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Citation Analysis On The Structure, Composition And Habitual Possibilities Of The Martian Atmosphere

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Abstract

The concerned study is an analysis of the Red Planet Mars's atmosphere and its various aspects in the past, present as well future and, thereby, the possibility of life on the planet, which has been done via the citation analysis of related journals and publications with keywords mars, Martian atmosphere, and life. The citation network developed by VOS Viewer is used for the statistical and conceptual analysis of the concerned papers. The studies of the Martian atmosphere have a significant impact on knowing the atmospheric compositions and dust storm activities in the Martian atmosphere. This work can be a valuable reference for further investigation in the field for having a smooth experimental and habitual environment.

Keywords: Citation Analysis, Mars, Martian Atmosphere, Life, Dust Storms, GCM

1. Introduction

Throughout recorded history, the planet Mars has been the main focus of potent scientific interest, and the urge of the public to know about the information gathered about the planet is profound. The comprehension of Mars has changed dramatically in the past years due to the valuable information contributed by Earth-based telescopes, orbiting telescopes, and spacecraft investigations. The existence of water and the planet's climatic and geologic history has played an essential role in understanding the planet's deep history, implying that the Earth was once capable of hosting ecosystems and that it may still be an incubator for microbial life today. The first generation missions to Mars started in the 1960s. Astronomers carefully mapped Mars' movement across the sky long before the telescope was created in 1609. Careful observations regarding the movement of Mars across the celestial sphere led to derive two finding about the planet.

First, they discovered that the sidereal period, the amount of time needed to return to the same position in relation to the stars, is equivalent to around 687 Earth days. The second thing is the strange looping path across the sky (Fossil Hunters). Mars also played an essential role in determining the shape of the planetary orbits. The Surface of Mars is composed of loose dust and rock covers. The size is about 5974 km/4200 miles, its mass is 6.5×10^{23} kg, and its density is 3900 kg/m^3. Mars is less dense than Earth (Earth's density is 5510 kg/m^3). The surface gravity of Mars is only about 38% (1/3rd) of the surface gravity on Earth. It is home to large volcanoes like Olympus Mons, the largest in our solar system, and mountains, some of the largest in our solar system. Unlike Earth, Mars has two Moons, namely Phobos and Deimos. Mars's entire surface area is similar to that of all of Earth's continents combined.

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The martian atmosphere was determined in the mid-1970s by the Viking landers. Mars is a terrestrial planet with a thin atmosphere consisting of 95% Carbon dioxide, 3% Nitrogen, 1.6% Argon and traces of Oxygen and Water. The amount of water vapour in the Martian atmosphere, which was measured at 0.03%, is substantially lower than it is on Earth. However, a hard trap effect—a standard laboratory procedure—causes a seasonal net movement of sublimed water vapour from the warmer and more permanent northern polar cap to the colder and permanent southern polar cap. In comparison to Earth's atmosphere, which has a mean molecular weight of 29 g/mole and is dominated by oxygen and nitrogen, Mars' atmosphere has a mean molecular weight of 43.3 g/mole (Science Direct). Since the planet lacks an intrinsic magnetic field, unlike Earth, there is no magnetosphere on Mars, so the solar wind interacts directly with the Martian ionosphere, lowering the atmospheric density by stripping atoms from the outer layer. Despite the reddish appearance, the Martian atmosphere is colder than Earth's. Because of the oxidizing nature of the Martian atmosphere, photochemical processes frequently lead to the oxidation of organic species and their conversion to carbon dioxide or carbon monoxide. Despite the recently launched and the most sensitive probe ExoMars Trace Gas Orbiter failed to find methane in the entire Mars's atmosphere, unexpected methane levels were found in the Martian atmosphere by a number of earlier missions and ground-based telescopes. In the middle of the 20th century, scientists began taking measurements of the Martian atmosphere because of advancements in spectrometer technology and growing comprehension of the optical characteristics of atmospheric gases. Two Viking programme landers gave the first ever in situ measurements of the Martian atmosphere's structure in 1976. The gases present on current Mars are diminished in lighter stable isotopes, suggesting that during the course of its history, some mass-selected processes have altered the Martian atmosphere (Wikipedia). When attempting to reconstruct the ancient Martian atmosphere, scientists frequently turn to observations of the isotope composition. Any landing site on Mars has access to the known composition of the Martian atmosphere. It has been suggested that human exploration of Mars could use methane that could be produced from the atmosphere's carbon dioxide as rocket fuel for the mission's return.

