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Life on Mars- Extracting the signs for future Human Habitation on the Red Planet

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Abstract

The burning crisis of Global Warming on Earth is a threatening sign to the possible vanishing of human life on Earth. Considering this in mind scientists around the world are working for human habitation on an Earth like Planet in the near future. Amongst all planets in the Solar System, Mars is believed to be a Planet where life either existed in the past or could be established in the near future considering the vast similarities between Earth and Mars. Life on Earth has existed in some form in various conditions with the passage of time and the similar conditions have been found on Mars too. The Meteorites falling on Earth have shown the sign of micro-organism in their composition. It's believed that the early life on Earth started from the micro-organism so its existence on Mars can help us in tracing the signs of life on Mars. It is believed that Mars once had Climate to support life and it's believed that traces of its past climate are buried beneath its surface. The confirmation of frozen Water Ice by NASA's Phoenix Mission in 2008 is a great success in our search for potential signs of life on the Red Planet. It's very difficult to think of life until and unless we have liquid water. We have not been able to trace out liquid water yet which is the foremost requirement for development of human lifecycle. The most recent discovery of rocky outcroppings by NASA's Mars Science Laboratory "Curiosity" shows that Mars once had significant water movements on the surface of the planet. The smoothed pebbles in rocky outcrops are similar to the rocks found on Earth. The latest findings about the signs of life on Mars and the vast similarities between those signs on Earth point towards Earth like conditions on Mars in the past. The discovery of signs of life on Mars and the rich similarities to the signs found on Earth can be a potential platform in establishing human habitation on Mars in the future.

INTRODUCTION

The ongoing exploration of Mars in search of traces of life on the Red Planet reflects the uttermost need of establishing human habitation on the Red Planet considering the rise of Global warming on Earth and the fear of loss of human life. The exploration of the Red Planet for the signs of life and the vast similarities between the signs of life on Mars to those on Earth points out towards the fact that Mars once had conditions to support life and still most them are hidden somewhere on the planet till they are explored. The similarities between the features on Mars and Earth shows that life could have existed in some form on Mars and there must have been Water flowing on the surface of the Red Planet in the past. With each and every mission to Mars the new discoveries about the existence of life increases our quest for other potential life supporting sources. The extraction of those life supporting features most importantly being the Liquid Water can fulfill our ambition of establishing human habitation the Red Planet in the future. The paper focuses on the life supporting features discovered on Mars and similarities to those features found on Earth in quest for future human habitation on the Red Planet.

LIFE ON MARS

Life on Mars has been subject of wide discussion from the very early beginning. In 1877, Giovanni Schiaparelli produced the first "modern" map of Mars, on which he showed a system of what he called canali, meaning "channels" but the term was mistranslated into English as "canals". In 1976 NASA' Viking landers carried a sophisticated instrument to look for possible life forms on the Martian surface. The Viking biology experiment weighed 15.5 kg (34 lbs) and consisted of three subsystems: the Pyrolytic Release experiment (PR), the Labeled Release experiment (LR), and the Gas Exchange experiment (GEX). In addition, independent of the biology experiments, Viking carried a Gas Chromatograph/Mass Spectrometer

(GCMS) that could measure the composition and abundance of organic compounds in the Martian soil. The most important result for the detection of life came not from the biology experiment, but from the GCMS. It found no trace of any organic compound on the surface of Mars. Organic compounds are known to be present in space (for example, in meteorites), so this result came as a complete surprise. The GCMS was definitely working, however, because it was able to detect traces of the cleaning solvents that had been used to sterilize it prior to launch. The total absence of organic material on the surface made the results of the biology experiments moot, since metabolism involving organic compounds were what those experiments were designed to detect. However, the results from the biology experiments were sufficiently confusing to be worth examining.

