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The new Mars synthesis: A new understanding of the geochemical history of Mars

Abstract

The New Mars Synthesis is a new interpretation of the mass of Mars data from meteorites, Mars rovers, orbiters, and telescopes. This Synthesis proposes an Earthlike Mars in the past where a biosphere was a major force in shaping Mars geochemistry and did so until approximately ½ Billion years ago. This synthesis is based in part on data from ALH84001, younger Mars meteorites, and Viking life experiments that indicate life began on Mars 4.5 Billion years ago and has continued until the present day. Mars had a liquid ocean for most of its geologic history, that would have served as a refuge for life and stabilizer of Mars climate. The average age of most identified Mars meteorites is only ½ Billion years and indicates that the Mars cratering rate is at 4xLunar making the estimated ages of the Mars ocean and water channels roughly the Mars average surface age and indicating that liquid water existed on Mars for most of its geologic history. The high oxidation state of the Mars surface and exposed sedimentary layers, is consistent with massive photosynthesis in the past. The Lyot impact in the Early Amazonian appears to coincide with a lessening of liquid water channeling activity on Mars, suggesting it had a role in climate change on Mars. Therefore, a broad range of evidence indicates a living, Earthlike Mars until approximately ½ Billion years ago with a liquid ocean, and a photosynthetic biosphere. This indicates life not only began on Mars but had time to evolve into intelligent forms on Mars.

Keywords

Mars; Biosphere; Oxygen atmosphere; Biology, Gaia principle, Ocean, Mass extinction.

INTRODUCTION: THE BASIC STORY OF MARS GEOCHEMICAL HISTORY

It possible we now know the core story of Mars. The riddle of Mars's appearance, its many ancient water channels in what is now a frozen desert, its vast canyons exposing many layers going to kilometers' depth, the redness of the layers and its surface, the dry basin of an ocean, its many meteorites sent across the abyss to land on Earth, and even what appear to be massive archeological ruins, now tell a story as tragic as it is fascinating. We can now understand the riddle of Mars in large part. The key to the riddle is the word "life." With the understanding that Mars was once a living planet like Earth, its whole puzzling array of data can be understood to a great degree.

We speak here of a New Mars Synthesis[1]: a new overarching concept of Mars history based on the vast array of Mars data from meteorites, Mars landers and rovers, Mars Orbiters, ever-more capable telescopes, and a deepening understanding of life on Earth. The result of this new viewpoint on Mars is that the geochemical history of Mars cannot be understood without including biology as a factor in the climatic and chemical evolution of the Red Planet. Life is the one actor that allows us to understand Mars. With this one key piece, the whole puzzle of Mars falls into place. The New Mars synthesis has as its basic premises:

1 Mars, like Earth, was a living planet from the time liquid water could exist on its surface.
2 Mars had Earthlike conditions and thus a liquid ocean[2] and hydro-cycle for most of its geologic history this required a dense atmosphere with strong greenhouse effect.

