Exploration Of Venus: The Venera Program

Background

In the 1960's, with the Space Race well under way between the US and USSR, the Soviets set out to explore our sister planet, Venus and uncover what was hidden beneath the clouds. Venus "may have been the first habitable planet in the solar system" and is often referred to as "Earth's evil twin," due to its similar size, mass and composition (David, 2018), and its global warming effect caused by excess carbon dioxide levels. However, the similarities end there – a day on Venus is longer than an Earth year, the atmosphere is made of 97% carbon dioxide and the clouds are made of corrosive sulphuric acid (Richard, 2008). The temperature is hot enough to melt lead, at 737K, and the pressure is 90 times that of Earth's, which is the equivalent to being 1km deep in the ocean (Deziel, 2017). Therefore, very few missions have made it to the surface of Venus, and those that did lasted for only 20 minutes to little over 2 hours before being crushed by the tremendous heat and pressure.

The Venera Program

The Venera program began in February 1961, with the failed launch of Venera 1VA (proto-Venera) (Scott, 2013). Nine days later, the Soviets launched Venera 1, which did make it out of Earth's orbit. The Soviet Union kept their space program very private, often keeping plans for future achievements a secret until they were actually accomplished because the Kremlin wanted the space program to remain prestigious and did not want to admit any failures. Many Soviet spacecrafts at the time, where renamed "Kosmos" if their mission had failed and they hadn't reached their intended destination, hence, there were probably many more Venera spacecraft that we don't know of (Zak, 2019).

Venera 1 and 2 were flyby probes to Venus, with no intention of entering orbit. Venera 1 and 2 were launched in 1961 and 1965 respectively, and both suffered telemetry failures – radio communication was lost, and no data was obtained. Venera 2MV-1 No.1and No. 2 both succumbed to engine failures, preventing them from going into successful heliocentric injections, which caused them to crash-land on Earth. The Venera 2MV-2 was destroyed when the third stage of the spacecraft exploded (Scott, 2013). The Soviet Union launched several other failed attempts at flyby probes to Venus, however, they did not receive recognition as part of the Venera program since they were not announced as planetary missions at the time.

The Venera 3-6 probes were very similar. They were atmospheric probes, however, did not have any special landing apparatus. Venera 3 was the first human-made object to impact another planet's surface. On March 1, 1966, it crash-landed on the surface of Venus after losing communication in the atmosphere. On October 18, 1967, the Soviet Union claimed that the Venera 4 spacecraft reached the surface intact, as it became the first spacecraft to measure the atmosphere of another planet (90-95% carbon dioxide) (Williams, 2005). However, the Venera 4 probe could only withstand 25atm of pressure, and when the American Mariner 5 spacecraft flew past Venus, the surface pressure was re-analysed and found to be much higher at 90atm. This proved that the probe would have been crushed before reaching the surface. The spacecraft did, however, capture data about the atmosphere of Venus and transmitted data

for a long time before crashing and became the first interplanetary broadcast. Venera 5 and 6 were constructed to withstand this pressure by abandoning half their payload before entering the atmosphere. The Venera 5 and 6 missions provided more precise measurements of the atmospheric composition before the batteries failed after 50minutes. They detected presence of atmospheric nitrogen and oxygen (Sack, 2017). The photometer detected light level of 250 Watts per square meter (Williams, 2005).

On 15 December 1970, after 14 attempts and 11 failures, Venera 7 became the first probe to survive Venus's surface conditions and to make a soft-landing on Venus and broadcast from the surface of another planet. This probe had measuring instruments on board to measure the pressure and temperature. However, there were still many failures on this spacecraft, for instance, there was an internal switchboard failure stuck in the "transmit temperature" position and the parachute failed 29minutes before craft landed (Williams, 2005). Fortunately, the spacecraft survived the landing and collected data for 23 minutes before surrendering to the extreme heat and pressure. The antenna was also misaligned and so, the radio signal was very weak and difficult to detect. The windspeed was measured to be 2.5m/s and the surface temperature was 475 degrees Celsius.

Venera 8 was a lander which returned 50minutes of data. It measured the windspeed as it descended through the atmosphere and the surface composition was also measured using a gamma-ray spectrometer. It confirmed the temperature on Venus was 470 degrees Celsius and the pressure, 90atm. It also measured light levels to be similar to that on Earth on an overcast day with 1km of visibility. Sulfuric acid in the clouds was detected (Williams, 2005).

