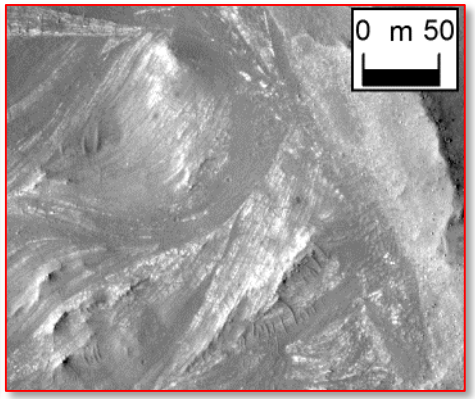
1. Delta deposits record environmental conditions during valley/lake phase. Deltas **accumulate & preserve organic material.**
2. Basin fill, basin marginal deposits with **carbonates.**
3. Floor Unit – potentially **datable** with sample return.
4. Ancient **impact crater materials** on Jezero rim.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

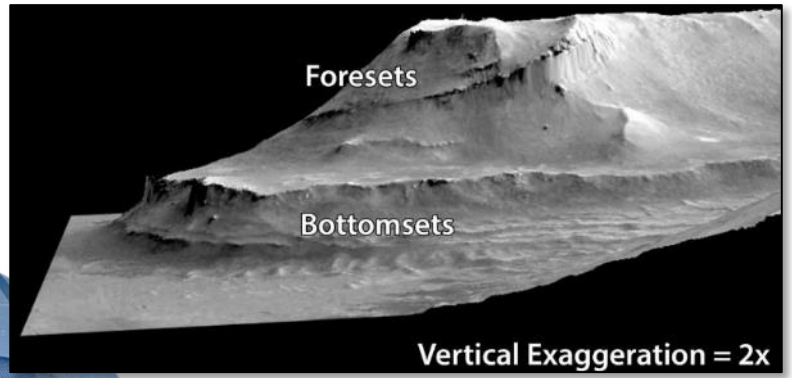
Mars Sample Return: Mars 2020 Targets

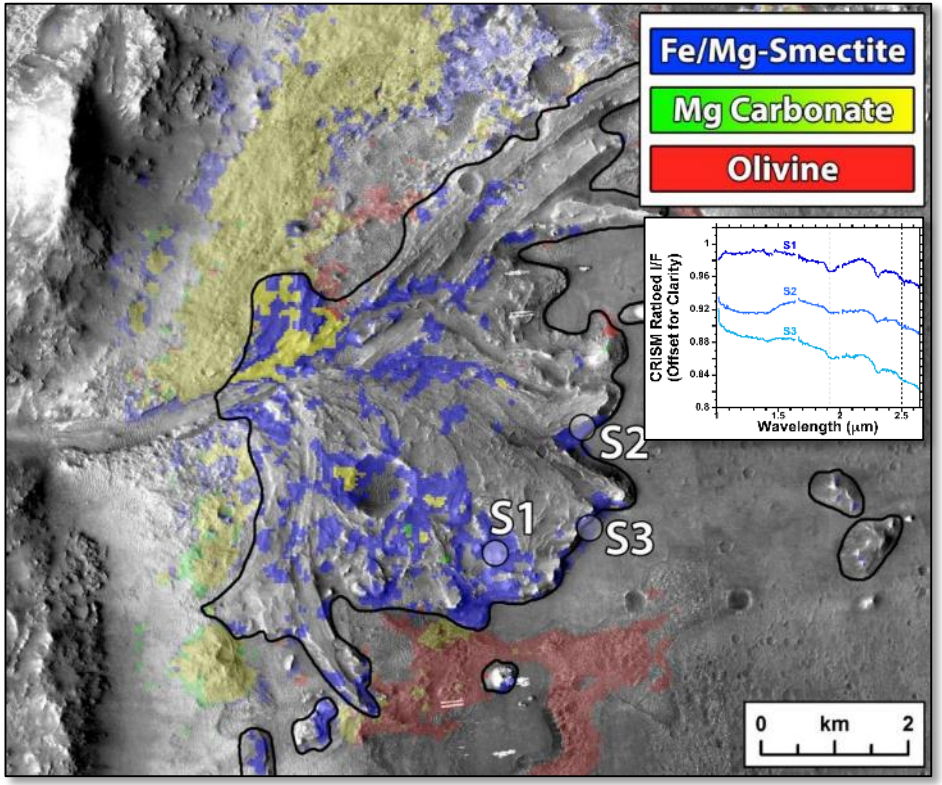
High Resolution Imaging (MOC + HiRISE)