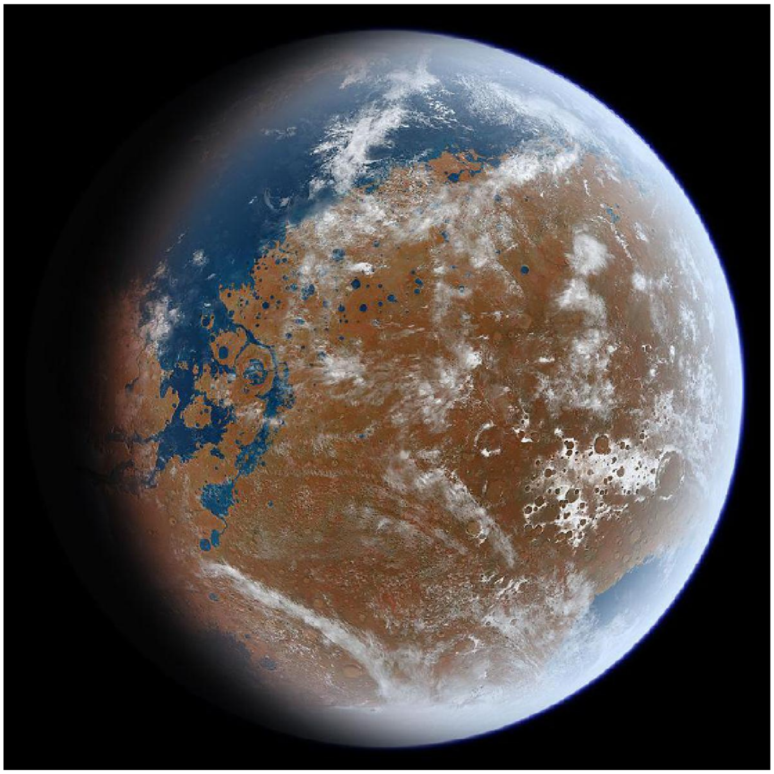

Figure 1 : Mars with its ancient ocean was essentially and Earth-like planet in the past

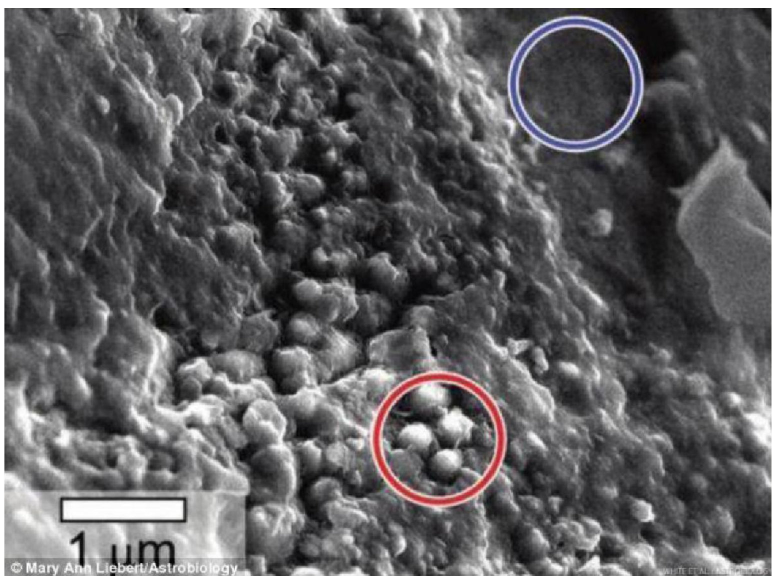

Figure 2 : Nano fossils found in a Mars meteorite

3 Mars not only had life but a biosphere that altered its geochemistry creating an oxygen atmosphere that helped stabilize the greenhouse: A Martian Gaia[3].

4 Mars cratering rate is approximately 4xLunar, making the apparent ages of the water channels and ocean much younger than present estimates with liquid water enduring until approximate ½ Billion years ago[4].

SUPPORTING EVIDENCE FOR AN EARTHLIKE MARS IN THE PAST

Based on the extensive evidence of life found by NASA researchers in ALH84001, the oldest of the Mars meteorites[5], and also more recent ones, Mars, like Earth, was apparently the dwelling place of life early in its history. Since early Earth rocks, 3.5 Billion years old, show signs of life also[6] the source of this life was most likely spores that have traveled between stars since some forgotten time in cosmic history. Life then originated far from Earth or Mars, "a long time ago, in a galaxy far-far away..." So Mars and Earth were both seeded from a common source. This concept is not new; it is called Panspermia, and was first discussed in

