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Trip to Mars Part 1

Introduction

The question of if life exists beyond Earth is one that has always fascinated humans, and the attention of this question extends to other galaxies and other planets in our solar system. Mars has become the face of this search. Through analysis of the planet's geology, weather, surface, past and present features gathered from years of remote explorations performed by NASA since the 1990s and with comparison to Earth and life as it exists on Earth, context around if and what kind of life could have existed on Mars or beyond is possible.

Atmosphere, Geology and Water

Over the course of NASA missions to Mars lots of data that could be indicative of life has been collected. The surface temperature ranges from high of 20 ºC and low of -153ºC but heat escapes the planet easily and rapidly from the atmosphere being thin which is not conducive to aerobic life (1). The atmosphere is thin, due to being composed predominantly of carbon dioxide, nitrogen, argon and very small amounts of oxygen (1). The thin atmosphere leaves the surface of the planet exposed to meteorites, asteroids, and comets altering the surface (1). Mars is prone to frequent and long lasting dust storms as a result of the thin atmosphere and current absence of liquid water (1). Water is not present on the surface of the planet, as it has never been found by rover or orbitor expeditions, and the thin atmosphere and fluctuating temperatures on the planet are not conducive conditions for liquid water to exist long in (1). However, liquid water did once exist on the planet due to the presence of minerals found that require water for formation such as gypsum (1). Additionally, Mars has geographic structures on the surface that have presumed hydrologic formation based on Earth's analogues (2). This includes the Valles Marines Canton larger than the Grand Canyon, likely formed from river erosion and a semi arid climate, river valley networks of sediment deposits, deltas, lake beds and alluvial deposits (1-4). The Gale Crater also used to be a lake bed from sediment composition chemical data collected by Curiosity Rover and physical remains as shown in Figure 1.

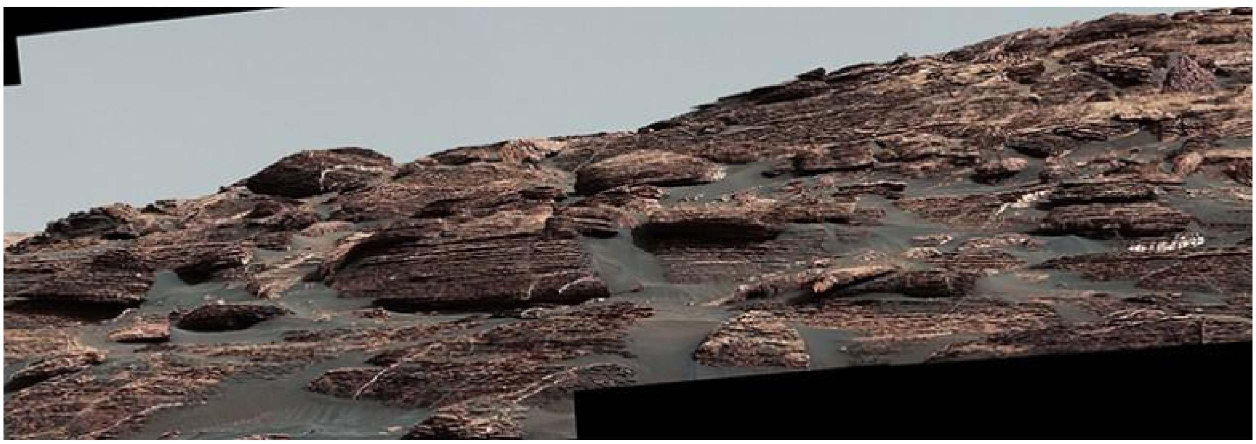

Figure 1. Image of Vera Rubin Ridge at Mount Sharp Gale Crater from NASA Curiosity rover. Shown are stratified rocks with white cut veins across them. Chemical data from Curiosity Rover indicates calcium sulfate presence and prior evaporation of water. Veins and rock cuts suggest erosional cycles and water levels, indicative of mild arid climate and changes in water levels. Credit: NASA/JPL-Caltech/MSSS (5)

Curiosity Rover found the bed of Gale Crater contained organic molecules for life: sulfur, nitrogen, phosphorus, carbon and oxygen similar to Earth lakes and deep ocean hydrothermal locations (6-7). Mars also contains several clusters of volcanoes (2), the largest being Olympus Mons, and some of these volcanic areas have had seismic activity reported from Insight, despite Mars lacking plate tectonics (3). The rock and sandy surface of Mars is high in iron from physical looks and chemical analysis (2).

