



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 10, October 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com



Theoretical Study on Colonization of Venus Planet System

Shreya Mane^{1,*}

Department of Research and Development, ASTROEX RESEARCH ASSOCIATION, Deoria, India ¹

ABSTRACT: The similarity of Venus and Earth in bulk properties make Venus an appealing target for future colonization. Several proposals have been put forward for colonizing and even terraforming Venus despite the extreme conditions on the planet's surface. Such a terraforming project would face large challenges centred around removing Venus's massive carbon dioxide atmosphere and replacing it with a habitable environment. Although the atmosphere of Venus is the most Earth like environment in the solar system (apart from Earth itself) at a height of around 50 kilometres above the surface, Venus' surface is a highly hostile environment. Here it is suggested that in the near future aerostat vehicles in Venus' atmosphere could be used for human exploration, and that in the long run cities built to float at an altitude of around 50 kilometres could be used for permanent settlements. Venus' atmosphere is a fascinating area to research scientifically and to explore with humans in the future. Because of its hostile environment, which is the result of a huge and dense super-greenhouse atmosphere, Venus is frequently passed over as a candidate for habitation or terraforming. In the scenario presented in this research, Venus might be made habitable and ready for colonization in a matter of centuries. In addition, the materials used to build the orbital infrastructure required to start and sustain the terraforming process are also utilised to build orbital homes.

KEYWORDS: Exploration, Overview, Human Settlement, Terraforming, Venus Express, Atmosphere

I. INTRODUCTION

Due to its similar size and mass to Earth, Venus is frequently referred to as the sister planet. Venus is obviously not Earth's twin in reality, at least not in terms of planets. Venus is the brightest object in Earth's night sky, aside from the Moon and the Sun, due to its thick layer of Sulphur dioxide clouds, which reflect almost 90% of all incoming visible light from the Sun [1]. This prevented early astronomers from getting even a brief view of the surface. Many people mistakenly believed it to be Earth's twin because of how similar in size and composition it is to our planet. While some imagined a parched, desert planet, some imagined the entire planet to be covered in a steamy, carbonaceous jungle beneath thick clouds of water Vapour. Venus developed a mythological quality in the public's mind, much like Mars did. The planet was depicted in science fiction of the era as a warm, primaeval hothouse filled with greenery and odd, fascinating creatures.

The hottest and brightest planet in the solar system is Venus, which is located two planets from the sun. Because it shone the brightest among the five planets known to ancient astronomers, Venus may have been called after the most attractive deity of the Roman (and Greek) pantheons. Venus was known as Aphrodite in the city-states of ancient Greece, nevertheless. The evening star and the morning star, or the stars that first emerged at sunset and daybreak, were regarded to be two separate stars in the past, Venus. They were referred to as Vesper and Lucifer, respectively, in Christian Latin. Further space-age measurements, however, reveal an extremely hostile climate on Venus. Because spacecraft do not last long on Venus' surface, it is incredibly challenging to examine Venus up close.

No planet comes closer to Earth than Venus, which is also the nearest big object to Earth save the Moon at its closest point. Venus can only be seen during the hours just before sunrise or just after sunset since Venus's orbit brings it closer to the Sun than Earth's does. It is the most luminous planet in the sky when it is visible. Venus is represented by the letter v. Prior to the development of sophisticated astronomy tools, Venus' motions were watched and studied for centuries. Venus was one of the five planets that were known in antiquity, along with Mercury, Mars, Jupiter, and Saturn. Because of the similarities in their masses, sizes, and densities as well as their similar relative positions within the solar system, Venus has been referred to as Earth's twin. They probably share similar overall chemical compositions since they are thought to have originated from the same kind of rocky planetary building components in the solar nebula.



It was widely believed that Venus was a warm, wet world, maybe similar to Earth in its primordial epoch of swampy carboniferous forests and teeming life, because early telescopic studies of the planet revealed a constant veil of clouds, suggesting a large atmosphere. However, scientists now understand that the surface environments of Venus and Earth have evolved to be very dissimilar. Venus is so harsh in many respects, including being extremely hot and dry, that it is unlikely that life as we know it could have evolved there. Understanding how Venus' severe conditions developed, which may offer valuable lessons about the causes of environmental change on Earth, is one of scientists' main objectives in researching the planet.

With a gravity of 0.9 Earth, it appears that this planet is extremely comparable to Earth. However, due to the greenhouse effect, Venus' atmosphere is hotter and denser than that of Earth [2]. It is primarily made up of CO₂ [3], has clouds of sulfuric acid, and contains 4% nitrogen [4]. Some studies predict that the surface temperature of ancient Venus was around +11 °C. Such a moderate value, adequate heat, and liquid water might be present in the required ratio for the emergence of a particular form of life [5–8].

