Earth Science: Origin And Geology Of The Solar System

Introduction

[image: Image result for planets in order] Humans have always been interested in Mars. Records dating back to siting's in 1500 BC to 1609, when Galileo observed Mars through a telescope, show the continued interest in this planet.1 400 years later and scientists are still constantly trying to analyze, learn and explain the known and unknown of our solar system.1 Mars is the fourth planet from the Sun (Fig.1), in between Earth and Jupiter.2 It is named after the Roman God of war and is also known as the Red Planet because of its red soil and atmosphere.2 Mars is the second smallest planet in our solar system and is considered a Terrestrial planet, which is a planet composed of primarily silicate rocks or metals.4

Mars is currently the most investigated planet for the sustainability of life due to its proximity and similarity to Earth. The only other planets in orbits near Earth are the Moon and Venus, which both have very few vital resources needed to sustain life and inhabitable atmospheres.5 Venus has extreme heat, acid rain and a toxic atmosphere, 5 while the Moon has no protection from radiation, no weather and no water with extremely long days.6

The definition of life is any organism that has "open systems that maintain homeostasis, are composed of cells, have a life cycle, undergo metabolism, can grow, adapt to their environment, respond to stimuli, reproduce and evolve."7 If one is able to find life on Mars, it would be a huge step towards understanding the planet and potentially a second home for humanity and other living organisms if Earth is no longer able to sustain life. The current belief to date is that there is no proof that life ever existed on Mars.4 However, there are people who currently believe there is the possibility of life on Mars, such as Gilbert Levin.8 Gilbert Levin was the principal investigator of the Viking's Labeled Release life-detection experiment beginning in 1970's.8 The experiment was the U.S.'s first attempt to land on Mars, sending 2 Viking spacecraft to complete the mission.8 Even though scientists could not come to a consensus on the possibility of life on Mars, Levin stated that the experiment did detect life on Mars and NASA failed to investigate it further.8

This report will argue that life can be sustained on Mars and how scientists are currently using analogue studies to discover how and where life can survive on the planet.

Can Mars Support Life?

In order for a planet to sustain and support life, it requires five basic elements- energy, nutrients (food), temperature, atmosphere and liquid water.9 These five elements can support all life forms, from single cell organisms to multicomplex organisms like humans. Organisms need a steady input of light or chemical energy in order to run their specific functions to survive.9 They need key nutrients found in food to help them grow, develop and maintain themselves. Organisms need a certain temperature range, approx. minus 15 to 115 degrees Celsius, in order for atoms and molecules to react properly.9 They also need liquid water in order to dissolve and transport chemicals within and between cells.9 Lastly, organisms need a thick enough atmosphere in order to trap heat, shield from radiation and provide chemicals like

nitrogen and carbon dioxide necessary for life.9 Mars was able to meet three of these elements required for life to be sustained at some point in time. There is evidence that shows Mars had rivers that flowed on the surface billions of years ago that eroded Fi on the planets rugged terrain.10 Figure 2 is a picture taken by NASA's Viking Orbiter in 1975 displaying the dry river beds on Mars surface.10 There are two competing theories in the science community on what form of water took place on Mars. One theory claims that Mars was once warmer and wet due to it once having a thicker atmosphere before its planetary magnetic field disappeared.10 This would of allowed for the planet to protect itself from charged particles streaming from the Sun through solar winds, keeping the planet at the optimal temperature for water to remain liquid.12 The other theory claims that Mars has always been cold, however "water trapped as underground ice was periodically released" when heat caused the ice to melt and come to the surface.12 Liquid water would only be able to form on Mars due to temperature and atmosphere, which go hand in hand.

In 2014, NASA launched MAVEN to study Mars upper atmosphere and collect data on whether the planet once sustained life and possibly could now.13 After analyzing 6 months of data, MAVEN discovered that Mars is extremely cold and dry is due to solar winds stripping away its magnetic field and most of its CO2 and O2.13 A strong magnetic field is important for a planet as its inner core cannot grow and stabilize a magnetic dynamo- celestial body or star's ability to generate a magnetic field.14 Over the next hundred million years, powerful solar winds picked away at Mars unprotected atmosphere at a rate of 100 to 1,000 times greater than that of today.15 Figure 3 displays the impact solar winds have on Mars compared to Earth due to a lack of a magnetic field. All of these factors influenced Mars ability to adequality retain heat and maintain a strong, thick atmosphere that would allow it to possibly sustain life.