Analysis, Methods and Technology

Data on Mars has been collected from a number of methods and forms of technology, and analyzed and synthesized to form conclusions about the processes of the planet. NASA has been sending flybys, orbitals, stations, rovers and rover helicopter combinations to Mars since the 1990s, and currently has a diversity of these on site actively collecting data (1). The technologies onsite of the planet or in orbit collect data that is transmitted back to Earth where scientists can analyze it, compare recordings and use multiple collection points to cross examine (1). Without data collected on Mars, much would be unknown as most of the technology requires being close for data collection. Many of the technologies work together to inform scientists about conditions for future expeditions and with each other to confirm findings from one mode with another. Table 1 outlines key expeditions and technologies NASA has used to gain critical information about Mars pertaining to the qualities that would be crucial for life to have existed and to find life on Mars. This includes expeditions focused on gaining comprehensive data of conditions and more specific missions to targeted locations looking for specific minerals and rocks. However, no conclusive signs that life did exist have been found, but increasing amounts of conditions and elements that could have supported life in similar ways to Earth are being discovered to have once existed on Mars. Overall current data and missions summarized in Table 1 show that water was present on mars from topographic, rock and mineral presences, and that organic materials and water minerals can be found in soils but have yet to find concrete evidence life did exist.

Table 1. Overview of Technological methods for Mars explorations that produced and continue to produce data critical to understanding of water, land, composition, atmosphere, surface processes, tectonic conditions and mineral composition on Mars. Mixture of land rovers, orbital observations, technology on rovers or orbitals and stationary surface data collectors.

Method	**Overview and Purpose**	**Findings and Additional Information**
Perseverance Rover (8)	Exploration of Mars with the	Has collected 17 rock cores, 2

	goal of looking for signs life existed, collecting samples of rock and soil with the potential return to Earth for analysis. Rover and helicopter components. In Jezero Crater. Active since February 18, 2021.	regolith samples and 1 atmospheric sample. Operations to last at least one Mars year.
Curiosity Rover (6) (7)	Exploration of Mount Sharp and Gale Crater with the goal of determining if conditions were suitable for life or to find traces of microbial life. Hunting for rocks with traces of water or hydrated minerals and organics used for and by life. Samples rocks with drilling and composition analysis via pinpoint spotting and chemical fingerprint reading to determine surface compositions and rock history. Active since August 5, 2012.	Water was common in past Mars. Smooth pebbles, 1,000 vertical feet formed from mud. Mars was a place that was suitable for life chemically. Contained nitrogen, oxygen, phosphorus, sulfur, carbon when drilling. Organic Carbon found, which is a building block of life. Methane in the atmosphere detected from Tunable Laser Spectrometer onboard Curiosity detected seasonal varying amounts of methane. Damaging amounts of radiation currently. Mars had a thicker and more humid atmosphere in the past through isotopes.
Insight (3)(4)	Stationary lander collecting data on the interior of mars. Stationed on the smooth plane Elysium Planitia. Goals to understand the evolution, formation and interior of Mars. Understand and determine tectonic activity and conditions of Mars. Active since November 26, 2018.	Detected at least 1,3000 quakes most centered around Cerberus Fossae region of volcanic formations. Insight into layers of Mars interior via seismic waves and understand geologic past and heat capacity of the planet in the past. Detected meteoriod impact with aid from Reconnaissance Orbiter located ice which could be used for dating. History of magnetic field found in rock formations. Studies dust storms, weather patterns and