II. VENUS OVERVIEW

Venus Exploration

Venus is the hell planet in many respects. Bougher, Hunten, and Phillips' summary of the findings from spacecraft investigations of Venus's atmosphere and surface (1997):

- Lead, tin, and zinc melt at surface temperatures of 735 K, with hot spots reaching temperatures of more than 975 K.
- 96 Bar (1300 PSI) atmospheric pressure is equivalent to the pressure one kilometre under the ocean.
- 96 Bar (1300 PSI) atmospheric pressure is equivalent to the pressure one kilometre under the ocean.
- 90% of Earth's surface gravity is caused by gravity.

An alternate perspective, however, shows that Venus's issue is simply because the ground level is too far below the one atmosphere level. At the level of the clouds, Venus is the planet of paradise. As depicted in figure 2, the atmospheric pressure is equivalent to the atmospheric pressure of the Earth's surface at a height of about fifty kilometres above sea level (1 Bar). Venus's environment is safe at this level.

- Solar energy is abundant above the clouds.
- The ambient temperature is between 0 and 5 °C, which is suitable for life.
- The major volatiles (Carbon, Hydrogen, Oxygen, Nitrogen, and Sulfur) needed for life are found in the atmosphere.
- 90% of Earth's surface gravity is caused by gravity.

While sulfuric acid droplets are present in the environment, scientists have utilised well-established techniques to prevent acid corrosion for centuries. In a nutshell, Venus' atmosphere is the solar system's closest environment to that of Earth. Despite the fact that they are unable to breathe in the atmosphere, humans are not required to wear pressure suits or vessels to maintain the habitat's one atmosphere of pressure.

In earlier study, the argument was made for human colonies in the Venusian atmosphere's habitable zone [9]. In the near future, aerostat vehicles in Venus' atmosphere may be used for human exploration, and in the long run, cities that float fifty to sixty kilometers above the planet's surface may be used for permanent habitation. Despite the fact that they cannot breathe the atmosphere, humans are not having to wear pressure suits or vessels to maintain the habitat's one atmosphere of pressure (although they would still need to wear enough clothing to prevent direct skin contact with aerosol droplets outside the habitat).

Overview of Venus Aerostat habitats

Although it has a lower lifting power than the gases often used for aerostats, hydrogen or helium, breathable air on Venus (i.e., an oxygen/nitrogen combination at a ratio of around 21:78) is a lifting gas in the carbon dioxide atmosphere of Venus. Because air is buoyant, the entire aerostat might possibly be filled with breathing gas, making the entire space habitable. It is not necessary for the habitat's interior to maintain a pressure difference. Since the exterior



pressure is almost one bar at the heights of interest, the atmospheric pressure inside the envelope would be equal to or nearly equal to the pressure outside. Therefore, a home in the atmosphere wouldn't need to be a high-strength pressure vessel and might instead be very light. Ripstop fabric with high-strength tension parts would make up the envelope material itself. Even a fairly substantial break in the envelope would take thousands of hours to leak significant amounts of gas with zero pressure differential between the inside and exterior, giving enough time for repair. (The envelope would also include a number of separate units for safety.)

A significant health risk of residing in space is eliminated by the dense atmosphere's one kilogram of mass per square centimeter of mass shielding, which is sufficient to protect people from the majority of the danger from both solar coronal-mass ejection proton radiation and galactic cosmic radiation. The gravity, which is just under one Earth gravity, should be enough to prevent the negative effects of microgravity on the residents' bones, muscles, and cardiovascular system.

Solar power is abundant at the altitudes of interest, above the dense middle cloud layer, and solar arrays would actually create almost as much power when pointed downward (at the reflective clouds below) as when pointed upward (at the sun).