Venera 9-12 had a fresh design – it involved both a lander and orbiter, however, every lander had problems with the camera lens caps not releasing. Venera 9 and 10 took black and white photographs with one of the 2 cameras – the other lens cap did not release, while Venera 11 and 12's imaging system failed entirely, thus, returned no pictures as neither lens cap released. The Venera 9 lander transmitted the first black and white photographs of the planet's surface while the orbiter was the first to orbit around Venus and take photos of the clouds and upper atmosphere (NESTA, 2012). Venera 11 and 12 landers investigated the structure and composition of the atmosphere and clouds and measured solar radiation. There was also evidence of lightning and thunder, sulphur, and chlorine in the cloud layers (ESA, n.d.).

The Venera 13 and 14 landers contained instruments to take scientific measurements of the ground and atmosphere, using cameras, a microphone, a drill and surface sampler, a seismometer, as well as instruments to record electric discharges during its decent stage. It took 4 months for the spacecraft to reach Venus, before parachuting down to the surface. It landed on March 1, 1982, in an area in the southern hemisphere, containing lava flows and small dome volcanoes. This indicates an active surface? Venera 13 returned the first colour panoramic images of Venus's surface (14 colour and 8 black and white) and lasted for 127 minutes. In some photos, the surface looks yellow, however, it is difficult to know what the true colour of Venus is, as the clouds filter out blue light. Soil analysis from the Venera 13 missions left NASA scientists to conclude that "the surface characteristics correspond to compacted ash material such as volcanic tuff." (Howell, 2019). During soil analysis with the Venera 14 craft, the soil compressibility tester arm landed directly on top of the lens cap, returning data for the compressibility of the titanium lens cap, rather than the surface of Venus. Another failure! These missions used an X-ray fluorescence spectrometer, which discovered leucite basalt (rare on Earth) in a soil sample (using a spectrometer) and also tholeiitic basalt, similar to that found on

Earth’s mid-ocean ridges (ESA, n.d.). The nephelometer detected 3 distinct cloud layers.

Venera 15 and 16 (1983) were orbiters, launched 1 day apart, that collected radar imaging, which provided a detailed study of mesosphere and cloud tops by high-resolution thermal emission spectroscopy (ESA, n.d.). These were the most important Soviet missions to Venus as they provided a broader understanding of the planet. Many geological features, such as lava planes, volcanic constructs, volcanic tectonic features (called coronae) unique to Venus and impact craters were first discovered through Venera 15 and 16 data. This is a result of the radar system being able to produce very high-quality images of the surface – a map of the northern quarter of Venus (Encyclopaedia Britannica, 2019).

Summary

13 Venera spacecraft successfully transmitted data from Venus’s atmosphere, and 10 of these 13 sent back information from the planet’s surface (COSMOS, 2017). Despite having experienced so many failures over the course of 23 years, from 1961 to 1984, the Soviets ultimately chalked up many firsts with the Venera program:

- 01/03/1966: Venera 3 – first manmade object to crash-land on another planet
- 18/10/1967: Venera 4 – first probe to transmit information back to Earth while entering the atmosphere of Venus
- 15/12/1970: Venera 7 – first spacecraft to successfully make a soft landing on Venus
- 22/10/1975: Venera 9 – first spacecraft to send black and white photographs from the surface of another planet back to Earth
- 01/03/1982: Venera 13 – first to transmit colour photographs from the surface of Venus
- 10/10/1983: Venera 15 – carried the first radar systems to another planet

Why go to Venus again?

Discovery missions to any planet cost approximately $0.5 billion. “Unlike Mars, Venus is Earth-sized and thus the best test of how the two planets diverged climatically and geologically,” says Martha Gilmore, who co-chairs the Venus Exploration Analysis Group. Venus is Earth’s twin and understanding how two similar planets became so different can tell us so much more about the evolution of our own solar system and Earth-like worlds around other suns. It would also distinguish whether these worlds orbiting nearby stars are habitable.

No one has sent a probe to Venus in the last 34 years, so we still don’t know very much about it, but it is believed to have once contained water on its surface which boiled away in the heat. Understanding Venus can help provide an insight into what Earth could become if we don’t look after our planet. Extreme amounts of carbon dioxide triggered a runaway global warming effect in once habitable planet (Redd, 2017).

Venera-D?