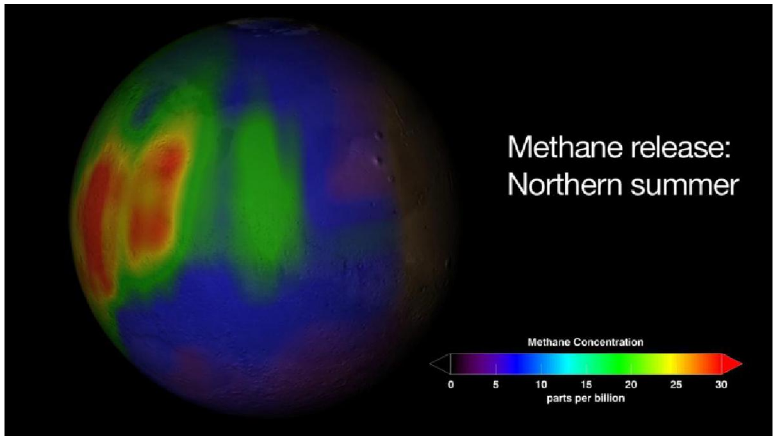

Figure 3 : Seasonal methane releases observed on Mars by telescope

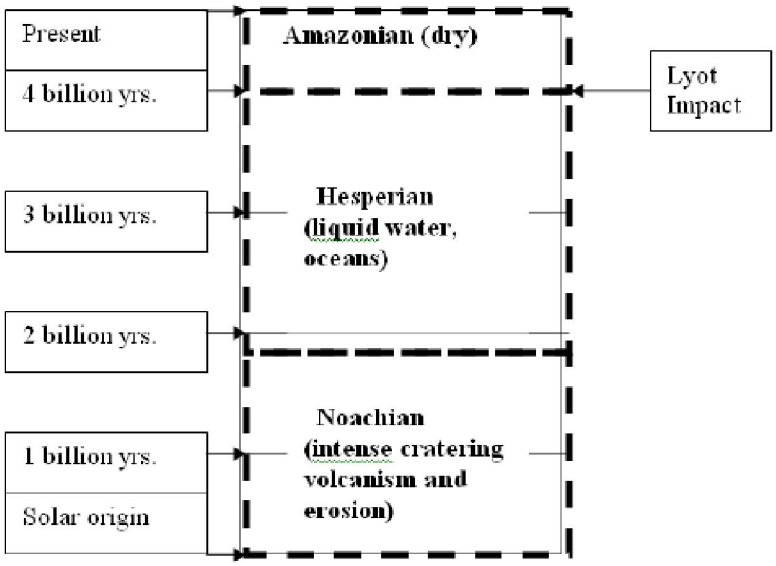

Figure 4 : The Geologic Ages of Mars, assuming an approximately 4xLunar cratering rate, epochs assigned based on the models in ref. 4

detail by the Swedish scientist Arrhenius[7]. The idea even predates him, going back in some form to Greek philosophers. So life predated the planets of this solar system and perhaps the galaxy itself. This would mean that Mars has told us the same story our own planet has, that we dwell in a living cosmos.

The results of the Viking Labeled Release experiment experiments on Martian soil[8], local methane releases observed by the Curiosity rover[9] and telescopic observations[10] of large scale seasonal methane releases into the Martian atmosphere are consistent with a biological remnant of a past biosphere on Mars.

We can now reconstruct a story-line for Life on Mars using the geologic ages on Mars seen in Figure 3. and the known history of life on Earth. Mars was smaller, so had less geologic heat and thus would cool more quickly. Thus, Mars life would have a head- start over Earth life, since Mars would have cooled earlier than Earth. This was during the Noachian epoch. The hammering of the leftovers of Mars accretion on its surface was less intense. It was farther from the early weak light of the Sun, so its initial dense greenhouse produced by carbon dioxide produced only moderate temperatures compared to the hothouse of the early Earth. Mars's core was hot and generated a strong magnetic field to shield it from cosmic rays and solar flares. The scattered waters of Mars would have gathered into one place in the north, abandoning, to a large extent, the highlands of the south. A hydro-cycle of evaporation and rainfall would have begun which filled rivers that emptied into the Northern Ocean. As Mars cooled, temperatures would have dropped to be very favorable to complex micro-cellular life with nuclei and a diverse set of enzymes for surviving in a wide variety of habits now forming on Mars. Thus did the Noachian age end.

Based on the Earthly record of life, this advanced Mars microbial life would have been very fertile and vigorous and spread through the northern ocean and rivers that fed into it. In keeping with Mars's smaller geologic heat engine, tectonic movements of stony plates ground to a halt after a short period. This meant oxy-

Figure 5 : Highly oxidized sedimentary layers exposed on Mars at gale crater

Figure 6 : A Comparison of two red planets: Earth and Mars. both Mars and desert areas of Earth are red due to hematite, highly oxidized iron

Figure 7 : What appears to be a fossil Martian marineworm. Found by opportunity rover

gen could begin building up its atmosphere from photosynthetic cyano-bacteria, since fresh lava rock was not being renewed on its surface to be a sink for oxygen. Mars began to thrive. This would have occurred in the Early Hesperian. The fact that oxygen began to appear in the Early Hesperian age on Mars is reflected in the fact that exposed strata in VallisMarinerisand elsewhere show bright red hues, showing iron in its highly oxidized “ferric state” Fe^{+3}.