The atmosphere is dusty, containing about 1.5 micrometers in diameter particulates, which give the Martian sky a tawny color when seen from the Surface. The average temperature of Mars is about -80^{0}F or -60^{0}C. It can vary from -195^{0}F at the poles during winter to -70^{0}F at the equator around midday. The carbon dioxide-rich atmosphere is also about 100 times less dense than Earth's average. Nevertheless, the atmosphere is thick enough to support clouds and winds. This red planet has significant amounts of ice caps on its polar regions, the only planet other than Earth in our solar system to have so much ice. In fact, if the ice on its solar pole is melted, the resulting water would be sufficient to cover the planet's entire Surface to a depth of 11 meters. The elongated Mars's orbit causes the length of a year on Mars to be about 687 Earth days. However, the length of a day is almost the same as Earth's 24 hours and 37 minutes. Since the 1960's space programs from around the world have launched missions to Mars and attempted to understand the planet's past, present, and potential for sustaining life. Dozens of crewless space crafts, including orbiters, landers, and rovers, have been sent to Mars by the Soviet Union, United States, Europe, India, UAE, and China to study the planet's surface, climate, and geology. As of 2022, Mars is currently hosting 14 functioning spacecraft: eight in orbit and six on the Surface – the Mars Odyssey, Mars Express, Mars Reconnaissance Orbiter, Mars Exploration Rover Opportunity, and the Mars Science Laboratory Curiosity, Perseverance.

The objective of the present study is to understand the current status of published works on the structure, composition, and habitual possibilities of the Martian atmosphere from the clarivate database ascended from Web of Science and thereby generated citation network is used for the chronological review of the concerned paper. The scientific reasons for going to mars and related exploration results are investigated from the rest to comprehend whether or not the scientific community accepts the existence of life on mars.

2. Methodology

The Martian atmosphere and its various aspects, thereby, the possibility of life on the Red Planet, is thoroughly studied using the related articles, journals, and papers via the retrieved database from the Web of

Science followed by the Citation network developed by VOS Viewer. From the obtained data, it gets known that till the year 2022, there were 726 publications, out of which 629 articles, 80 review articles, 77 proceedings papers, eight early access, eight editorial materials, seven meeting abstracts, four book chapters, surplus there were news items, notes and retracted publications on Martian atmosphere and its diverse aspects. The preceding citation analysis is used to endure the Knowledge about the past, present, and to some extent, the future epochs of the atmosphere of Mars and examine the results of various papers discussing the structure, composition, and habitual possibilities of the Martian Atmosphere. The theoretical papers comparing the experimental results and papers that discuss the investigation of Martian atmospheric behavior beneath the experimental data using spacecraft missions, papers discussing only the theoretical analysis were considered under this citation analyzing study. A vast range of information that could be collected from the result of certain selected papers with more citations is authentically reviewed. Such 20 papers with more citations from the database are thoroughly investigated using filtering the database on the essence of the current study.

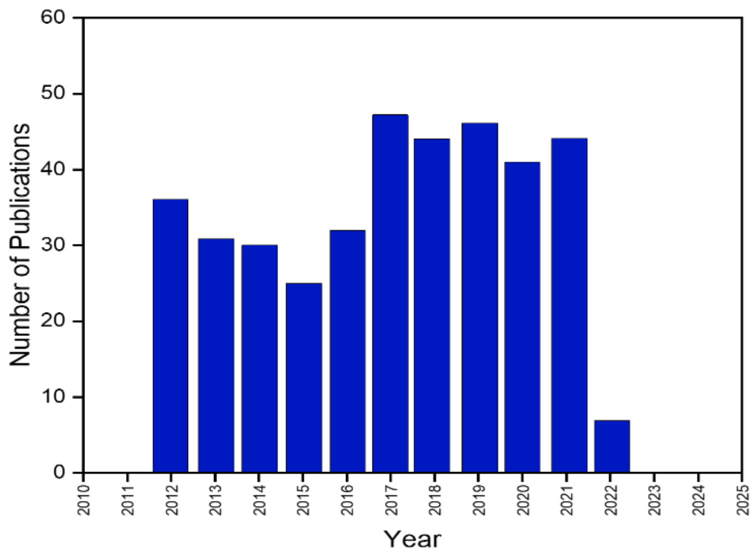
SL. No.	Title (Author, Year) of the document	Total Citation
1	Improved General Circulation models of the Martian Atmosphere from the Surface to above 80km- (F.Forget, 1999)	1216
2	Interannual Variability in TES Atmospheric Observations of Mars during 1999-2003- (Michael.D.Smith, 2004)	826
3	Detection of Methane in the Martian Atmosphere: Evidence for Life?- (Vladimer A Kransnopolsky, 2004)	687
4	Properties & Effects of Dust particles Suspended in the Martian Atmosphere- (James B Pollack, 1979)	644
5	A Photochemical Model of the Martian Atmosphere- (Hari Nair, 1994)	384
6	Properties of Dust in the Martian Atmosphere from the Imager on Mars Pathfinder (IMP)- (M.G.Tomasko, 1999)	340
7	Photochemistry and Evolution of Mars' Atmosphere: A Viking Perspective- (Michael B Mcelroy, 1977)	294
8	Spacecraft Observations of the Martian Atmosphere- (Michael.D.Smith, 2008)	197
9	Diurnal Tide in the Martian Atmosphere- (Richard.W.Zurek, 1975)	190
10	Life Detection by Atmospheric Analysis- (Dian R Hitchcock, 1966)	184
11	Outgassing History and Escape of the Marian Atmosphere and Water Inventory- (Helmut Lammer et al., 2013)	180
12	Evolution of the Martian Atmosphere- (Robert.O.Pepin, 1994)	165
13	Structure and Composition of the Neutral Upper Atmosphere of Mars from the MAVEN NGIMS Investigation- (P. R. Mahaffy, 2015)	163
14	Heterogeneous Chemistry in the Atmosphere of Mars- (Franck Lefevre, 2008)	159
15	The Martian Atmosphere: Mariner 9 Television Experiment Progress Report- (C.B.Leovy et al., 1972)	156

