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# Perseverance Finds Organic Carbon in Jezero Crater on Mars

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# Perseverance Finds Organic Carbon in Jezero Crater on Mars

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## WHY IN NEWS

A peer-reviewed study in *Nature* (September 2025), in which NASA's Perseverance rover detected intact **macromolecular organic carbon (MMC)** in two mudstone rocks, named **Cheyava Falls** and **Walhalla Glades**, in the **Bright Angel** outcrop of Mars's **Jezero Crater**, continues to anchor the scientific case for the planned Mars Sample Return mission. The associated mineral textures are treated as one of the strongest **potential biosignatures** found on Mars, though they are not proof of past life.

## THE FINDING: ORGANIC CARBON IN MARTIAN MUDSTONES

For the first time, intact **macromolecular organic carbon** has been identified at **multiple sites** and, critically, **within Martian mudstones** rather than only in isolated grains. Mudstones are fine-grained sedimentary rocks that, on Earth, form in calm water and are excellent at preserving chemical traces of ancient environments and even microbial life.

The two key rocks lie in the **Bright Angel** outcrop, an ancient riverbed along the banks of **Neretva Vallis**, a channel that once fed water into Jezero's lake:

- **Cheyava Falls** shows organic carbon tightly associated with iron phosphates and iron sulfides.
- **Walhalla Glades** shows organics linked to carbonate and sulfate minerals, indicating a distinct water-chemistry history.

The most striking feature is a pattern of millimetre-scale mineral rings nicknamed "**leopard spots.**" These contain:

MINERAL	CHEMISTRY	SIGNIFICANCE ON EARTH
<b>Vivianite</b>	Hydrated iron phosphate	Forms in peat bogs and around decaying organic matter
<b>Greigite</b>	Iron sulfide	Often produced by microbes as a metabolic by-product

KEY FACT	DETAIL
What was found	Macromolecular organic carbon (MMC) in mudstones
Rocks	Cheyava Falls and Walhalla Glades
Location	Bright Angel outcrop, Neretva Vallis, Jezero Crater
Signature texture	“Leopard spots” with vivianite + greigite
Detecting instruments	SHERLOC and PIXL
Published in	<i>Nature</i> (peer-reviewed study)
Status	Potential biosignature, NOT confirmed life

### What This Means: Habitability vs Proof of Life

A **biosignature** is any substance, feature or pattern that may have a biological origin. The Cheyava Falls texture is classified as a **potential biosignature candidate** because, on Earth, the pairing of vivianite and greigite in reaction fronts can be created by microbes harvesting organic carbon, sulfur and phosphorus for energy.

The caution is essential. These minerals can also form **abiotically** (without life) under sustained high temperatures and acidic conditions. However, the Bright Angel rocks show **no evidence** of such heat or acidity, which strengthens (but does not confirm) the biological interpretation. Confirming that carbon is complex is **not** the same as confirming its origin. Only Earth-grade laboratory isotopic analysis can settle the question, which is why the samples have been sealed and cached.

### The Perseverance and Mars 2020 Mission

Perseverance is the centrepiece of NASA’s **Mars 2020** mission. It landed in Jezero Crater, chosen because it is an **ancient river delta and lakebed**, an ideal place to search for preserved signs of past habitability.

FEATURE	DETAIL
Mission	Mars 2020 (NASA)
Landing site	Jezero Crater (ancient delta and lakebed)
Landing date	18 February 2021
Companion	Ingenuity helicopter (first powered flight on another planet)
<b>SHERLOC</b>	Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals, UV spectrometer detecting organic compounds
<b>PIXL</b>	Planetary Instrument for X-ray Lithochemistry, fine-scale X-ray fluorescence for mineral chemistry

SHERLOC identified the organic carbon, while PIXL mapped the vivianite and greigite at sub-millimetre resolution.