Based on the Earthly record, as oxygen built up in the atmosphere of Mars, it began to determine the type of life that would dominate the Mars biosphere. This life was vigorous, powerful, aggressive, and always hungry. The oxygen created a protective double layer of UV protection, a molecular layer to stop the hemorrhaging of water, an ozone layer to protect life that crept out of the water onto land looking for food. The oxygen made Mars a slightly sour place, where carbon dioxide could find no resting place on the surface, and was locked into the sky. Mars’s atmosphere stabilized in pressure. It was secure from the Sun’s UV, and it was secure from chemical combination with the soil. The magnetic field of Mars began to die as the core of Mars grew colder; however, the oxygen layer created a dense plasma that trapped magnetic flux and thus shielded the atmosphere from the erosive bombardment of the solar wind, even as the core magnetism faded. Mars had suddenly become a good, stable place to live. Mars biosphere had now begun shaping its environment to make it more suitable for life: This would also occur later on Earth and is called the Gaia Principle[3].

Figure 8 : An “oxbow” lake on Mars, similar to those found on Earth, and indicating a river on Mars that flowed for millions of years

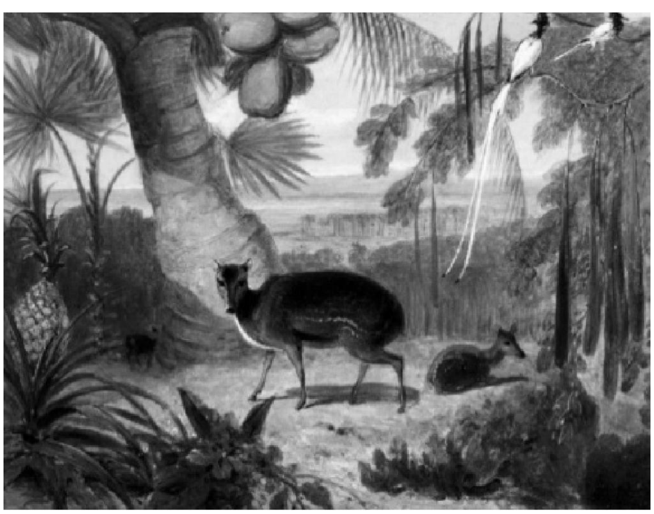

Figure 9 : How far did life advance on Mars in 4.0 billion years?

Life on Mars was running the place now, like the planet was a giant organism. This probably occurred in the middle of the Hesperian Epoch, approximately 2 Billion years ago. This would mean life of Mars was advancing far more rapidly that Earth-life at the same period. Earth would not achieve an oxygen atmosphere until 1.5 Billion years later. It was the young days of the Martian Gaia. Photosynthetic bacteria made oxygen to sustain the atmosphere. The oxygen created an ozone layer to stop UV and allow life to flourish on dry land. Other bacteria ate the sulfur and phosphorus from volcanoes and burned it with the oxygen to make energy and sulfuric and phosphoric acids to keep Mars pickled, and thus sustain its carbon dioxide green-