16	Rocket Dust Storms and Detached Dust Layers in the Martian Atmosphere- (Aymeric Spiga, 2012)	130
17	Baroclinic Wave Transitions in the Martian Atmosphere- (M.Collins, 1995)	110
18	Influence of Gravity Waves on the Martian Atmosphere: General Circulation Modelling- (Alexander.S.Medvedev, 2011)	95
19	Structure and Composition of the Neutral Upper Atmosphere of Mars from the MAVEN NGIMS Investigation- (P. R. Mahaffy, 2015)	78
20	Atmosphere Biomarkers of Subsurface Life on Mars- (Michael E Summers, 2002)	77

Table 1: Selected documents related to the keywords Mars, Martian Atmosphere, Life (Web Of Science)

3. Results and Discussion

From the study, it gets known that from 1989 to 2022, there were 726 publications, out of which 629 articles, 80 review articles, 77 proceedings papers, eight early access, eight editorial materials, seven meeting abstracts, four book chapters, surplus there were news items, notes and retracted publications also. The year 2017 saw the highest number of publications, with around 47, besides the year 2019, with 46 publications, and the past year 2022 witnessed 44 publications (Fig 1). Most of the contributions to the field were by Schuerger with 33 and McKay C.P. with 32 disseminated works, and Lammer H, Cockell CS follows the hierarchy with 28 and 17 documentations (Fig 3). It is observed that there were publications from the USA (397), France (118), Germany (115), and England (84), which nailed in the first four places, and also the list includes Japan (57), Austria (55), Spain (50) (Fig 2). India has contributed ten concerned documents and is in the 20th place on the list. And hence it is known that most of the studies about the Martian atmosphere and concerned areas were concentrated in the USA; afterward, there was France and Germany. A spectrum of information was collected from certain selected papers with more citations. And among the collected papers, 1134 is the highest citation number published by F.Forget et al. in 1999. The papers predominantly found on the citation network are used for collecting the findings, and their discussions are made.



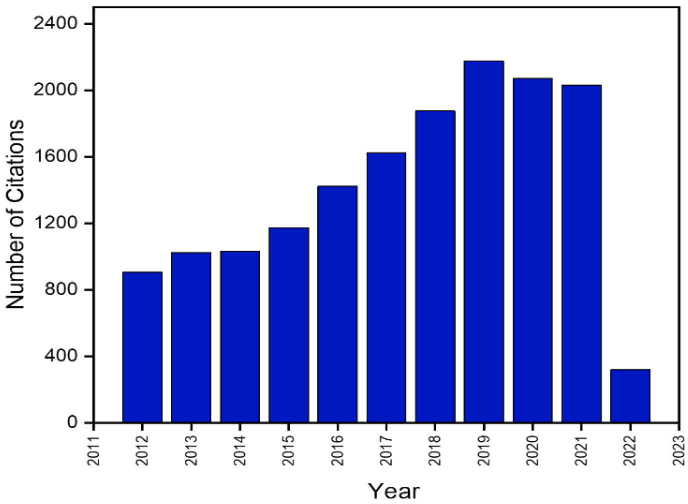


Figure 1: Graph showing the total number of publications and total number of citations for documents related to Mars, atmosphere, and life