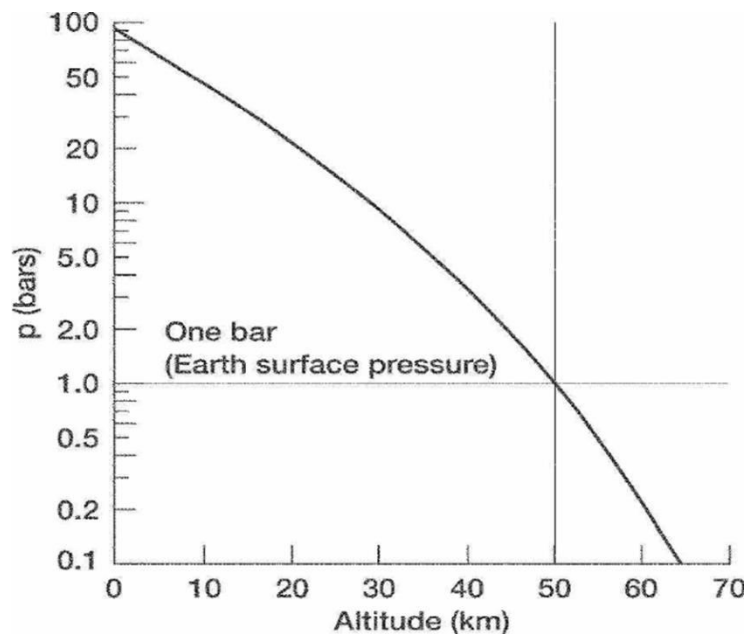


Fig. 1 Pressure as a function of altitude in the atmosphere of Venus

Telerobotic exploration in the near future

Despite being a very hostile environment, Venus' surface is still of considerable scientific interest to examine. The development of high-temperature electronic components employing high-bandgap semiconductors has advanced significantly [10], despite the fact that standard silicon microelectronics cannot operate at Venus' surface temperatures. It is plausible to anticipate that remotely controlled rovers or telerobots will be able to conduct surface exploration [11, 12]. Making a highly capable telerobotic rover for "virtual telepresence" that could operate on the surface and connect to humans in real time via a high-bandwidth connection would be one possible system. This would essentially put humans on the surface without actually exposing them to the environment there.

The Human Exploration utilizing Realtime Robotic Operations (HERRO) concept, which keeps human operators in Venus orbit, is one variation of this idea that has been put out [13,14]. To give the humans a fully-detailed virtual presence within the robotic body, a high-fidelity, high-bandwidth connection is necessary. Although Venus's slow rotation prevents it from having synchronous orbits, which are orbits that remain above a specific landing site, it is still possible to choose an orbit that provides eight hours of daily direct line-of-sight operation over a landing site by using high bandwidth relay satellites (thus allowing operation on a reasonable human schedule).



However, putting the human dwelling in Venus' atmosphere would be an alternative. Although oxygen, which is largely absent from Venus' atmosphere, would still be needed for humans in this telerobotic exploration scenario, the environment is otherwise ideal for them. As previously mentioned, the 0.9 Earth g gravity of Venus and its dense atmosphere are healthier than orbital microgravity and radiation settings, making a residence there safer for people's health than one on Mars' surface.

More Prolonged: Human Settlement

Permanent colonies in the form of cities built to float above the cloud level of Venus' atmosphere might eventually be established. A trade-off between pressure and temperature must be made while choosing an altitude for a habitat on Venus. The required altitudes range from 50 km to 61 km, where 50 km is roughly one (Earth) atmosphere pressure level and 61 km is the 0.2 bar altitude, where a pure oxygen ambient provides oxygen that is similar to that found at sea level, if the interior pressure is equal to the ambient pressure at the float altitude. These values correspond to atmospheric temperatures that range from 77°C at low altitude to -14°C at the highest altitude. Just below 56 km altitude, a 20 °C atmospheric temperature is attained. Since the atmospheric pressure at this altitude is roughly 0.56 bar, a mixture of 37% oxygen and 63% nitrogen would produce breathing conditions that are similar to those at sea level. An elevated altitude is preferred if heat rejection rather than heating is a problem.

As mentioned, mixes of oxygen and nitrogen act as a lifting gas in the atmosphere of carbon dioxide. However, if the lifting envelope is filled with hydrogen or helium, a substantially larger lifting capability can be achieved. Since Venus' atmosphere lacks large helium resources, hydrogen is probably the better option out of these three. Because Venus' atmosphere doesn't contain oxygen, the risk of hydrogen igniting would be significantly lower than the risk posed by hydrogen balloons in Earth's atmosphere. At an altitude of 1 bar, or around 50 km, air has a lifting power of about 0.55 kg/m³, which decreases to about 0.28 kg/m³ at 56 km, whereas hydrogen has a lifting strength of about 1.4 kg/m³ at 1 bar, which decreases to about 0.78 kg/m³ at 56 km.

