General Geographical overview of Mars

Abstract: Extending living creatures on Earth from 4.0 billion year ago to date lived and diversified under a specific physical & environmental condition of Earth, where Earth's gravity plays an important role. But populations of this planet are growing ~~at a~~ so rapidly ~~speed~~; to the point of concern-that the Earth's Carrying Capacity has been overcome. So, for maintaining the Carrying Capacity, it is important to find out another/other planets which are like Earth. In our generation, there are some who believes that an ecosystem fit for human survival is creatable on Mars (Red planet) . Although there seems to be no life on present Mars, there is substantial evidence, returned by various robotic missions, that in the early Mars' history, liquid water environments existed, and conditions may have been suitable for the origin of native life.

Key words: NASA, Atmosphere, Earth, Genesis of Life, Mars, Regolith.

Introduction

In our Solar System, the fourth planet from the Sun is the Mars, called Red planet due to presence of reddish iron-oxide on its surface which is a dusty, cold, dry, desert world with an ultra-thin atmosphere. The atmospheric dynamics of Mars and Earth are similar. The rotational periods and seasonal cycles of Mars and Earth are also similar. The diameter of Mars is approximately half of the Earth's. And, Mars s about 15% of Earth's volume, 11% of Earth's mass, and 38% of Earth's surface gravity (Table 1), but without the Earth's plate tectonics and global oceans. The present-day tilt of Mars axis (25.2°) is alike to that of Earth (23.5°), where as the Orbital eccentricity of Mars (0.09) is much larger than Earth's (0.015).Orbitals elements of Mars exhibit Milankovitch cycle, alike Earth at period varying from 50,000 to several million years, that greatly affects how much of the sunlight which modify Mars climate reaches its surface .

TABLE 1

Comparison between Earth and Mars orbital parameters:

Property	Earth	Mars
Mass (kg)	5.972 37×10^{24}	6.4171× 10^{23}
Volume (km)	1.083 21×10^{12}	1.6318×10^{11}
Axial tilt (°)	23.439 2811	25.19
Orbital eccentricity	0.015	0.09
Mean density (g/cm³)	5.514	3.9335

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Surface gravity (m/s^2)	9.807	3.720 76
Average orbital speed	29.78	24.007
Radius (m)	6 369	3 394
Length of solar day (s)	86 400	88 775
Spin-axis inclination (°)	23.5	25.2

Aim & Objective

The objective of this study was to assemble the scattered information of the physical environment of Mars available.

Data base & methodology

Secondary data collected from different websites, and articles was used in this study.

Scientific investigation on Mars: To investigate Mars, NASA's Mariner 4, was the first successful flyby, carried by Atlas LV-3 Agena-D Rocket, that return the first close-up images of the Red Planet, and within 25 minutes it took 21 full pictures of this planet. After Mariner 4, NASA's Mariner 6, Mariner 7 (1969), are the dual successful missions to Mars, whose goals were to study its surface and atmosphere . The first spacecraft to orbit another planet was the NASA's Mariner 9 which reached the red planet's orbit on 14 November 1971,to make follow-up of the atmospheric studies initiated by Mariner 6 and 7. Mariner 9 returned 7329 images, revealed river beds, craters, extinct volcanoes, canons, Valles Mariners. Mariner 9 ends its investigation on 27 October, 1972. Its cameras were the first to capture the gamut of Martian geology. Martian Moons (Phobos and Deimos) are also captured by Mariner 9's camera. NASA's robotic spacecraft, 2001 Mars Odyssey, reached Mars orbit on 25 October 2001. About 85% of the images captured by *Spirit*, and *Opportunity* have reached Earth via Mars Odyssey orbiter. To map the Martian landscape, NASA's Mars Reconnaissance Orbiter was inserted on a Mars orbit on 10 March, 2006, and it played an important role in the selection of the landing site of Phoenix lander. To determine how the Martian atmosphere and water were lost over time, NASA's MAVEN (Mars Atmosphere and Volatile Evolution), was inserted on Mars orbit on 22 September 2014. A global mapping mission for Mars, NASA's Mars Global Surveyor inserted in Mars orbit in 12 September 1997 continued its mission up to 2 November, 2006. India's first Mars mission "Mars Orbiter Mission", (*Mangalyaan*) reach Mars Orbit to investigate atmosphere, surface feature, morphology, mineralogy. Exo-Mars Trace Gas Orbiter reached on Mars orbit on 19 October, 2016, and its goal was to investigate the methane and other trace gases in the Martian atmosphere. Two successful gravity assister used in Mars investigation are Rosetta and Dawn. NASA'S Viking (Viking 1, Viking 2) mission objectives were to capture images of Martian surface, and to examine its atmosphere and surface . Viking 1 and Viking 2 entered Mars orbits on 19 June, 1976 and 7August, 1976 respectively, generating images which

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revealed volcanoes, lava plains, canyons, cratered areas, and evidences of surface water on Mars.