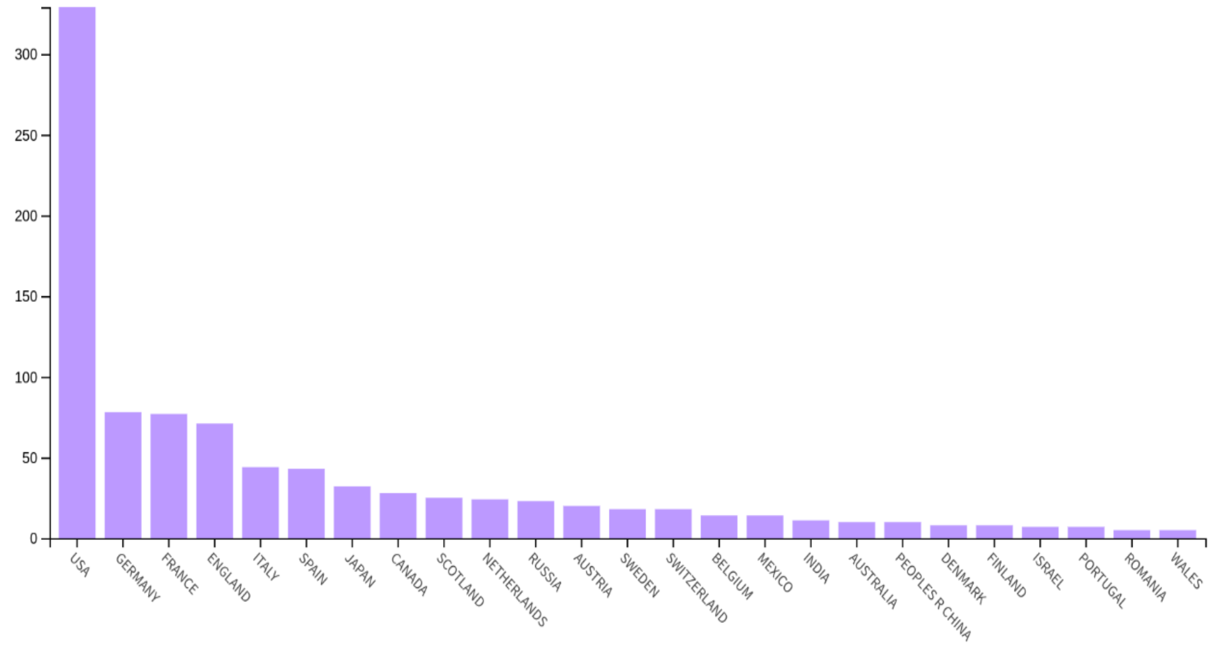


Figure 2: Graph showing the relation connecting the number of publications and country

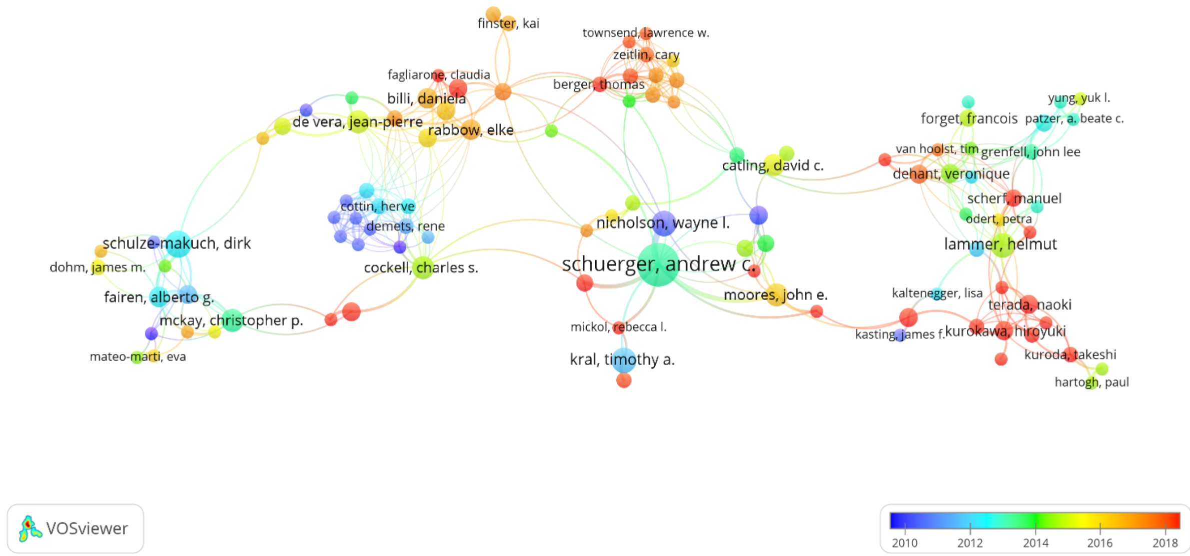


Figure 3: Citation network co-authorship analysis with keywords Mars, Martian atmosphere, and Life (Each item stands for an author).

As far as the experimental information is concerned, the methodology of the Martian atmosphere has been studied from the in situ data collected from the spacecraft, earth-based techniques, and ongoing orbiters and rovers on Mars. Most studies used specific mathematical models to compare and predict the Martian atmospheric phenomena and their properties.