As a result, a given volume of hydrogen can lift almost three times as much air as it can. However, the rate of hydrogen leakage will be considerable, necessitating a constant supply of hydrogen, most likely obtained by removing hydrogen from accessible sulfuric acid. A compromise would be to employ methane as the lifting gas. Methane has a lifting power between hydrogen and air, but it leaks far less frequently than hydrogen. The benefit of the entire envelope being a liveable volume must be balanced against the larger mass that hydrogen allows for. A mixture of helium and oxygen could be utilized to increase lifting power while maintaining a breathing atmosphere. Such a mixture would, while maintaining breathability, have double the lifting force of air at an altitude of 56 km; nevertheless, it would lack a local supply of helium for gas replenishment on Venus.

Altitudes of interest, the atmospheric winds round the planet considerably more quickly, taking about four days to complete the rotation. Therefore, on the habitat, the solar "day" would be the same length as the solar "night," which would be approximately fifty hours. Although this is longer than an Earth Day, it is still extremely comfortable when contrasted to other lengths of time, like the six-month night in near-polar terrestrial locales. The atmosphere of Venus has an abundance of the resources needed for human life as well as greenhouses that can produce food and oxygen. These resources are needed for a permanent settlement. Nitrogen and carbon dioxide are abundant in the atmosphere. The essential ingredients for human living can be found in the atmosphere, along with hydrogen produced by condensation of sulfuric acid droplets in the atmosphere. A settlement will need both industrial and structural elements. The surface material, which is thought to be predominantly a basaltic silicate, can be mined for these materials, including silicon, iron, aluminum, magnesium, calcium, potassium, sodium, etc.

Partial Terraforming in the Long Term

Advocates for space settlement consider terraforming Venus in the very distant future. The concept of terraforming Venus dates back to Carl Sagan's assertion that Venus may be changed to resemble Earth in 1961 [15]. Unfortunately, it turns out that terraforming Venus is incredibly challenging (far more challenging than Sagan had anticipated, back when very little was known about Venus) [16]. Since the atmosphere's high concentration of carbon dioxide is the main cause of the greenhouse effect, any successful terraforming technique would need to remove around 5.1020 kg (or 500 quintillion kilograms) of extra carbon dioxide. The "sweet zone" in the atmosphere, where pressure and temperature are



similar to Earth, has been identified as a potential strategy for partial terraforming. To achieve that earth-like level, structures may theoretically be erected all the way from the surface to a height of 55 kilometers. In essence, this would entail creating a "shelf" at the proper altitude in the sky out of high-temperature composite materials like graphite ("carbon carbon") composite or, in the future, carbon nanotubes that could be produced from the surrounding carbon dioxide atmosphere. If convection is suppressed so that the oxygen-rich upper layers are not well mixed with the carbon-dioxide-rich lower atmosphere, it is reasonable to suggest that at least the top portion of the atmosphere could be converted to contain oxygen by photosynthesis in such a structure, even though it would still not have the breathable atmosphere that humans desire.

About 55 kilometers above the surface, temperatures in the upper atmosphere are so low that extremely concentrated sulfuric acid can condense into massive clouds that cover the entire planet. These clouds produce precipitation that drops to a height of 25 kilometers before dissipating. Large lava flows and extinct volcanoes litter the earth's surface. Venus lacks plate tectonics as well, making it difficult for heat to move efficiently from the mantle to the surface. Over the course of 100 million years, the crust weakens as heat accumulates in the mantle, and eventually vast chunks start to rapidly subduct, entirely reworking the surface in a spasm of global volcanism. Such a severe atmosphere being revealed prompted analogies to the Christian Hell. The crushing atmosphere, corrosive clouds, and burning heat of Venus, on the other hand, would cause more or less rapid death rather than torment.

Gas	Concentration
CO ₂	96.50%
N ₂	3.50%
SO ₂	150ppm
Ar	70ppm
H ₂ O	20ppm
CO	17ppm
H _e	12ppm
N _e	7ppm

The removal of Venus' thick atmosphere will be the largest obstacle to making the planet habitable. The key elements of the Venusian atmosphere are shown in Table 1. It includes some $1.2 * 10^{20}$ kg of CO₂, almost all of which needs to be removed in some fashion. This is the first step to any attempt at terraforming Venus. Venus, also known as the "greenhouse planet," is an amazing location for science. This mission concept study focuses on Venus, which is commonly referred to as Earth's sister planet due to its proximity to the planet and similarities in size. Venus's climate is very different from Earth's, despite the fact that they are similar [17–20]. Our comprehension of our own planet's atmosphere, climate, geology, and history could be greatly improved by learning more about Venus.