Mars mission Landers and rovers which were successful are tabulated below:

Spacecraft	Landing site	Time period
Lander:		
1. Viking 1	Chryse planitia	20.7.1976 - 13.11.1982
2. Viking 2	Utopia Planitia	3.9.1976 - 11.4.1980
3. Mars pathfinder	Oxia palus quadrangle Ares Vallis, Chryse planitia	4.7.1997 - 27.9.1997
4. Phoenix	Vastitas Borealis, Green valley	25.5.2008 - 2.11.2008
5. Insight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport)	Elysium Planitia	26.11.2018 - present
Rover:		
1. Sojourner	Area Vallis region	4.7.1997 - 27.9.1997
2. Spirit	Gusev cater	4.1.2004 -22.3.2010
3. Opportunity	Bowl crater within the Meridiani Planum region later nicknamed ''Eagle Crater''	24.1.2004- 10.6.2018
4. *Curiosity*	Yellowknife of Aeolis Palus, located between Gale crater and the northern foothills of Aeolis Mons	6.8.2012 –present

Physical Environment of Mars.

1. Surface topography

Mars has a surface area of about 144.8 million km^2~~,~~ (about 28% of Earth's ~~(~~510.1 million km^2), which is dotted with impact craters alike Moon, and contain Basin, Valleys~~,~~ and extinct Volcanoes similar to the - Earth's. These ~~is~~ Martian surface features have been divided on the basis of intersection relations and the numbers of superimposed impact craters into three age groups—the Noachian, Hesperian, and Amazonian(Scott and Carr, 1978; Tanaka, 1986). , Noachian terrains survived the early heavy bombardment era of the early period of Red planet. Noachian era refers to the heavily cratered Noachis region, and ended around 3.7 Gyr ago. Middle Hesperian period started from the end of late heavy bombardment, refers to the Hesperia Planum (a broad lava plain, located along the broad north-eastern rim of the giant Hellas impact basin), and characterised as a period of expansive volcanic activity. Hesperian era ended around 2.9–3.3 Gyr ago. Present day Amazonian era is today's continuing most

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modern period of Mars, Amazonian (~0-3 Ga), named after Amazonis Planitia (24.8°N, 196.0°E), sometimes subdivided into Early, Middle, Late Amazonian periods, and characterised by low rates of meteorite and asteroid impacts. Most of largest topographic features were formed during or before Noachian periods. Within all Martian topographic features the most important large scale features are the Tharsis bulge, the Hellas impact crater, the Argyre impact crater, and the north-south dichotomy.

Impact craters: Largest visible impact crater in our Solar System, the Hellas basin (42.4°S 70.5°E), which was the first Martian features discovered from Earth ~~by~~ using Telescope, and is 7,152 m deep and 2300 km diameter. Victoria crater (2.05°S, 5.50°W) in Meridiani planum was first identified by Opportunity (Table 2). Opportunity (MER-B), after landing at Meridiani planum (0.2°N 357.5°E) identified the numerous craters listed on Table 2 :

TABLE 2

Craters visited by MER-B:

Crater	**Location (Coordinates)**
Ada	3.0°S, 3.2°W
Airy	5.1°S, 0.1°E
Argo	1.9°S, 354.5°E
Beagle	2.0°S, 5.5°W
Beer	14.6°S, 8.2°W
Bopolu	2.95°S, 6.33°W
Crommelin	5.1°N, 10.2°W
Eagle	1.95°S, 354.47°E
Emma Dean	2.0°S, 5.5°W
Endeavour	2.28°S, 5.23°W
Endurance	1.9°S, 5.5°W
Erebus	2.1°S, 5.5°W
Firsoff	2.66°N, 9.42°W
Iazu	2.69°S, 5.2°W
Madler	10.8°S, 357.3°W
Santa Maria	2.172°S, 5.445°W
Victoria	2.05°S, 5.5°W
Vostok	1.9°S, 35.5°E