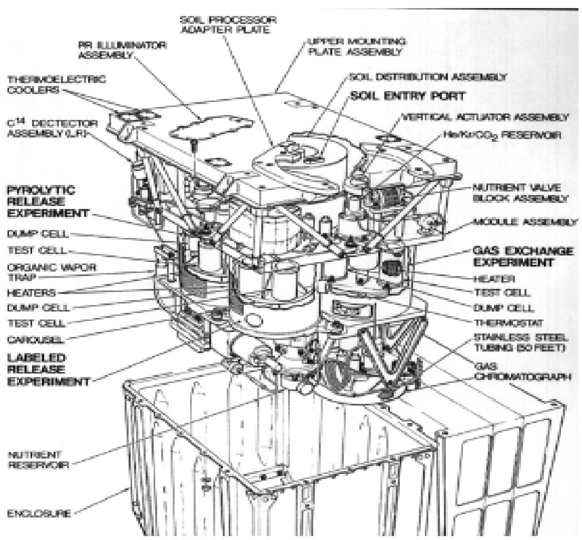

Fig.1 Viking Biology Experiment

The environment of Mars in the past was very different than it is today. Conditions then may have been favorable for the existence of life. Even though the Mars meteorite does not prove life once existed on Mars, it does not disprove the possibility. The rich similarities between the features explored on Mars and those found on Earth reveals that the conditions on Mars were much like the conditions on Earth in the past. In the past, Mars was much different than it is today. Liquid water used to flow on the surface in the past. Both Earth and Mars should have been frozen in their early history because the sun was weak at first, but both planets show that water was flowing, which suggests that they both must have had thick atmospheres in place to keep the surface warm. In this environment life may have once existed. The atmospheres on both planets came out of volcanoes. There were not many volcanoes on Mars, and those volcanoes were never very active. Compare this to the Earth where volcanism continues today. The volcanic eruptions produce a lot of water. The water eventually falls to the ground or into the oceans. Mars is small, and so cooled off very rapidly. Mars was sufficiently cold for water to be absorbed into the ground and freeze like tundra in the Canadian northwest. Today scientists estimate that a large amount of water is frozen into the surface of Mars. They estimate this happened by 2.8 billion years ago.

LIQUID WATER AND LIFE

Liquid Water is the first most important requirement for the development of life cycle. The Life supporting Oxygen generated by trees and plants is possible by the mechanism of Photosynthesis process for which water in liquid form is must in order to perform Photosynthesis process. Life on Mars has been subject of deep discussion much before the robotic missions to Mars started exploring for the traces of life on the Martian surface. The mystery behind the presence of Liquid Water on the Martian surface has been subject of deep interest to the scientists around the world from the very beginning. The most important question is that why are we hinting for liquid water on Mars. The answer lies in the molecule itself. First, the water must be in liquid form to allow for transport of the chemicals into the cells. Water vapor and water ice don't have nearly the same ability to transfer substances as liquid water does. Second, protein acts as catalyst within cells and requires more liquid water for proper function. Third, water has a few unique properties compared to other liquids that make it essential for life. (A) Water remains liquid over a wide range of temperature, permitting life to survive in climate and weather changes. (B) In opposite sense, liquid water has a high capability to hold energy, moderating weather and climate. (C) Unlike almost all other molecules, water floats when it freezes. This insulates the water below, which remains liquid below and supports life. (D) Water molecules are "polar", with slightly a positive and slightly negative side. Each end of the water molecule attracts other electrically charged particles. These polar substances, like sugar and salt that are essential for living cells, will dissolve easily in water, while non-polar molecules, such as oils and lipids making up cell membranes, are very difficult to dissolve. Hence before thinking of any human life on Mars, Water in Liquid form must be present on the Red Planet along with other life supporting minerals.

LIQUID WATER ON MARS- SIMILARITIES WITH FEATURES ON EARTH

The Global Water Map of Mars mapped by Mars Global Surveyor and the vast similarities between those features found on Earth gives a strong proof of water on Mars. The analogies between the water flow features on Earth and those mapped on the Martian surface shows that Water was flowing on Mars in the ancient time. A close up look of the features on the Martian surface reveals that the condition on Mars were much like the same as on Earth and it's believed that life might have existed on the Martian surface at that time when water was flowing on the Red Planet.