Since Venus has the closest atmosphere to that of the Earth of any planet in the solar system, it is of great importance to the study of terrestrial atmosphere. Venus, however, serves as an illustration of the "runaway greenhouse effect" [21]. We could gain a great deal of knowledge about the functioning of the Earth's atmosphere by understanding the dynamics and history of Venus' atmosphere. Additionally, astrobiology is somewhat interested [22].

The three terrestrial planets with atmospheres, Venus, Earth, and Mars, which are situated near to one another in the inner solar system, have a lot in common. Particularly, Earth and Venus are almost the same size and appear to have shared many characteristics during the period when they formed and cooled, perhaps with abundant CO₂ in Earth's atmosphere and liquid water oceans on Venus' surface (and Mars).

Venus Express

The Mars Express spacecraft, a 600 kilogram, three-axis stabilized platform with a body fixed communications antenna, served as the inspiration for the Venus Express design [23]. It is the first mission focused on studying Venus' atmosphere and plasma since NASA launched its Pioneer Venus orbiter and probes more than 25 years ago. It was launched by the Russian Soyuz-Fregat launcher from Baikonur, Kazakhstan, on November 9, 2005. It arrived at Venus on April 11 and went into full operation in June of the same year, using new modes of observation and a new generation of instrumentation [24].

Middle & Lower Atmosphere

In addition to specific localized 'weather' occurrences, these initial observations made with great spatial resolution and across a variety of depths in Venus' atmosphere also shed light on the general structure of the atmospheric circulation. With convective and wave-dominated meteorology in the lower latitudes and a sudden change to smoother, banded flow at medium to high latitudes, three broad regimes are clearly apparent in the middle and lower atmosphere [25].

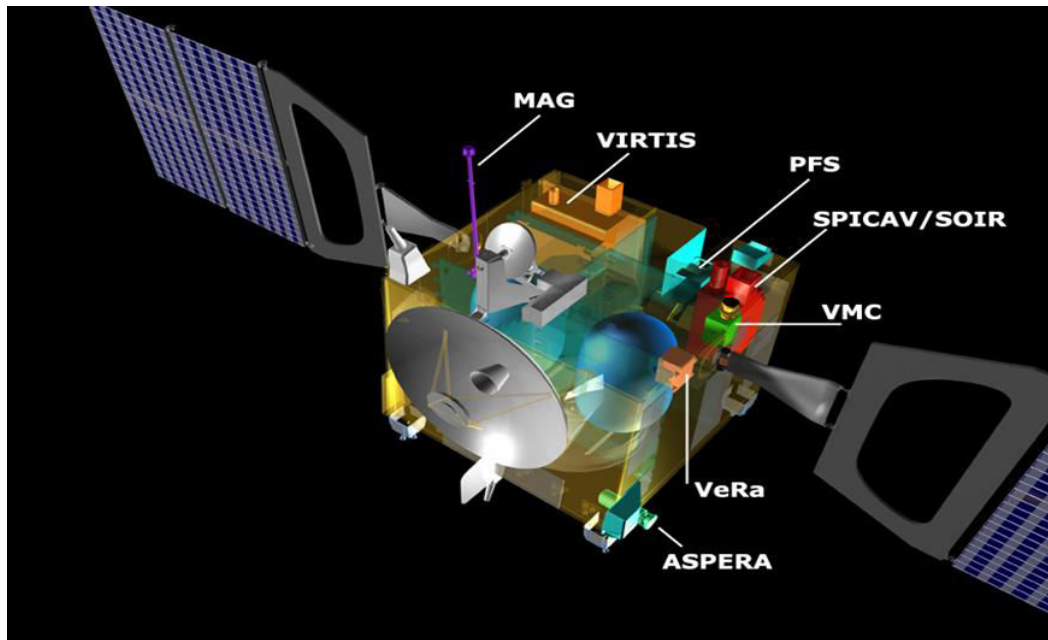


Fig. 2 The Venus Express Spacecraft

The latter comes to an end at the cold polar collar that earlier missions identified, which is located approximately 30 miles from the pole. This encloses a massive structure like a vortex that is thousands of kilometers across and rotates every 2.5 to 2.8 Earth days. The disparities at both wavelengths, despite reflecting different atmospheric altitudes, are generated by the same circumpolar dynamical regime, according to simultaneous measurements in the ultraviolet and thermal infrared spectral ranges, which show associated patterns [26]. The cloud top in the polar collar is situated at an altitude of 70–72 km, or roughly 5 km or one scale height higher than in the eye, according to spectroscopic measurements, which also show significant variations in temperature and cloud structure in the vortex. While the vortex structure and circulation appear to be limited to the cloud top region, night-side observations in the transparent spectral windows revealed that they occur at least as deep as the lower cloud deck at 50–55 km. The Hadley circulation, the planet-wide overturning of the atmosphere in response to the concentration of solar warmth in the equatorial zones, appears to have a poleward limit that is marked by the edge of the polar collar at 50–60° latitude shown in below figure. Monitoring the latitude distribution of minor elements, particularly carbon monoxide as dynamical tracers in the lower atmosphere, provides indirect evidence of such meridional circulation.