Basin: The Borealis Basin (North Polar Basin) is located in the northern hemisphere of Mars, covering 40% of the planet. Within Borealis Basin, is where Utopia Planitia (46.7°N, 117.5°E), Arcadia Planitia (47.2°N, 184.3°E), Acidalia Planitia (49.76°N, 339.3°E), Vastitas Borealis (87.73°N, 32.53°E), and Planum Boreum (88.0°N, 15.0°E) are also located. A plain, Helllas planitia is located within the impact basin Hellas (42.4°S, 70.5°E, Hellas quadrangle). This basin floor is 7152 m deep, 3000 m deeper than the Moon's South Pole-Aitken which is the about 13 km deep largest known impact crater in the solar system .

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Valleys: Valles Marineris (4,000 km long, 200 km wide and up to 7 km deep) the largest canyons of the Solar System, discovered by Mariner 9 runs along the Martian surface east of the Tharsis region. Mangala Valles, is a criss-crossing channel on Tharsis region of Mars, that extends 350 km along the 151° W. meridian, from approximately 9° S to 4° S., but the main channel constitutes only 180 km of this distance. Mariner 9 orbiter (1971-1972),by discovering a great variety of channels and channel-like features on the Martian surface, provide a basis of Martian evolutionary history.

TABLE 3

Channels visualized by Mariner 9:

Channel	**Location(Coordinates)**
Ares Channel	Chryse, 0°-13°N., 15°-25°W
Ceraunius Dome Channel	Ceraunlus, 24°N., 89°W
Dendritic Tributary Channels	Tithonlus, 8°S., 84°W
Deuteronilus Channel	40°N., 338° W
Kasei Channel	Lunae Palus, 20°-27°N., 55°-75°W
Ma'adim Channel	Rasena, 16°-29°S., 181°-184°W
Nirgal Channel	Mare Erythraeum, 29°S., 40°W
Shalbatana Channel	1.5°-8°N., 42°-45°W
Xanthe Channel	0°-8°N., 48°W

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Volcanoes: One of the largest volcanoes in the Solar System, Alba Patera (40.5°N, 250°E), lying on the northern margin of Tharsis, covering more than 4.4×106 km² that is about one-third the height of Olympus Mons (18.65°N, 226.2°E), the largest and most prominent volcano on the planet Mars. Alba Patera has an overall basal width of 1015×1150 km and a summit elevation of 6.8 km. Vast volcanic plateau Tharsis, extends from Amazonis Planitia (215°E) in the west to Chryse Planitia (300°E) in the East, covering up to 25% of Mars' surface area. Arsia Mons, Pavonis Mons, and Ascraeus Mons are the three shield volcanoes located in this Tharsis region, which are jointly known as the Tharsis Montes. Ascraeus Mons is the tallest (18.2 km) of the Tharsis Montes. Tharsis Montes together with Olympus Mons , represent the most remarkable volcanoes on Mars. Beside these larger volcanoes, a wide variety of smaller volcanoes and volcanic features are also recognized on Mars.

TABLE4

The volcanoes recognized on Mars

Alba Patera	Jovis Tholus
Albor Tholus	Olympus Mons
Amphitrites Patera	Pavonis Mons
Apollinaris Patera	Peneus Patera
Arsia Mons	Syrtis Major Mereo Patera
Ascraeus Mons	Syrtis Major Nili Patera

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Biblis Patera	Tharsis Tholus
Ceraunius Tholus	Tyrrhena Patera
Elysium Mons	Ulysses Patera
Hadriaca Patera	Uranius Patera
Hecates Tholus	Uranius Tholus

2. Soil

In general, soil is a mixture of organic matter, minerals, gases, liquids, and organisms, based on which Earth is considered biologically active, Genesis of life. Key components of soils are minerals, organic matter, water and air. Martian soil differs from Earth’s ł due to the toxic perchlorates it contains, . Martian soil characteristically refers to the finer fraction of regolith, that is a geologic unit comprised s dust, sand, rocky fragments. Olivine and pyroxene are two important classes of rock-forming minerals, also found by Curiosity rover on Mars crust.

“In places this covering is made up of material originating through rock-weathering or plant growth in situ. In other instances, it is of fragmental and more or less decomposed matter drifted by wind, water or ice from other sources. This entire mantle of unconsolidated material, whatever its nature or origin, it is proposed to call the regolith.” _George P. Merrill, American geologist.