The general circulation model, a computer-driven mathematical model, was used by F Forget et al., which developed a new set of two "new generation" GCM of the Martian Atmosphere studied the Martian atmosphere from the ground to above 80km and produced a Martian climate database. The average temperature obtained using this GCM model is vaguely too warm compared to the observational data from on-site spacecraft and Earth-based instruments. The upper Martian atmosphere is extremely sensitive to poorly constrained processes over Mars. And this high sensitivity may occur due to the coupling of the upper and lower Martian atmosphere via wave propagating vertically (F.Forget, 1999). Martian atmospheric chemistry-related inference reported by Hari Nair et al., with a 1D photochemical model, examined the constituents like CO, O_2, and O_3 in the Martian atmosphere. As per their study oxygen escape flux of 1.2 x, 10^8 cm^{-2}/s (Hari Nair, A Photochemical Model of the Martian Atmospehre, 1994) is required to agree with the observed atomic hydrogen flux of 1.8 x 10^8 cm^{-2}/s (Donald.E. Anderson, 1971). A baseline model, which is a simple model to set up and, in turn, gives level-headed results, was used by Robert O Pepin to understand the evolution of the Martian atmosphere from past to present conditions with a particular set of assumptions and parameterizations. Xe (Xenon) and $\delta^{13}C$ sustain as isotopic tracers of atmospheric history before the transition to low pressure (Robert.O.Pepin, 1994). Sputtering losses and the series degassing is the reason for the isotopic constraints, which wasn't mentioned as the real cause of isotopic evolution in the post-3.7 Gigayear era in the early developed isotopic evolution models of the Martian atmosphere. Franck Lefevre et al. make out a comparison of the photochemistry of Martian atmosphere ozone predicted by the General Circulation Model sophisticated, created at Dynamic Meteorology Laboratory (LMD), and the data collected by the SPICAM almost exceeding one Martian Year inferred hydrogen radicals quickly destroy ozone, it is a sensitive tracer of the chemistry that regulates Mars' atmosphere and implies that heterogeneous chemistry on ice clouds has a significant impact on the stability and composition of the Martian atmosphere. The LMD GCM was integrated on 32 vertical levels from the ground up to around 120 km at a resolution of 3.75u latitude and 3 5.625u longitude (Franck Lefevre, 2008). Alexander S Medvedev developed a nonlinear spectral gravity wave (GW) parameterization using the Martian general circulation model (GCM) expanded to a height of about 130 km and found particularly significant temperature changes take place above the winter pole when GW-altered meridional circulation raises both "middle" and "upper" atmosphere maxima by up to 25 K (Alexander.S.Medvedev, 2011).

Michael D Smith uses experimental data for the theoretical analysis, which used the data provided by the Thermal Emission Spectrometer and focuses on its complete analysis, thereby giving an overview of the Martian atmospheric data obtained from TES data during mapping operations of Mars Global Surveyor. They have examined inter-annual variability in water vapor column abundance, which failed to observe by the Viking RTM. Also, I have done a seasonal assessment and variability of the current Martian climate (Michael.D.Smith, 2004). In studying the Martian sky brightness, the Imager on Mars Pathfinder (IMP) camera observed the brightness distribution at wavelengths from 444nm to 965nm over three months on the Martian surface (P.H Smith, 1997). M G Tomasko et al. assert that the entire aerosol observation sequences and IMP panorama image sequences of the Martian sky opposite to the Sun it can find any correlations of aerosol properties with the variations in extinction optical depth observed during the IMP mission, able to find the imaginary refractive index variations at individual IMP filter wavelengths. Martian suspended dust particles have an average geometric cross-section weighted particle radius of 16±0.15 micromet (M.G.Tomasko, 1999). Michael D Smith, in 2008 reviewed the data from various spacecraft missions to analyze the present state of the Martian atmosphere about 60km from the Surface. The water vapor is most significant in both hemispheres near the summer pole. Unlike the aphelion season, the biggest inter-annual variance occurs during the perihelion season, which is characterized by occasional massive dust storm episodes (Michael.D.Smith, 2008). Mariner 9 spacecraft captured pictures were investigated by C B Leovy et al., dust storm conditions in the Martian atmosphere, southern spot volcanoes, and height over which confident elemental presence of carbon dioxide was inferred, the Martian atmosphere is highly veiled by a global dust storm during the initial period of the orbit that is during the global storm dust was blown to heights of more than 30 kilometers. This dust storm could have a single-scattering albedo of between 0.7 and 0.85. These low numbers imply that the mean particle radius was comparable to that in bright areas, i.e., greater than 10/micrometer (C.B.Leovy et al., 1972). P R Mahaffy et al. investigate the composition and structural analysis of the upper neutral Martian atmosphere from the MAVEN (Mars Atmosphere and Volatile Evolution) NGIMS (Neutral Gas and Ion Mass Spectrometer) data and is reported that it provides sensitive detections of neutral gas and ambient ion composition of Martian atmosphere.