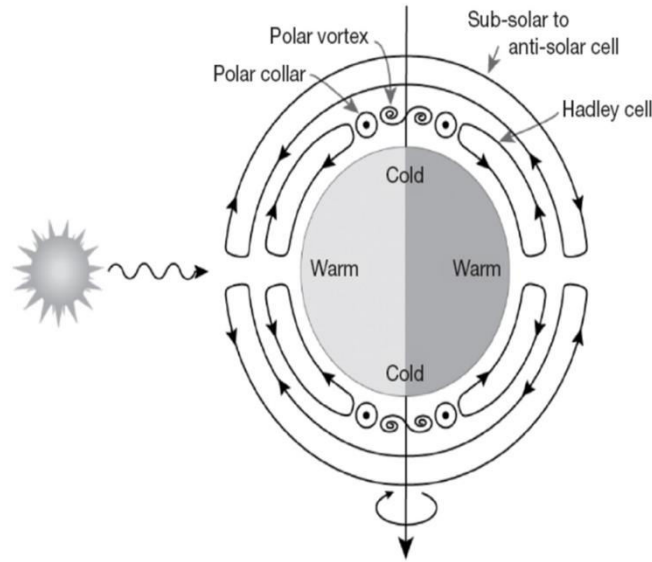


Fig. 3 Schematic view of the general circulation of Venus's atmosphere

Upper Atmosphere & Plasma Environment

Because Venus lacks an internal magnetic field, the solar wind interacts directly with the upper atmosphere, resulting in a different distribution of electron, ion, and energetic neutral atom energies and densities than that found around Earth [27,28] shown in below fig. The data made by Venus Express during solar minimum complete the Pioneer Venus plasma studies that were made during solar maximum. When the satellite passes the pericentre at a distance of 250–350 km and dips into the ionosphere, photoelectrons with an average energy of 22–28 eV are recorded in situ.

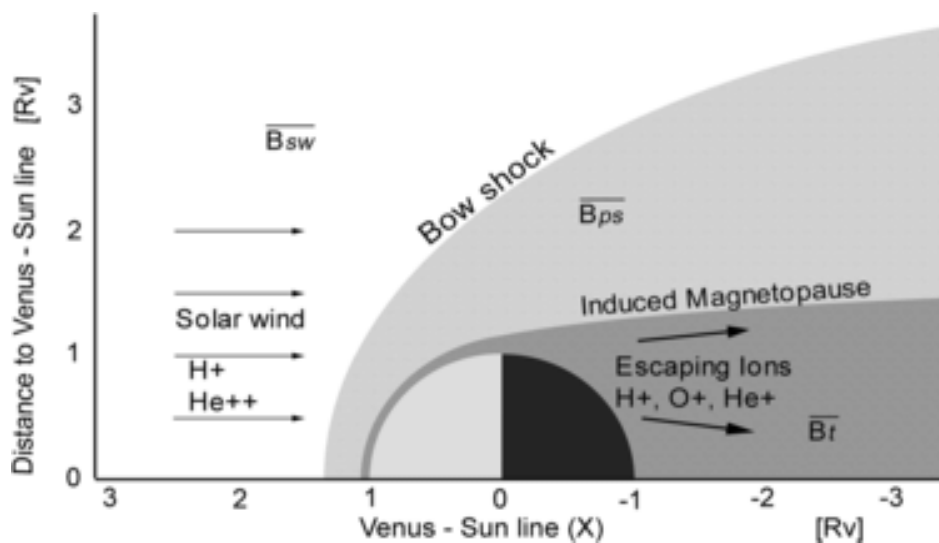


Fig. 4 The plasma environment of Venus as determined by Venus Express



Radio occultation's [29] detection of the vertical distribution of electron density below this height points to a stable ionosphere bottom at 120 km. The electron density peaks at about $4 \times 10^5 \text{ cm}^{-3}$ at about 140 km altitude, and a very dynamic topside ionosphere is observed.