Rover Sojourner was the first to detect the elemental chlorine on Martian soil. Presence of perchlorate also has been detected by Mars Odyssey orbiter. NASA’s spirit rover find-out wide evidence of carbonate and hematite, associated with water environment. Phoenix lander was the first that detect the chlorine-based (0.5%) compounds on Martian soil. These chlorine-based compounds are toxic to plants as well as humans. Martian surface is sulphur-rich and sulphates are abundant on Hesperian and Noachian terrain. The searching carried out by Pathfinder and Viking landers revealed that sulphur is a substantial component of Martian’s soil dust and surface rock.

3. Atmosphere:

In the mid-1970s,Viking landers determined the composition of Martian atmosphere. Ultra-thin atmosphere of Red planet is dominated mainly by carbon dioxide (95.97%), whereas Earth’s atmosphere is dominated by nitrogen (78.08%) (Table 5). In addition to the carbon-dioxide, the atmosphere also contains trace amount of water vapour (0.1%), nitrogen and trace amount of free oxygen. Trace amount of noble gases, neon, argon, krypton, xenon, are also identified. Methane (CH_4) also detected recently in trace amount. Unlike Earth’s atmosphere due to absence of ozone layer, ultraviolet rays openly penetrate the atmosphere, and reach the surface. Mars does not bear stratosphere due to absence of ozone layer. According to Viking lander and Pathfinder lander the troposphere extends up to ~60 km (12 km, Earth), with average lapse rate of about ~2.5 K/km (~6.5 K/km, Earth).As reddish iron oxide prevalent on Mars surface, the atmosphere is quite dusty and orange red in colour. Average atmospheric pressure of Martian surface is about 6.1 mbar, that is about 0.6% of earth’s mean sea level pressure of 1013 mbar. Detected atmospheric pressure value by Viking

1 was 0.69 kpa to 0.9 kpa. Estimated temperature range by Viking lander site, was -17°C to -107°C. The highest temperature estimated by the Viking Orbiter was 27°C. Observed temperature by NASA's Spirit rover was 35°C (highest level), but commonly recorded temperature well below of 0°C. The average surface temperature on Mars is approximately -63°C with an average diurnal range of around 103°C to -5°C (Hiscox, 2000). Dust storms would-be the common phenomenon of Mars world. According to size, Dust storms are categorised as the devil , the local , the regional storms and the planet-encircling storms, in which the last lasts for months and occurs quasi-annually).

TABLE 5

Comparison between Earth and Mars atmosphere Constituent:

Constituent	**Earth**	**Mars**
Carbon-di-oxide	0.0408%	95.97%
Oxygen	20.95%	0.146%
Nitrogen	78.08%	1.89%
Argon	0.934%	1.93%
Carbon-mono-oxide	0.000025%	0.0557%

4. **Water :**On the basis of geologic evidence returned by various rover and orbiter mission it is often stated that there is sufficient evidence for water on Mars, but there has been no direct observation of liquid water, only ice, vapour, and geomorphologic traces of the action of past liquid water. Mars' North Polar Region is covered with CO_2 ice during winter, whereas the south cap is covered year-round by CO_2 frost. Evidence of past liquid water on the surface of Mars suggests that this world once had habitable conditions for origin of life. Mars Odyssey orbiter detected subsurface ice, in high latitudes location.

Concluding Remarks: In our Solar System beside Earth, the best-studied planet Mars is the high-priority target for human exploration programme. United states National Aeronautical and Space Administration (NASA)**,** Indian Space Research Organisation (ISRO), The European space agency (ESA), Soviet-union, conducted various mission to Mars, for investigation. From Mariner 4 (launch on November 28, 1964) until Insight lander Mars has been successfully observed by several Orbiters and Landers, four of them rovers. In future there are some missions will be launched from 2020. Rosalind Franklin rover conduct by Russian Roscosmos State Corporation and European Space Agency's that's planned landing site is Oxia Planum (21 March 2021). NASA's mission Mars 2020 rover, planned landing site is Jezero crater. The Hoppe Mars mission constructed by United Arab Emirates that's planned lunched date is July 2020. Indian's second Mars mission is the *Mangalyaan* 2with a planned mission duration of 1 year, that's lunch date is 2022-2023.

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