NASA's MAVEN mission has also yielded an interesting image of what the surface of Mars might have looked like in its early stages, over 4 billion years ago. Figure 4 displays an image from a video created by NASA's Goddard conceptual image lab for MAVEN that showing the planet to have similar features to Earth.16 Places like Hawaii, Salten Skov in Denmark, Atacama Desert and more are all places that are similar to Mars from volcanic structure to soil to red-coloured sediments.17 With this environment, it could have been possible for early life forms to once of sustained life on Mars. Analogous conditions of Earth could definitely be found on early Mars. Dr. Joseph Grebowsky, who is the project scientist for NASA's MAVEN mission stated that "There are characteristic dendritic structured channels that, like on Earth, are consistent with surface erosion by water flows."16

Analogous Studies of Life on Mars

Scientists are using analogous studies on Earth to further understand if sustainability of life is possible on Mars. One study conducted by Jeffrey Marlow, Zita Martins and Mark Sephton looked at how experimental analysis of terrestrial soils on Earth can prepare scientists for what they will encounter on Mars.17 This study is trying to prove that using soil analogues to their full potential will allow for continued exploration of Mars, which will be safer and more 'scientifically productive.'17 Missions to Mars can be very expensive and by maintaining a "comprehensive and reliable database on soil analogue properties," researchers could target specific sites in order to obtain more accurate and reliable data.17 This study is analogous as the researchers are comparing types of Earthly soils that best mimic the ones similar to Mars.17 They are comparing chemical, mechanical, physical, magnetic and organic analogous soils to those

found on Mars.17 They used several sites that display “Mars on Earth” such as volcanoes in Hawaii, the Atacama Desert in Peru, the Mojave Desert in California (Fig. 5), Arequipa Desert in Southern Peru and more.17

Finally, they studied 34 pieces of know Martian meteorites that landed on Earth, looking at their “near-certain source of organic molecules on Mars.”17 They observed the need for testing terrestrial soil, as it [image:]provides a preview of what the physical environment could potentially be on Mars.17 Centralized data on the soil is limited and inconsistently acquired, making the records either out-dated or disparate.17 These gaps in the collected data so far can be seen in Table 1. They are also able to simulate what type of soil a rover will drive on and “materials that on-board instruments will sample.”17 By studying soil analogues, it helps to prepare and predict the materials needed to “trace levels of organic molecules” (aka. possible life.)17 This study is extremely crucial as it is a cheaper and safer way to prepare scientists for what they will potentially encounter on Mars surface.17

A second analogues study on Mars was conducted by Marjorie Chan, W. Adolph Yonkee, Dennis Netoff, Winston Seiler and Richard Ford looked at polygonal and rectangular cracks in bedrock on Earth and Mars and its implication for weathering.19 They are trying to prove that small-scale, shallow crack systems observed on the Jurassic Navajo Sandstone in southern Utah and northern Arizona can be used to show the potential weathering process through Burn formations on Mars.19 This analogous study allows researchers to study sedimentary deposits and compare them to Burn formations on Mars.20 By studying these Burn formations, it can lead to far more information on the weathering and erosion of Mars surface.20 When comparing Navajo Sandstone to Burns formation on Mars, researchers found that both surfaces contained thin cracks that formed perpendicular to boulder and outcrop surfaces.19 The development of weathering cracks may have grown in small steps from “individual thermal and precipitation events.”19 The smaller-scale polygonal cracks in the Burns formation are potentially due to more “rapid temperature and surface stress changes on Mars, or different host rock properties.”19 By studying the impact of weathering patterns on Earth, it can help to understand the evolution of Mars surface and if it, at one point, could of sustain the same chemical makeup and nutrients that allow life on Earth to thrive.

Conclusion

The dynamic planet called Mars is one of the most explored celestial bodies in the solar system.4 Evidence tracing back billions of years shows a more Earth-like Mars.16 This now cold, deserted planet has been speculated to have once sustained life and can be seen through multiple studies conducted by NASA, especially MAVEN.4 Targeted at learning and analyzing all aspects of Mars, researchers are using analogues studies to compare similar conditions of soil17 and rock formation found in various sites all over the world.20 Therefore, findings derived from missions and studies like terrestrial soil may lead researchers to one day be able to answer the question- Can Mars support life?

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