		atmospheric variances of seasons.
Reconnaissance Orbiter (9)	Orbiting Mars. Goals to characterize the surface geology of Mars, the atmosphere and climate of Mars. Understand if life or conditions for life ever existed on mars from surface observations. Gain knowledge for human exploration of Mars. Utilizes HIRISE and CRISM technologies for data collection. Active since March 10, 2006	Gained photographs and surface topography data to understand the surface of Mars. Uses spectroscopy for surface composition analysis. Gains data on atmosphere and weather conditions. Been used alongside rovers and Insight to gain multiple perspectives on sites. Used to help locate landing locations and sights of rover explorations.
High Resolution Imaging Experiment (HIRISE) (10)	Goal to photograph topography on Mars in large amounts and see small features for land and surface evolution processes. Photographs with visible wavelengths and telescopic lens and near-infrared for mineral compositions. Pictures sites determined by other data and Mars Odyssey.	Captures topographic images. Tracks evolutions of surface changes and land processes giving insight into weather, atmosphere and surface conditions. Tracks mineral compositions and aids in providing background information for other missions.
COmpact Reconnaissance Imaging Spectrometer CRISM (11)	On board Reconnaissance Orbiter. Goal to detect mineral residue and signatures from former water using visible, infrared and near-infrared wavelengths.	Maps surface topography and mineral composition. Determines areas of past water flows, presences of water landforms and mineral deposits. Used to determine ideal areas for rover sampling based on water past potential for life and water locations.
Mars Odyssey (12)	Study global and elemental composition of Mars and study radiation for future human and technological missions. Understand geological structure and formation. On board includes Thermal Emission Imaging System (THERMIS) for	Provided results that information around the conditions stated to give the comprehensive knowledge of Mars combined with further data collected from newer missions. Used to help understand the best next

	thermal and mineral data collection. Gamma Ray Spectrometer (GRS) for water and ice analysis. Mars Radiative Environment Experiment (MARIE) for radiation. Active since October 24, 2001.	missions.

Martian Past, Present and Potential of Life

Mars surface and geology undergoes weathering in particular areas and preservation in others due to climate, seasonality, topography and present thin atmosphere. Mars is prone to dust storms as a result of the thin atmosphere allowing harsh winds against sediment and rocks, something different from Earth due to difference in atmospheric thickness and water content in soils (1). Impact craters also litter the surface of Mars, as the thin atmosphere prevents protection from them; these can be dated if remnants of ice are left and were in the material landed to determine when in the history they occurred, which can give insight into how long the atmosphere has been thin (1). Mars has crustal movement but lacks plate tectonics unlike Earth as Insight recorded and is discussed in Table 1 (1, 3-4). Crustal movement on Mars can be attributed to the cooling of the planet's interior and cooling accounts for volcanoes no longer being active (1). Some differences between Earth and Mars that could be crucial to life existing in a similar fashion to Earth include the day length of Mars being 24.6 hours compared to Earth 23.9 hours and more significantly a Mars year being 687 Earth days and altering the seasonal balance (1). Despite Mars having a similar tilt to Earth 25 degrees to 23.4 degrees respectively, the seasons do not split evenly in proportion due to the egg rotation Mars has around the sun, this is a strong difference between how life on Earth exists with seasonality and how life on Mars could have lived with seasonality (1). However, the majority of early microbial life on Earth is theorized to have begun in hydrothermal aquatic areas high in minerals and organic matter, conditions not exactly found to be replicated on Mars. This may be due to them having existed but not having been able to be preserved due to the limitations of the hard surface and weather Mars presently faces.

Conclusion

While life on Mars has yet to be found, strong evidence of pieces that could have led to the right conditions have been found on Mars. Presence of hydrated minerals, and minerals formed with water, prove liquid water existed at one point. Organic molecules have been found which would be essential for understood life and life processes. Meanwhile the topography shows change over the planet with some areas preserved and others transformed with change as the planet cooled and atmosphere thinned. While still unanswered the hunt for life on Mars continues as more knowledge is gained on mars and about early life on Earth.

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