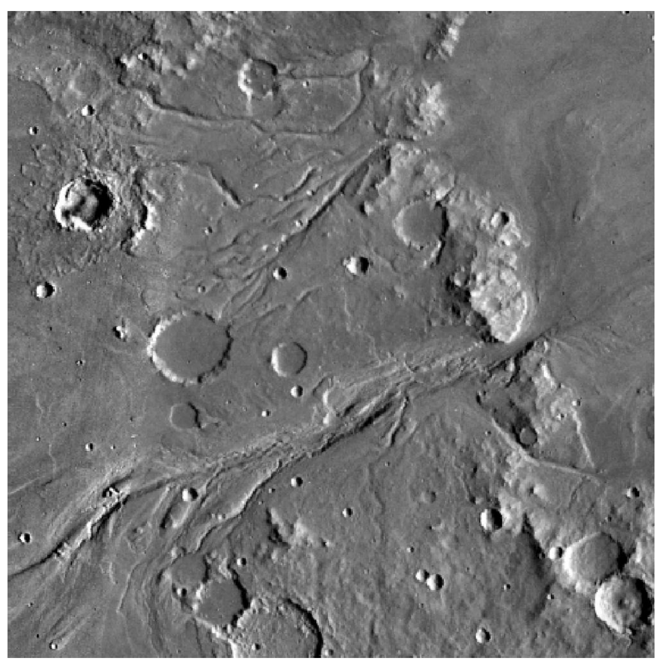

Figure 10 : Water flowing from craters.Obviously the cratering rater on Mars was higher than Earth or the Moon because of the nearby asteroid belt

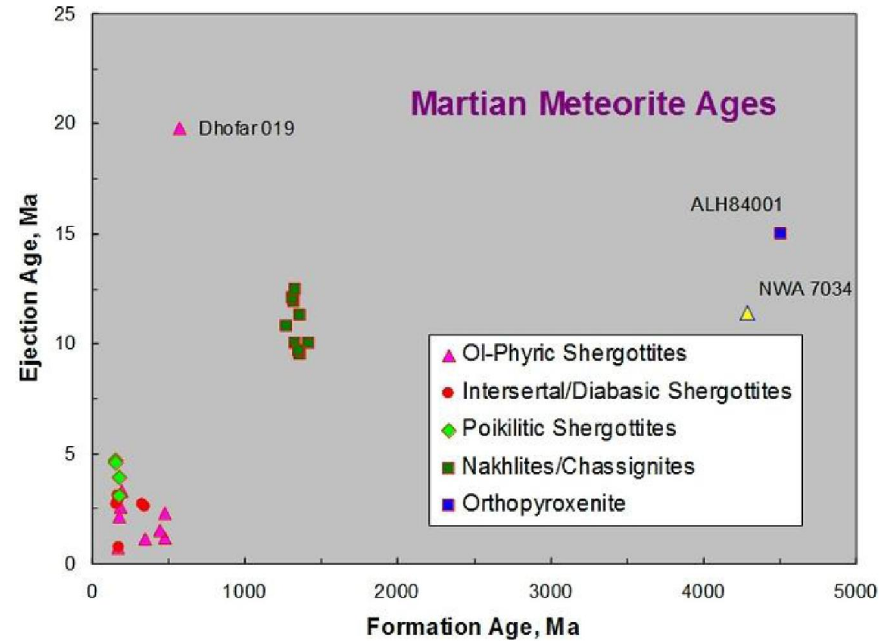

Figure 11 : Crystalization ages of Mars meteorites, Note the ages are skewed very much to young ages and thus represent a mean Martian surface age, NWA7034 data taken from reference 12

Figure 12 : Things might periodically go into a deep freeze on Mars

house. The vast geochemical engine of life kept Mars atmosphere full of oxygen and thus recycled all the CO_2 back into the atmosphere, sustaining the Greenhouse effect to keep Mars warm and wet. This was necessary to sustain Mars CO_2 greenhouse, which was unstable chemically over long periods. Without oxygen, and the acids it creates, the combination of CO_2 and liquid water forms carbonic acid which would attack the lava rocks of Mars to form carbonates with the reaction:

$2FeO + H_2CO_3 \rightarrow 2FeCO_3 + H_2O$

This iron, as found in the lava, would be in the ferrous (Fe^{+2}) oxidation state,however, with an oxygen atmosphere present oxygen would immediately attack the ferrous carbonate and form ferric oxide: rust, and free the carbon dioxide back into the atmosphere. This is same reaction that forms hematite iron ore (Fe^{+3})from ferrous iron carbonate on Earth, when it is exposed to the atmosphere:

$2FeCO_3 + 2O_2 \rightarrow Fe_2O_3 + CO_2$

Other bacteria would ferment the sugars made from photosynthesis and make methane to buttress the already formidable carbon dioxide and water vapor greenhouse. The oxygen and ozone layers protected the methane from the ultraviolet that would destroy it quickly, so instead the methane oxidized slowly. Other bacteria opportunistically ate the methane-making bacteria when they got too numerous, while other bacteria ate the methane itself when it became common, and turned it back into carbon dioxide and water from whence it came. Perhaps some even used the energy from this to move and at night and would emit light like fireflies, to proclaim their complete reversal of photosynthesis. Some bacteria began to eat the plant bacteria, and later, they ate any other bacteria that they encountered. Thus began an arms race on Mars. This was the Late Hesperian. Things evolved quickly, and plants invaded the land.