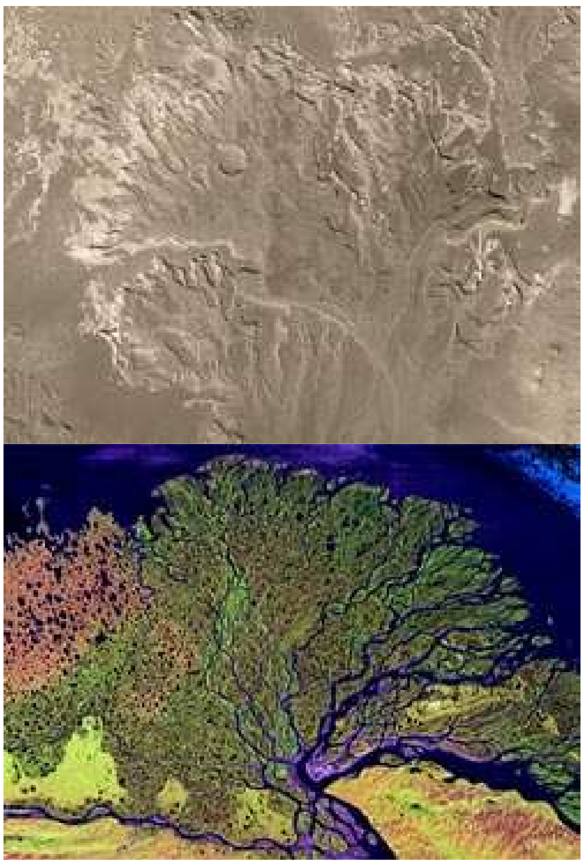

Fig. 2: In this set of images, the image on the top provided by Mars Global Surveyor, Mars Orbiter Camera shows the presence of meandering channels, a cut-off meander, and criss-crossing channels in the Eberswalde Delta provided the first clear evidence that some valleys on Mars experienced persistent flowing liquid over a long time period, much like rivers on Earth. While the image on the bottom provided by Landsat 7 Enhanced Thematic Mapper Plus shows that just before it empties into the Laptev Sea in northern Siberia, the Lena River splits into several small rivers that flow into a flat plain to create the Lena River Delta. At 4,400 km (2,800 miles) long, the Lena River is one of the largest rivers in the world. The pattern of Delta formation by the river water on Earth and the similar pattern on Mars give a strong indication about the presence of Liquid Water on Mars in the past.

Fig. 3: Mars Location

In the above figure this false-color image taken by Mars Rover Spirit's panoramic camera (Pancam) shows salt deposits on the basin floor of Gusev Crater on Mars. These salts may record the past presence of water on Mars, as they are most easily mobilized and concentrated in a liquid solution.

Fig.4: Earth Location
In the above figure the image shows evaporite deposits near springs in the region of Cuatrocienegas, Mexico. Evaporites are sediments that form from the evaporation of saline water.

The similarities in the physical features on Mars and the analog on Earth in the Figures 1 and 2,Figures 3and 4 shows possible proof of Liquid Water on Mars in the past when the Martian climate was warm enough to support existence of Liquid Water.

WATER ICE ON MARS

NASA's Phoenix Lander Mission in June, 2008 confirmed the presence of frozen Water Ice on the Martian surface. The mission designed for the exploration of Arctic Plains of Mars had the right instruments for analyzing soil and ice to determine whether the local environment just below the surface of far-northern Mars has ever been favorable for microbial life. The confirmation of Water ice on Mars gives strong indication about the possible presence of liquid water on Mars subsequently leading towards existence of life on the Red Planet.

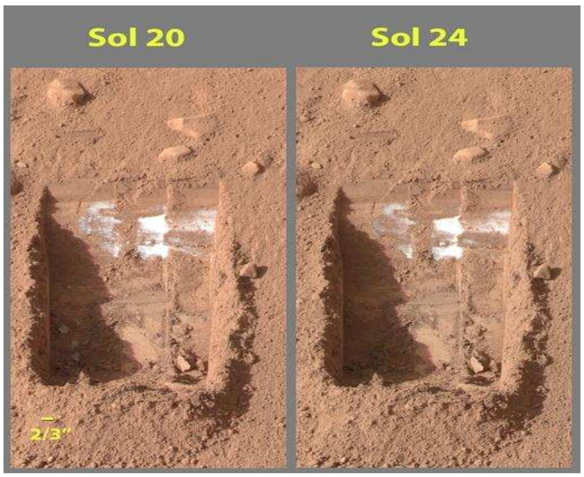

Fig.5: The color images acquired by NASA's Phoenix Mars Lander's Surface Stereo Imager on the 21st and 25th days of the mission, or Sols 20 and 24(June 15,2008 and June 19,2008). These images show sublimation of ice in the trench informally called "Dodo-Goldilocks" over the course of four day. In the lower left corner of the left image, a group of lumps is visible. In the right image, the lumps have disappeared, similar to the process of evaporation.

