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

Caleb Fassett
Mars: Volcanism

Small Shields

Olympus Mons

Lava
Mars: Ice and Glaciers

North Pole (MGS)

South Pole (MGS)

4.28 μs one-way
730 m in ice

6705

30 km
Mars: Environment

- Atmospheric pressure is only 6 mbars, mostly CO$_2$
- Avg <10 precipitable microns of H$_2$O 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

Why do we want to return samples?

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

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**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?**
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

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

Low Ridge, Gusev, MER Spirit
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

**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

**In-situ Resource Utilization (ISRU)**

**Hazards**
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**
- Analytical flexibility.
- Comprehensive and state of the art measurement.
Data used for Jezero’s discovery, 2004

MOLA Topography (MGS)

THEMIS IR (Mars Odyssey)

First step towards Mars Sample Return: Jezero Crater Lake

Fassett & Head, 2005
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.
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.
5. Highly promising extended mission (potential for a mega-mission traverse to another potentially habitable environment).
High Resolution Imaging (MOC + HiRISE)

Imaging Spectroscopy (CRISM, MRO)

Mars Sample Return: Mars 2020 Targets
Mars Sample Return: What might we find at Jezero?

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

Sample Handling

- Mafic Floor
  - Typical/Fracture (HCP-bearing)

- Olivine/
  - Carbonate-bearing Floor

- Distal Delta/Lake
  - Deposits (var. compositions)

- Regolith

- Blanks

- Point Bar unit
  - Deposits (Olivine/Carbonate/Silica)

- Inverted Channel
  - Deposits (LCP/clay-bearing)

- Marginal Lake
  - Deposits (var. compositions)

- Crater Rim
  - Fracture/Basement
**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.

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**Mars Sample Return**