James B Pollack et al. analyzed Martian sky brightness, and those results were helpful in the definition of radiative properties of the suspended dust particles in the Martian atmosphere, where the properties of dust particles and their role behind the dust storm formation were reported. It is this dust particle that sediments from the polar laminae of the Martian surface. They derived an approximate rate of erosion for equatorial and mid-latitude regions of Mars as 7m/million years (James B Pollack, 1979). Richard W Zurek reported about the everyday thermo-tides and their variation in the Martian atmosphere, where Martian diurnal tide in its global form can sustain the global dust storms on the Red Planet. Static and shear instabilities nested within the tidal fields will generate substantial, albeit variable, zones of turbulence in the middle Martian atmosphere (Richard.W.Zurek, 1975). This turbulence's vertical mixing and transfer by the tide itself may stabilize the middle Martian atmosphere against light-induced breakdown or separation of molecules, which is against photolysis. Examining the Surface pressure data from the Viking Lander mission and GCM simulations of the Martian atmosphere, remarkably consistent oscillations with bimodally distributed frequencies and peaks corresponding to durations of roughly 2-4 and 5-7 days, respectively (M.Collins, 1995) are observed and have reported transitions of baroclinic waves in the Martian atmosphere. As per Aymeric Spiga et al., the principal climatic agent in the Martian environment is airborne dust; they forecast the evolution of a local dust storm recorded by OMEGA on board Mars Express using mesoscale modeling that incorporates the movement of radiatively active material. The high-altitude tropical dust maxima detected by Mars Climate Sounder are consistent with the peak activity of rocket dust storms predicted to occur in low-latitude regions during clear seasons (Aymeric Spiga, 2012). Using the Field Mill measurements of dust devils (dust devil is a solid, well-formed, and relatively short-lived whirlwind), where a field mill is an electromechanical device that measures the electric field strength in the atmosphere with the vital parameter called atmospheric electricity, it is observed that electric fields of 10 kV/m to 100 kV/m is at the Surface beneath suspended dust in the terrestrial atmosphere. Some electrification has been observed to persist in the dust at levels to 5km, as well volcanic mixtures (R. G. Harrison, 2015).

Martian atmosphere evolution is considered the isotopic configuration of oxygen and nitrogen measurements and is essential in analyzing the constraints on the evolution of the Martian atmosphere. Measurements of noble gases in the Martian atmosphere (Owen T, 1976) pose additional constraints on planetary evolution. Like earth Mars too have a thermosphere, and the temperature measurements by Viking in the thermosphere of Mars show it is below 200^0K, which means it is much colder than those given by remote sensing experiments on Mariner 6, 7, and 9 and Mars 3 (Michael B Mcelroy, Photochemistry and Evolution of Mars's Atmosphere: A Viking perspective, 1977). The abundant nitrogen N_2 in the past atmosphere of Mars is more than that of the presence of much carbon dioxide CO_2 in the present Martian atmosphere. The planet is said to have superabundant sources of H_2O. It is inferred that the nitrogen abundance in the atmosphere of Mars acquired this in its early time. Helmut Lammer et al. covered the effectiveness of EUV-powered escape during the early Noachian and its impact on the formation of a secondary CO_2 atmosphere and focused on non-thermal atmospheric escape to space as well as potential surface sources of CO_2 and H_2O that allow the surface pressure to reach its current amount (Helmut Lammer et al., 2013).

Methane, a prominent bio signature detected on Mars in trace amounts Vladimir A. Krasnopolsky et al., worked on the spectrum of Mars observed using the Fourier Transform Spectrometer at the Canada-France-Hawaii Telescope (Vladimer A Kransnopolsky, 2004). For the apodized (a signal processing technique) spectrum, they watched a strong CH_4 band at 3.3 micrometres with a resolving power of 180,000 at the P-branch (Vladimer A Kransnopolsky, 2004). It is impossible to originate methane from an extinct biosphere; therefore, methanogenesis by living organisms is a reasonable and probable explanation for this discovery of a strong methane band. Life beyond Earth and other planets may be considered by simple measurements of their physical environment and superficial chemical composition. Thus a more detailed understanding of the nature of life forms can be compactly and thoroughly investigated via complex approaches such as those of the biological sciences (Dian R Hitchcock, 1966).

Planetary geologists at the University of Hong Kong have discovered that Mars underwent an outstanding oxygenation event billions of years ago. This event caused Mars to become red as its iron-rich Surface and atmosphere oxidized. As we know, the current Mars is a dry, sterile, cold planet, but it is believed that over 3.5 billion years ago, the Earth could have had hostile life, which means it was a warmer, wetter planet (Innovation News Network, 2021). And hence we can assure that subsurface life could or could persist to the present. Also, there is necessary Evidence regarding the existence of liquid water on the Martian surface and traces of water vapor in the Martian atmosphere. Mars Orbiter Surveyor MOC images of geologically young gullies that were likely formed by the action of liquid water also suggest that liquid water is present at shallow depths on the Martian subsurface (Malin M.C., 2000). Michael E Summers et al. inferred that most of the observed organic traces of gas in the Martian atmosphere are of short lifetimes as far as chemically concerned. One significant inference from the study is that methane is in trace amounts in the Martian atmosphere with a chemical lifetime of 300 years; hence, it is noted that this CH_4 constituent tends to spread uniformly in the Martian atmosphere (Michael E Summers, 2002). The possibility of consumption of H2 by bacteria on Mars has been recently studied by (Kral, 2000). Both methane and hydrogen molecule consists of similar bonds, and the upper limit of the methane in the Martian atmosphere is 0.05 parts per million volume; therefore, it is impossible to use this amount of methane in the subsurface biosphere.