IRON BLUEBERRIES- EVIDENCE OF MICROBIAL LIFE ON MARS

Small spherical "blueberries' found in Martian rocks may have been formed by microbes, indicating that life existed on Mars in the distant past. The small spherical hematite balls, dubbed "blueberries" were discovered by NASA's Opportunity Rover in 2004 in the Martian soil. Researchers from the University of Western Australia and University of Nebraska have found that such iron-oxide spheroids, when they appear on Earth, are formed by microbes. If the 'blueberries' found on Mars are of a similar composition, it could provide long sought strong evidence for the existence of life on the red planet. On Earth, such spherical iron-oxide concretions are commonly found on beaches and deserts around the world. Similar examples to those discovered on Mars have been found in the Jurassic Navajo Sandstone near the Colorado River, Utah, where the concretions range in size from small marbles to cannonballs and consist of a hard shell of iron oxide surrounding a softer sandy interior. Previous theories suggested that they had been formed by simple chemical reactions, without any help from life forms. However the scientists at the both universities have showed that there is a clear relationship between the spheres found in Utah and biological elements such as carbon and nitrogen, which indicates that they were formed by microbes. These critters ate the iron and used the carbon as an energy source, starting a chain of chemical reactions that eventually created the blueberries. The team of scientists explained that "If the surface of Mars has been largely inactive for the past x billion years, then "blueberries' or other structures that exhibit an iron oxide rich rind and depleted interior may represent the intact fossilized remains of microbial activity".

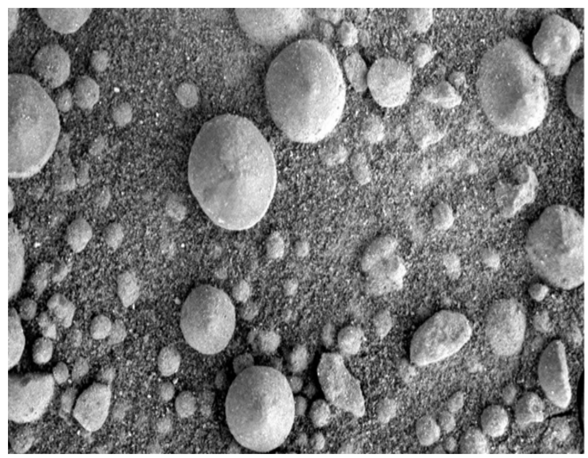

Fig.6: Blueberries spotted by NASA's Opportunity Rover, 200 meters north of Victoria Crater on Mars.

STREAMBED ON MARS

NASA's Mars Science Laboratory "Curiosity" discovered ancient water Streambed on the Martian surface. There is earlier evidence of presence of Water on Mars, but this evidence- images of rocks containing ancient streambed gravels- is the first of its kind found on Mars. The finding site lies between the north rim of Gale Crater and the base of Mount Sharp, a mountain inside the crater. The Rover found the evidence that stream once ran vigorously across the area on Mars. From the size of gravels it carried, we can interpret the water was moving about 3 feet per second, with a depth somewhere between ankle and hip deep," said Curiosity science co-investigator William Dietrich of the University of California, Berkeley. The rounded shape of some stones in the conglomerate indicates long-distance transport from above the rim, where a channel named Peace Vallis feeds into the alluvial fan. The abundance of channels in the fan between the rim and conglomerate suggests flows continued or repeated over a long time, not just once or for a few years.

Fig.7: Ancient streambed on Mars, named "Hottah" after Hottah Lake in Canada’s Northwest Territories.

PROOF OF WATER TRANSPORT ON MARS

NASA's Curiosity rover found a rock outcrop called Link pops out from a Martian surface that is elsewhere blanketed by reddish-brown dust. The fractured Link outcrop has blocks of exposed, clean surfaces. Rounded gravel fragments, or clasts, up to a couple inches (few centimeters) in size are in a matrix of white material. Many gravel-sized rocks have eroded out of the outcrop onto the surface, particularly in the left portion of the frame. The outcrop characteristics are consistent with a sedimentary conglomerate, or a rock that was formed by the deposition of water and is composed of many smaller rounded rocks cemented together. Water transport is the only process capable of producing the rounded shape of clasts of this size.

Fig.8: Rock outcrop called Link pops out from a Martian surface that is elsewhere blanketed by reddish-brown dust.