Lightning

The existence of lightning on Venus has been debatable for a very long time. The Venus Express magnetometer discovered Whistler-mode waves during more than 10% of the pericentre passes, which is regarded as solid proof of lightning [30]. According to this, the lightning rate must be at least half that of Earth. It now appears likely that frequent lightning also occurs on Venus. Frequent lightning offers a considerable energy input that has important implications for the chemistry in the lower and intermediate atmosphere on Earth.

Venus is More Earth Like

After the initial stage of spacecraft exploration, the data from Venus Express' first year of operation give the impression that the differences between Venus and Earth, especially in terms of climate, are significantly less mysterious than previously believed. They are in line with theories and interpretations that claim Venus lost most of its water to space while Earth's oceans converted most of the planet's atmospheric CO₂ to carbonate rocks. These theories and interpretations suggest that the two planets once had similar surface environments but that they evolved differently. In addition to the high surface temperatures, Venus' deep atmosphere and enormous stockpile of greenhouse gases are to blame for the planet's high zonal winds and near-equatorial turbulence. The Hadley cell component of the atmospheric circulation, which is similar to Earth's, is able to extend closer to the poles where it spectacularly breaks down to form midlatitude jets and polar vortices that are larger and more energetic than Earth's but are otherwise quite similar. Venus' slow rotation may also be to blame for the lack of magnetic field that makes erosion of the atmosphere by the solar wind so effective.

III. CONCLUSION

In the long run, towns could be built that are intended to float at a height of around fifty kilometers in Venus' atmosphere. The Venus atmosphere has several advantages over other places in space where settlements are being considered, including an abundance of atmospheric volatiles necessary for life support, a benign climate, protection from solar and cosmic radiation, an abundance of solar energy, and easy access to the rocky (silicate) surface materials. Venus has a heated, high-pressure atmosphere close to the surface, yet conditions are suitable for powered flight above the cloud layers. Not only is solar-powered flight on Venus feasible, but it is also feasible to use a very small ship with a respectable payload of scientific instruments to study areas of the atmosphere, including the cloud tops. The analyzed aircraft are of a size that can be used for a cheap "Discovery" class mission. In the even farther future, if dwellings floating in Venus' atmosphere are constructed, such habitats may also be taken into consideration for other planets' atmospheres. Because the surface gravity of Saturn, Uranus, and Neptune is similar to that of Earth, it is possible to imagine dwellings in their atmospheres as well. However, in this scenario, heated atmosphere would be used as the lifting gas rather than oxygen and nitrogen.

Acknowledgment

I would like to express our gratitude towards Mr. Ankit Kumar Mishra, Executive Director and Research Advisor at **ASTROEX RESEARCH ASSOCIATION, DEORIA** for helping me throughout the research work and providing his sincere guidance and support for successful completion of the project.

REFERENCES

- [1]. Venus: Overview. (2013, October 25). Retrieved from <http://solarsystem.nasa.gov/planets/profile.cfm?Object=Venus>.
- [2]. Bullock M.A., Grinspoon D.H. (2013) The Atmosphere and Climate of Venus // Comparative Climatology of Terrestrial Planets, Stephen J. Mackwell, Amy A. Simon-Miller, Jerald W. Harder, and Mark A. Bullock (eds.), University of Arizona Press, Tucson.
- [3]. Grinspoon D.H., Bullock M.A. (2007) Searching for Evidence of Past Oceans on Venus // American Astronomical Society, DPS meeting #39, id.61.09; Bulletin of the American Astronomical Society, vol. 39, p. 540.