As per their study, the amount of hydrogen in the Martian atmosphere is 800 times more than that of the amount of methane; hence because of this reason there occurs the evolution of producers over consumers and a possible differentiation between the biological and geochemical sources in Mars is that whenever methane is detected in Mars the proceeding step is to find the isotopic fractionation of $^{13}CH_4$ and CH_3D and HDO (semi-heavy water) respectively. Similar to Earth, the possibility of the volcanic origin of methane in the Martian atmosphere was discussed by Ryan et al. (Ryan, 2006). The most crucial result A Geminale et al. found is the relatively substantial decrease of the methane mixing ratio from 21 ppbv in the northern spring-summer to the 5 ppbv at the end of the southern summer. This behavior raises a fundamental question: is methane destroyed, or is it recycled, hidden somewhere? (A Geminale, 2008).

The 2012 Mars curiosity rover discovered a global methane mixing ratio of 0.69±0.2 ppbv using a tunable laser spectrometer at the Gale crater (dry lake). For a period of 60 solar days on mars of monitoring in 2014, curiosity found increases in the methane content about 7.2±2.1 ppbv (Christopher.R, Mars Methane Detection and Variability at Gale Crater, 2014). Webster et al., discusses that the methane measurements made by Curiosity Rover's tunable laser spectrometer at Gale Crater from 2014 to 2017 reveal significant seasonal variations similar to those observed in 2003 (Peaking near the end of Northern summer) (Webster, 2018). Pressure, surface temperature, relative humidity, estimated water vapour abundance, and surface UV are the parameters recorded by Curiosity's instruments with solar longitude. Webster et al., compare their background values with these measurements from the Rover Environmental Monitoring Station (REMS). Due to the carbon dioxide that is condensed and vaporised in the polar caps, the variation in mean surface altitude between the two hemispheres, and the balance between the wind field and mass causing a dynamical effect, the atmosphere of Mars experiences seasonal changes in surface pressure.

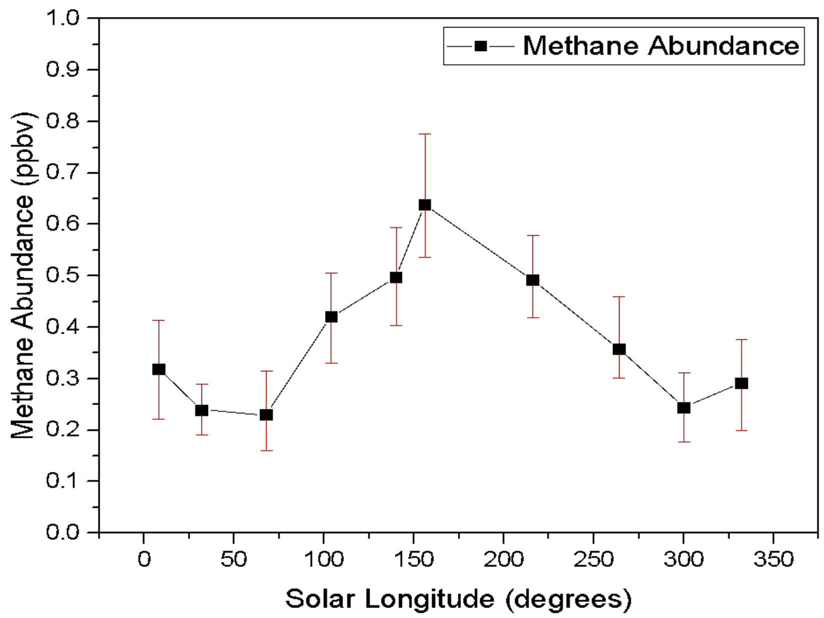


Figure 4: graph showing the seasonal variation of methane abundance in Mars (Webster, 2018)

Although local deviations from the seasonal trends can occur occasionally due to dust storms, at equatorial places like Gale crater, the pressure cycle is dominated by the polar cap contribution. For explaining the large amplitude of the background methane findings Webster et al., hypothesised that huge amounts of poorly mixed subliming CO_2 could reach the low latitudes of Gale crater at the higher pressures and result in low mixing ratios locally.