Imaging Spectroscopy (CRISM, MRO)

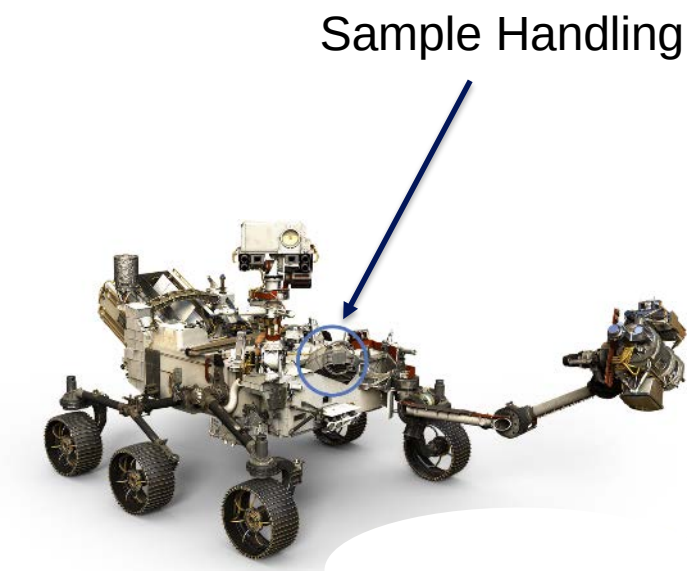


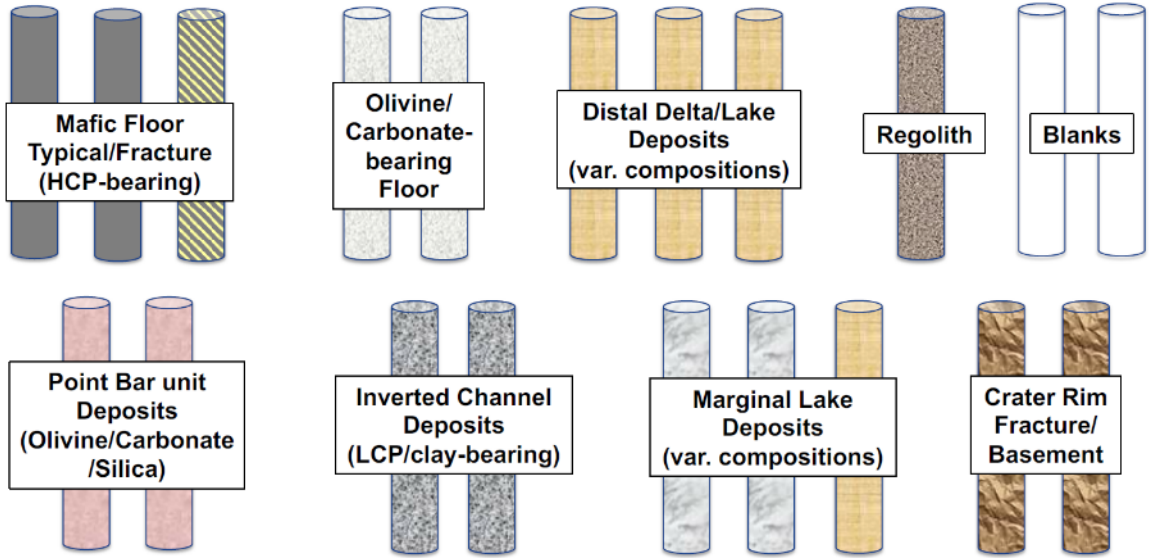






Mars Sample Return: Mars 2020 Targets





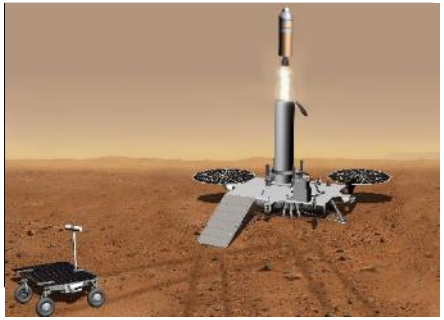
NOTIONAL Sample collection (by LSWG/ led by Sanjeev Gupta + Briony Horgan)

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.*