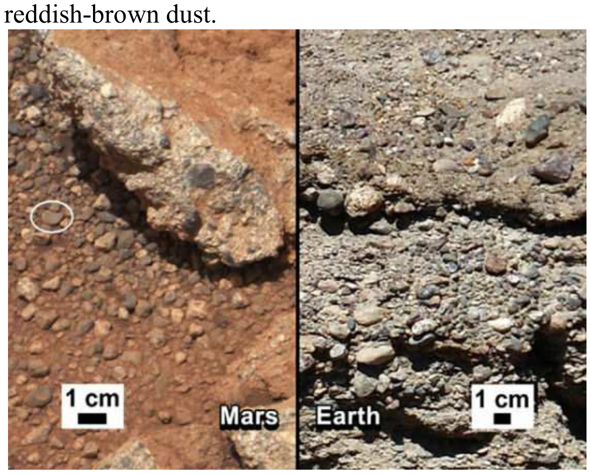

Fig.9: This set of images compares the Link outcrop of rocks on Mars (left) with similar rocks seen on Earth (right).

FOSSIL LIFE ON MARS

The meteorites falling on Earth have shown the composition of microorganism giving a strong indication of life on Mars in the past. Scientists believe that the early life on Earth started from the small microorganism. Hence the possible existence of microorganism in the composition of meteorites shows the possibility of existence of life on Mars. One such meteorite named ALH84001 was found in Antarctica in 1984. The study of this rock showed that it contains fossilized evidence of microbial life. In their paper in *Science* Magazine, Dr. David McKay of NASA and his co-workers give evidence that Martian bacteria may have lived in the Martian meteorite ALH 84001. McKay and his co workers describe three kinds of features in ALH 84001 that they interpret as evidence for ancient Martian life. These features are all in (and near) the carbonate mineral globules, which McKay and co-workers believe to have formed on Mars from liquid water. Life as we know it cannot form, multiply, or survive without liquid water. Liquid water acts as a solvent or catalyst for almost all the chemical reactions of life. So, McKay and co-workers have to show that ALH 84001 was infiltrated by liquid water, at least once, while on Mars. As all of McKay's evidence for Martian life is inside the carbonate mineral globules in ALH 84001, it is critical to show that the carbonate mineral globules are Martian and that they were formed by liquid water. This point that the carbonate mineral globules formed in Mars' ancient past is not really critical to the evidence for life. But an ancient age makes life more plausible. If, as McKay and co-workers report, the globules are 3.6 billion years old, they formed when Mars' atmosphere may have been much thicker than it is now, when temperatures were much warmer, and when liquid water could have been abundant. The surface of Mars now appears to be a sterile, frigid desert, most inhospitable for life that requires liquid water. Showing that the carbonate globules formed when liquid water was abundant makes it more plausible that they might contain traces of life. In the carbonate globules of ALH 84001, McKay and his co-workers found microscopic shapes that resemble living and fossil bacteria on Earth; microscopic mineral grains like some produced by living and fossil bacteria on Earth; and organic chemical compounds that resemble the decay products of bacteria on Earth. McKay and his co-workers found very small quantities of organic molecules near and in the carbonate mineral globules in ALH 84001. These molecules, called "polycyclic aromatic hydrocarbons" or PAHs, are a group of chemicals with similar structures; the only PAH that might be familiar to a non-chemist is napthalene, the chemical in mothballs. PAHs can form during decomposition of bacteria, but can also form in many other ways. In fact, PAHs are abundant in the carbonaceous chondrite meteorites, which are from the asteroid belt and did not ever contain life as we know it. McKay and co-workers try to show that the PAHs in ALH 84001 are derived from ancient martian bacteria by showing that they (1) are not contamination from laboratory procedures, (2) are not Earth PAHs that entered the meteorite while it was in Antarctica, (3) are not like PAHs in other meteorites (which have nothing to do with life), and (4) are consistent with decomposition of simple bacteria.

Fig.10: ALH84001 meteorite found at Allen Hills, Antarctica in 1984.