The biosphere on Mars would have begun to diversify and evolve. On Earth, bacteria quit merely congregating in mats where there was food, banded together in small platoons to hunt for food together. In unity there was strength, and movement, and successful hunting. Other bacteria banded together for protection from these roving units, and welcomed plant bacteria into their protective spheres to feed themselves in return for protection of the plants. We would expect all of this Earthly scenario to occur on Mars. Accordingly some units of bacteria on Mars would begin to get really organized and to develop specialist cells that did nothing but propel the colony by manning oar-like flagellum, others began acting as sensors of things to eat. Some would become grappling hooks to grab and pull bacteria and other smaller units into the killing zone of the hunting units. Some began to manufacture venom to kill whatever other units were encountered so they could be eaten more easily. Soon the ocean of Mars was an armed camp of prey and predator organisms, competing for food and for good places to live. At the water's edge organisms crept out onto the shore to outflank their competition or escape the mouths of those who could not follow. They found the shore more mellow and accommodating and they journeyed inland. They journeyed as far and wide and as high as they could. The great Martian biological enterprise was rolling and nothing, almost nothing, could stop it from attaining a highly advanced state.

Eons past, the troublesome asteroid belt next to Mars would occasionally visit the planet with terrible cataclysms, and life would be forced to retreat back into its burrows and to the oceans to regroup. Because it was nearer the asteroid belt Mars had a much high cratering rate than Earth or Earth's Moon.

The higher cratering rate at Mars explains the Meteorite Age Paradox: the fact that the vast majority of meteorites from the Red Planet have young geologic age, when most models of finding surface ages by counting craters predict old geologic ages[4]. (see Figure 10) Only two meteorites: ALH84001 and NWA 7034, are old[11].

The 4xLunar rate of bombardment of Mars, required[4,12] to bring Mars surface ages in line with the ages of Mars meteorites, is approximately 4 times that of the presently accepted model13. Occasionally big impacts would occur, but the ocean and the greenhouse held. Carbon dioxide might condense on the poles sometimes, but reinforced by the warm ocean and the methane as its backup greenhouse gas, Mars's climate would recover. Life would thrive again, this time even more tenacious and resilient.

Because of this 4xHigher than Earth bombardment rate, Mars would have favored life that could survive the occasional cold spell. Life on Earth is known to be tenacious and adaptable. Accordingly, life on Mars that could construct its own Noah's ark of a spore like covering, impervious to cold, to low pressure, to radiation that would leak through the occasionally thinned atmosphere, would come to dominate the place and when this life found itself suddenly grounded on a Mount Ararat after the flood, it would aggressively sally forth and begin hunting for food and places to live. Life was therefore favored that knew to be afraid and retreat to a cave when bright flashes occurred and winds blew, and perhaps take a nap. Successful life was the first to emerge and devour the frozen dead and have a new crop of offspring to dominate the thaw. Mars was where the survival of the fittest meant the cultivation of good habits, and a keen awareness of when to run for cover and go dormant.

Based on Earth's biosphere, we would expect that on Mars the biosphere pulsed with activity and continued to rule the planet. Then, the inevitable large impact occurred. An asteroid much larger than anything in the previous two Billion years impacted Mars. The impact was near the northern ocean shore, concentrating its force and dust cloud in the north, this was the Lyot impact. Based on the record of Earth's life, such a massive impact would have created mass extinctions on Mars.

It now seems possible that life on Mars survived even this last great extinction, and headed off in a new direction. Mars may have become drier and colder after the Lyot impact[14]. It now appears possible that just like the Chixulube impactdoomed the dinosaurs and paved the way for Mammals to take over the Earth, thus leading to humanity, so also on Mars the Lyot Impact may have set Mars on a course where intelligence rather than brute force came to dominate evolution. Thus the Lyot impact may have led the way to intelligent life on Mars.