NASA and Roscosmos, the Russian space agency, are thinking about Venera-D – a proposed future mission to Venus that would include an orbiter and lander that could last for months. The best launch opportunities occur in 2026 and 2031 and the spacecraft could include NASA components such as balloons, a subsatellite for plasma measurements, or a 24hr surface

station on the lander.

Goals of Venera-D mission (NASA, 2018):

- Investigate dynamics of the atmosphere
- Origin and evolution of the atmosphere
- Geological processes that have formed and modified the surface
- Study nature of the greenhouse effect
- Interaction between surface and atmosphere

Conclusion

Proposed planetary missions to Venus continue to be getting knocked back, and last year missions to asteroids was chosen instead. Reason for this being that more new data is acquired going to places like Mars or moons for the same cost. Also, “NASA’s planetary program has an emphasis on the search for life or the conditions that could lead to life,” – (?) Cleary Venus won’t be harbouring any life, but missions to Venus are the key into understanding our solar system and the fate of our own planet. In the end though funding is the main issue; “we have so many things that we want to do that we just can’t do it all,” says Jim Green, director of NASA’s planetary science division.

Bibliography

1. COSMOS. (2017, May 17). The Venera Program: When Russia Went to Venus. Retrieved from COSMOS: The Science of Everything: https://cosmosmagazine.com/space/the-venera-program-when-russia-went-to-venus
2. David, L. (2018, November 6). Will NASA’s Next Mission to Venus Be a Balloon? Retrieved from SCIENTIFIC AMERICAN: https://www.scientificamerican.com/article/will-nasas-next-mission-to-venus-be-a-balloon/
3. Deziel, C. (2017, April 25). Does it Rain on Planet Venus. Retrieved from sciencing.com: https://sciencing.com/two-planets-dont-solar-lunar-eclipses-2312.html
4. Encyclopaedia Britannica. (2019). Venus: Spacecraft Exploration. Retrieved from Encyclopaedia Britannica: https://www.britannica.com/place/Venus-planet/Spacecraft-exploration
5. ESA. (n.d.). Venus Express. Retrieved from European Space Agency: https://www.esa.int/Our_Activities/Space_Science/Venus_Express/Past_missions_to_Venus
6. Howell, E. (2019, March 25). Venera 13 and the Mission to Reach Venus. Retrieved from SPACE.com: https://www.space.com/18551-venera-13.html
7. Messier, D. (2018, March 26). Russian Launch Failures Aren’t a Bug, They’re a Feature. Retrieved from Parabolic Arc: http://www.parabolicarc.com/2018/03/26/russian-launch-failures-arent-bug-theyre-feature/
8. NASA. (2018). 49th Lunar and Planetary Science Conference 2018. Retrieved from usra.edu: https://www.hou.usra.edu/meetings/lpsc2018/pdf/1243.pdf
9. NESTA. (2012). Missions to Venus. Retrieved from windows2universe.org: https://www.windows2universe.org/venus/space_missions.html
10. Redd, N. T. (2017, March 15). The Case for Going to Venus. Retrieved from Smithsonian.com: https://www.smithsonianmag.com/science-nature/case-for-going-to-venus-180962534/

11. Richard. (2008, February 23). Venus: The planet where it rains acid. Retrieved from wordpress.com: https://blogearth.wordpress.com/2008/02/23/venus-the-planet-where-it-rains-acid/
12. Sack, H. (2017, Novemeber 16). Venera 3 and the Soviet Venera Space Probe Program. Retrieved from SciHi.org: http://scihi.org/soviet-venera-space-probe/
13. Sawyer, D. M. (2003, May 22). Venus Thumbnails. Retrieved from NSSDC: https://nssdc.gsfc.nasa.gov/imgcat/thumbnail_pages/venus_thumbnails.html
14. Scott, H. (2013, November 2). A Medium Corporation. Retrieved from What a Soviet spacecraft on Venus can teach you about failure: https://medium.com/@hunterscott/what-a-soviet-spacecraft-on-venus-can-teach-you-about-failure-f74f9c970a45
15. Williams, D. R. (2005, January 6). Venera 4. Retrieved from NASA: https://nssdc.gsfc.nasa.gov/planetary/venera.html
16. Zak, A. (2019, July 11). Spooky world of military satellites. Retrieved from russianspaceweb.com: http://www.russianspaceweb.com/spacecraft_military.html