METHANE ON MARS

Methane, made of once Carbon and four hydrogen atoms, is one of the simplest organic compounds. On Earth, 90 to 95 percent of Methane in the atmosphere comes from biological activity, mainly methanogenic bacteria and cow farts. As a result, many researchers regard Martian Methane as a possible indicator of Red Planet life. The traces of Methane on Mars was first reported by a team of scientists at NASA' Goddard Space Flight Center in 2003. Many saw the presence of the gas as a clear indication of life on the inhospitable planet, as on Earth methane is produced predominantly by biological processes. Others assumed geological processes, such as volcanoes, to be the cause. There has been much speculation about its source in the Martian atmosphere. The best-known hypothesis states that microorganisms produce the methane, and is thus an indication of life on the red planet. Another hypothesis assumes the source to be geological methane sources in Mars' interior. Non detection of Methane on Mars in its first few sniffs of the Red Planet air by NASA' recent active rover Mars Science Laboratory "Curiosity" casts doubt on previous claims of Methane hotspots due to microbes on Mars. Non detection of Methane suggests no modern day microbes on Mars. While the Curiosity result would also seem to cast doubt on previous claims, one proponent, Michael Mumma, of Goddard Space Flight Center in Greenbelt, isn't backing down yet. The plume he detected back in 2003 was in a different part of the planet, and could have dispersed by now, nearly a decade later, at the rover's landing site. "Gale crater is not an auspicious place to search for current releases," he says. The Curiosity team plans to keep hunting for Methane over the course of Curiosity's two-year mission on Mars.

EXTRACTING LIFE SUPPORTING COMPOUNDS FROM THE RESOURCES ON MARS

The life supporting compounds on Mars can be extracted from the resources present on the Martian surface. The life supporting breathable air requires two components: Oxygen and a suitably inert buffer gas. On Mars, the most likely candidate buffer gas is a mixture of Ar and N_2 which together make up about 5% of the Martian atmosphere. Oxygen and Water can also be obtained from the atmosphere. The table below represents the amount of Mars air that must be processed to obtain these materials. Obtaining breathable air and water from the Martian atmosphere is appealing for many reasons. This resource is ubiquitous and fairly well described with the previous knowledge. Processing gases and liquids is much simpler and reliable than handling solids. Furthermost the concentration of CO_2 and Ar/N_2 in the atmosphere are virtually constant with the day and season. However water vapor rises considerably.

Mass Flow Rates and Energy Requirements for Resource Extraction

Resource	Source	Amount to be processed	Energy required
1 kg Ar/N_2	Atmosphere	1,700 m^3	9.4 kW-hr[a] ideal = 0.1 kW-hr
1 kg H_2O	Atmosphere	10^6 m^3 (T_{frost}=196 K)	103 kW-hr[a] ideal = 0.3 kW-hr
	Hydrated soil	100 kg	10 kW-hr[b]
1 kg O_2	Atmospheric CO_2	70 m^3	12 kW-hr[c] ideal = 2.5 kW-hr
	Soil oxidant	60 tons (O_2 = 790 nmoles cm^{-3})	?

Table.1: Table showing Mass flow rates and Energy Requirements for resource Extraction

CONCLUSION

The ongoing exploration of Mars and the discoveries about the mystery of the Red Planet provides a strong platform in our quest for future human habitation on Mars in the near future. The signs of life being discovered by the robotic missions to Mars provide us a strong background about the possibility of existence of life on Mars in the past or prospective life in the near future. The features of life discovered on the Red Planet like the Iron blueberries, rock outcrop and the vast similarities between these features found on Earth provides a strong platform in our quest for an Earth like environment on Mars. However the atmosphere of Mars which mostly consists of Carbon-Di-Oxide constituting about 95% of Mars atmosphere somehow rules about the possibility of survival of humans in the open atmosphere as like on Earth. It's impossible to think of human life until and unless we have Oxygen in the environment. The amount of Oxygen present in Martian atmosphere is approximately 0.14% as compared to the amount of Oxygen on Earth which is approximately 21%. Hence it is impossible for the humans to survive on Mars in the present condition. The amount of Nitrogen present in the Martian atmosphere is approximately 1.9% while the amount present in Earth' atmosphere is approximately 78%. Since Nitrogen is essential for vegetation growth hence it would be difficult to think of vegetation growth in the present Martian atmosphere considering the amount of Nitrogen present in the atmosphere. The present condition on Mars which is very cold rules out the possibility of presence of Liquid Water on Mars. The utilization of resources present in the Martian atmosphere to produce oxygen for human survival and for plant growth can be the potential sources of establishing human life on the Red Planet in the near future.

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