SUMMARY AND CONCLUSIONS

Therefore, the redness of Mars surface and exposed sediments: indicating a past oxygen atmosphere, the ocean bed on the youngest part of the Mars and the many water channels leading from craters that functioned as lakes, the young age average age of the Mars meteorites, indicating a young surface average surface age of Mars and finally the evidence of past biology from these Mars meteorites, all present a picture of Mars past that was very Earthlike and alive in the past. This Earthlike Mars with a massive photosynthetic biosphere creating an oxygen atmosphere, chemically stabilized a heavy CO_2 greenhouse that maintained Earthlike temperatures with a liquid ocean and hydro-cycle. Mars did not just have life but a biosphere that altered its environment to sustain itself: a Martian Gaia. Based on the measured ages of meteorites ejected from random sites of Mars, an average surface age of approximately ½ billion years is found. This is consistent with an approximately 4xLunar cratering rate on Mars, as would be expected due to Mars location near the asteroid belt. This means the ages of the

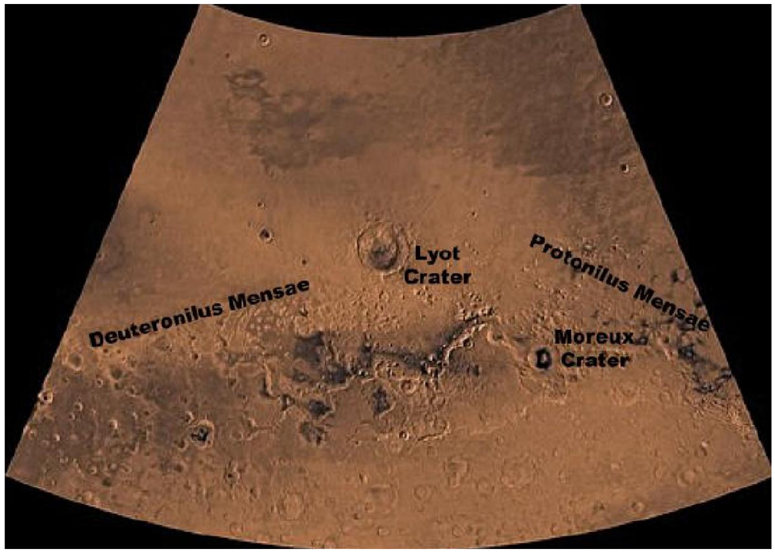

Figure 13 : The Lyot Impact basin which is near Cydonia and is a massive double-ring crater whose outer ring is 200km in diameter, similar in size to the Chixulube crater on Earth, which destroyed the dinosaurs

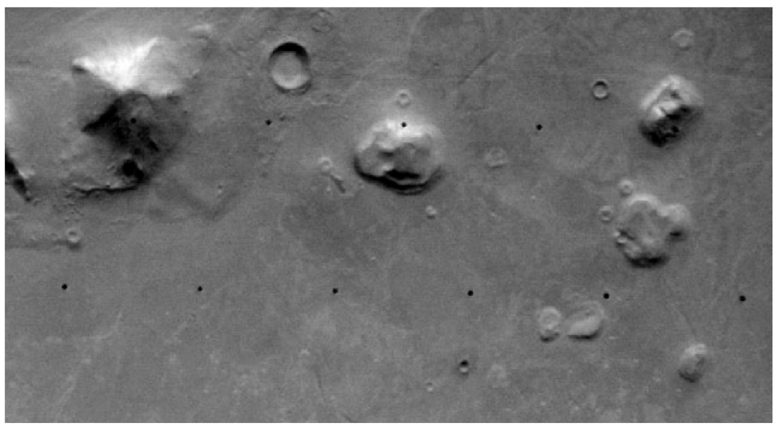

Figure 14 : Viking image 70A13 showing the face and D&M pyramid at Cydonia mensa on Mars. This may indicate the extent of advancement achieved by Mars life

northern ocean and water channels are all much younger than previously supposed and that Mars had Earthlike conditions until approximately 250 million years ago. This means that Mars life not only existed and shaped its environment, but it endured for a long period of geologic time. Based on an Earth-reference, Mars life would have had time to evolve intelligent life.

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