The amount of atmospheric methane on Mars is less than 50 and greater than 410 parts per trillion by volume when measured by ESA's ExoMars Trace Gas Orbiter and Curiosity rover respectively. John E Moores et al., justified this difference in amount of methane is that, all of Curiosity's methane concentration observations up until 2019 were place at night. Methane was substantially lower, or had decreased to 0.05 ppbv, when the crew measured it during the day. Sunlight is required for ExoMars' measurements (John.E.Moores, 2019). Christopher et al., explained this uncertainty in their study which summarized this day night difference is due to the weather essentially. Because of whatever process is essentially building up above the surface, it is cooler at night and methane can be seen seeping from the rocks. But as soon as the sun comes up, the air begins to warm up, setting up a classic weather pattern in which hot air rises, carrying methane with it, and then cold air descends, mining it all up in the atmosphere and bringing concentrations down below what ExoMars can detect throughout the day.

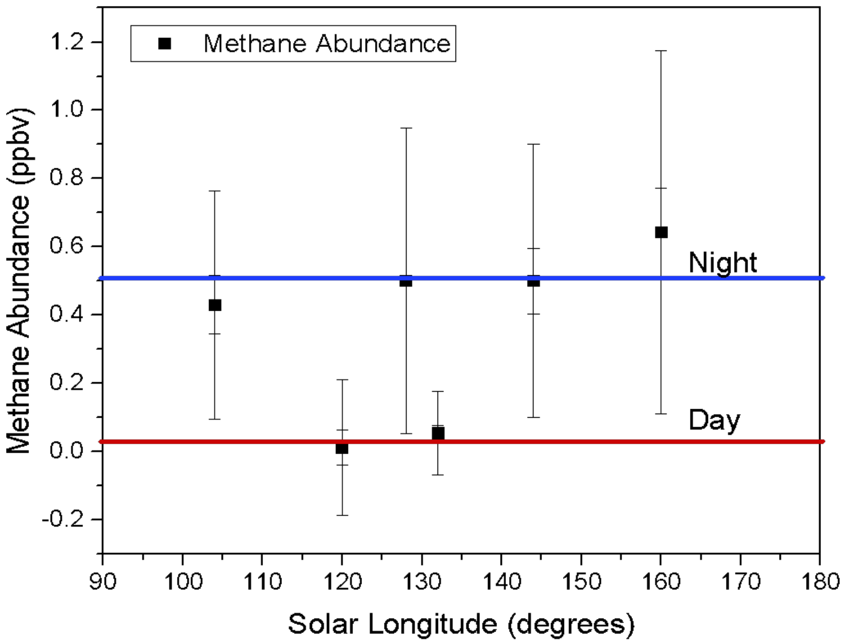


Figure 5: graph showing day and night time variations in abundance of methane (Christopher.R, 2021).

Methane can arise from biogenic or abiogenic sources, such as comet impacts, hydrothermal activity, or subterranean microorganisms that are active now or in the past. If the methane is generated by volcanoes, then SO2 should also be present in the atmosphere of Mars but it hasn't been found. Therefore, it is exceedingly unlikely that mars or methane have volcanic origins. Comets can only produce less than 1% of methane, although methane is created when serpentine combines with carbon flakes or crustal rocks' CO2, but it cannot escape from such vast depths and enter the atmosphere. As widespread as they are on Earth, subterranean and oceanic chemo lithographic bacteria are known to create methane as a by-product of metabolism. Mars' sub permafrost aquifer environment may be home to microbial colonies that use CO or H2 to produce methane.

3. Conclusion

A citation analysis of the journals and documents related to the Martian Atmosphere has been done to understand the structure, composition, history, and evolution of Mars' atmosphere and, thereby, the possibility of life on the planet. The citation analysis involved the study of different papers by renowned researchers invoking the experimental data as well as the theoretical data resulting from specific geographical and mathematical models. It is getting to know that Mars was a planet that supported life in its historical epoch, and it could help a habitual environment in the future. The dust storms in the atmosphere play a vital role in the manifestations of the structural and spatial formation of the Martian surface. USA, France, and Germany have done most publications on the related subject. From 2019 to 2021, there was a steep increase in the study. Our Knowledge about the Martian atmosphere has become significant because of intensive spacecraft exploration and earth-based observations using improved spectroscopic techniques. And this improved Knowledge leads to new quests about the present state, history, and origin of the Martian atmosphere. Solving those quests is necessary to understand the Martian atmosphere's evolutionary state in the past and hence into the future. And it gets to know that observations regarding the escape rate of escaping constituents over the number of Martian seasons could 58 provide information and data that allows such kind of exploration to be real. Also, the general circulation of Mars plays an immense role in the transportation of volatiles from one part to another part of the planet. Thus it is significant to understand the GCM models and their predictions of the Martian atmosphere. From the review of papers made in this work, it is understood that the theoretical data alone is not substantial, but observational data are also required for the complete treatment of understanding the Martian atmosphere.

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