## Mars Sample Return (MSR)

The rover cannot perform Earth-level analysis, so Perseverance has **cached** sealed sample tubes for the planned **Mars Sample Return (MSR)** mission, a joint effort intended to bring Martian rock to terrestrial laboratories. The Bright Angel discovery sharply raises the scientific stakes for MSR, as definitive life detection requires the isotopic and microscopic precision available only on Earth.

## India's Mars Programme

India is among a small group of nations to reach Mars:

- **Mars Orbiter Mission (Mangalyaan / MOM):** Launched **5 November 2013**, entered Mars orbit **24 September 2014**. It was **ISRO's first interplanetary mission**, made India the **first Asian nation** to reach Martian orbit and the **fourth space agency** globally to do so, achieved on a famously low budget and in the first attempt.
- **Mangalyaan-2 (Mars Orbiter Mission-2 / MOM-2):** A planned follow-up with a far larger scientific payload. Updated mission plans envisage a **lander, rover, helicopter, sky crane and supersonic** (<https://ujijari.com/vocab/supersonic/>) **parachute**, signalling India's ambition to move from orbital observation to surface exploration.

## ANALYSIS AND WAY FORWARD

The Bright Angel finding is a landmark in **astrobiology**, the study of life's potential beyond Earth. Several dimensions matter for policy and science:

- **Astrobiology methodology:** The discovery reinforces a cautious, evidence-graded approach, distinguishing **habitability** (could life have existed) from **detection** (did life exist). Over-claiming damages scientific credibility.
- **Planetary protection:** Returning Martian material raises **forward and backward contamination** concerns, governed by the **Outer Space Treaty (1967)** and COSPAR planetary-protection guidelines. Sample handling must prevent both contaminating Mars and introducing Martian material to Earth's biosphere unsafely.
- **International cooperation:** MSR is inherently multinational. The result strengthens the case for collaborative deep-space science and shared sample-curation facilities.
- **India's planetary-science ambitions:** With Chandrayaan successes, Aditya-L1, the Gaganyaan programme and a planned **Mangalyaan-2**, India is positioned to contribute instruments, analysis and eventually surface missions to the global Mars effort, advancing **self-reliance in deep-space technology**.

## UPSC RELEVANCE

- **GS Paper 3 (Science and Technology):** Developments in space, achievements of Indians in science, **indigenisation** (<https://ujivari.com/vocab/indigenisation/>) of technology and developing new technology. Mars exploration, biosignatures and the SHERLOC/PIXL instrument suite are directly examinable.
- **Prelims:** Jezero Crater, Perseverance, Ingenuity, SHERLOC, PIXL, Mangalyaan (launch and orbit-insertion dates), vivianite and greigite as biosignature minerals.
- **Mains:** "Habitability is not the same as proof of life." Discuss in the context of recent Mars findings. India's roadmap from MOM to Mangalyaan-2 and the governance challenges of Mars Sample Return (planetary protection).
- **Ethics / governance angle:** Planetary protection obligations and responsible communication of scientific uncertainty.

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Perseverance is NASA's Mars 2020 rover; it landed in Jezero Crater on 18 February 2021.

Its companion was the Ingenuity helicopter, which achieved the first powered, controlled flight on another planet.

Cheyava Falls and Walhalla Glades are the two mudstones in the Bright Angel outcrop that yielded macromolecular organic carbon (MMC).

The "leopard-spot" texture contains vivianite (iron phosphate) and greigite (iron sulfide), minerals often linked to microbial activity on Earth.

SHERLOC = Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals; PIXL = Planetary Instrument for X-ray Lithochemistry.

The finding is a potential biosignature, not confirmed life; samples are cached for Mars Sample Return.

India's Mangalyaan (Mars Orbiter Mission) launched 5 November 2013 and entered Mars orbit on 24 September 2014, ISRO's first interplanetary mission. A follow-up, Mangalyaan-2 (MOM-2), is planned.

Sources: NASA (<https://www.nasa.gov>), ISRO (<https://www.isro.gov.in>), *The Hindu* (<https://www.thehindu.com>)

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