- [4]. Vidmachenko A.P. (2016) Is there life on Mars and where necessary to search for its traces // Astronomy and present: materials of 5 Interregional Scientific Conference, April 12, 2016, Vinnytsia, Ukraine. / Science ed. A.V. Mozhovi. - Vinnytsia: FOP "NP Kostiuk". 241 p. P. 43-48.
- [5]. Vidmachenko A.P. (2016) Processes on the “young” Mars: possible developments of events // 18 International scientific conference Astronomical School of Young Scientists, the program and abstracts. National Aviation University, Kyiv, Ukraine, May 26-27 2016, p. 16-17.
- [6]. Vidmachenko A.P. (2016) Where is Necessary to Search Traces of Life on Mars? // Biosignature Preservation and Detection in Mars Analog Environments conference, held May 16– 18, 2016. Hyatt Regency Lake Tahoe. Abstract #2002.
- [7]. Vidmachenko A.P., Morozhenko O.V. (2014) The physical characteristics of surface Earthlike planets, dwarf and small (asteroids) planets, and their companions, according to distance studies // Main Astronomical Observatory NAS of Ukraine, National University of Life and Environmental Sciences of Ukraine. Kyiv, Publishing House "Profi". -388.
- [8]. Steklov A.F., Vidmachenko A.P. (2018) Possibility of accommodation in a satellite Europe // 20 International scientific conference Astronomical School of Young Scientists. May 23–24 2018. The program and abstracts. Uman, Ukraine, p. 61-63.
- [9]. G.A. Landis, “Colonization of Venus,” Conference on Human Space Exploration, Space Technology & Applications International Forum, Albuquerque NM, 2-6 Feb. 2003. AIP Conference Proceedings Vol. 654, 1193-1198.
- [10]. P. G. Neudeck, et al., “Operational testing of 4H-SiC JFET ICs for 60 days directly exposed to Venus surface atmospheric conditions,” IEEE Journal of the Electron Devices Society, Vol. 10; 10 December 2018, pp. 100-110. doi: 10.1109/JEDS.2018.2882693.
- [11]. G.A. Landis, “Robotic Exploration of the Surface and Atmosphere of Venus,” paper IAC-04-Q.2. A.08, ActaAstronautica, Vol. 59, 7, pp. 517-580, October 2006.
- [12]. G.A. Landis, R. Dyson, S. Oleson, J.D. Warner, A.J. Colozza, and P.C. Schmitz, “Venus Rover Design Study,” paper AIAA 2011-7268. AIAA Space 2011 Conference & Exposition, Long Beach CA, 26-29 September 2011. <https://doi.org/10.2514/6.2011-7268>.
- [13]. G.A. Landis, et al., “Human Telerobotic Exploration of Venus: A New Flexible Path Goal,” paper AIAA-2011-335, 49th AIAA Aerospace Sciences Conference, Orlando FL, 4-7 January 2011.
- [14]. G.R. Schmidt, G.A. Landis and S.R. Oleson, “HERRO Missions to Mars and Venus using Telerobotic Surface Exploration from Orbit,” AIAA Space 2011 Conference & Exposition, Long Beach CA, 26-29 Sept. 2011.
- [15]. C. Sagan, "The Planet Venus," Science, Vol. 133, 24 March 1961, pp. 849-858.
- [16]. G.A. Landis, “Terraforming Venus: A Challenging Project for Future Colonization,” paper AIAA-2011-7215, AIAA Space 2011 Conference & Exposition, Long Beach CA, 26-29 Sept. 2011.
- [17]. D.M. Hunten, L. Colin, T.M. Donahue, V.I. Moroz, Venus, University of Arizona Press, Tucson, AZ, 1983.
- [18]. S. Vougher, D. Hunten, R. Phillips (Eds.), Venus II, University of Arizona Press, Tucson, AZ, 1997.
- [19]. D.H. Grinspoon, Venus Revealed, Perseus Publishing, Cambridge, MA, 1997.
- [20]. J.B. Pollack, Atmospheres of the terrestrial planets, in: J.K. Beatty, A. Chaikin (Eds.), The New Solar System, third ed., Cambridge University Press, Cambridge, 1990, pp. 91–103.
- [21]. D.H. Grinspoon, Venus Revealed, Perseus Publishing, Cambridge, MA, 1997.
- [22]. G. Landis, Venus: the case for astrobiology, Journal of the British Interplanetary Society 56 (2003) 250–254.
- [23]. Svedhem, H. et al. Venus Express—The first European mission to Venus. Planet. Space Sci. 55, 1636–1652 (2007).
- [24]. Titov, D. V. et al. Venus Express science planning. Planet. Space Sci. 54, 1279–1297 (2006).
- [25]. Markiewicz, W. J. et al. Morphology and dynamics of the upper cloud layer of Venus. Nature doi:10.1038/nature06320 (this issue).
- [26]. Piccioni, G. et al. South polar features on Venus similar to those near the north pole. Nature doi:10.1038/nature06209 (this issue).
- [27]. Barabash, S. et al. The loss of ions from Venus through the plasma wake. Nature doi:10.1038/nature06434 (this issue).
- [28]. Zhang, T. et al. Little or no solar wind enters Venus’ atmosphere at solar minimum. Nature doi:10.1038/nature06026 (this issue).
- [29]. Pa’tzold, M. et al. The structure of Venus’ middle atmosphere and ionosphere. Nature doi:10.1038/nature06239 (this issue).
- [30]. Russell, C. T. et al. Lightning on Venus inferred from whistler-mode waves in the ionosphere. Nature doi:10.1038/nature05930 (this issue).



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.118



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details