VENUS

CANAN ZAİMOĞLU / SCIENCE LESSON

TERM PROJECT

“*VENUS*”

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8-G / 781

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Time to visit Venus... ☺

PLANET PROFILE

Mass (kg)..4.87 x 10^24
Diameter (km)..12104
Mean density (kg/m^3) 5250
Escape velocity (m/sec)..............................10400

Average distance from Sun (AU).......................0.723
Rotation period (length of day in Earth days)........243.0 (retrograde)
Revolution period (length of year in Earth days).....224.7

Obliquity (tilt of axis degrees).....................178
Orbit inclination (degrees)..........................3.39
Orbit eccentricity (deviation from circular).........0.007

Mean surface temperature (K).........................726

Visual geometric albedo (reflectivity)...............0.59
Highest point on surface.............................Maxwell Montes
(17 km above mean planetary radius)
Atmospheric components...............................96% carbon dioxide,
3% nitrogen,
0.003% water vapor
Surface materials....................................basaltic rock and
altered materials

VENUS

None of the *Venera* landers carried seismic equipment, so on direct measurements of the planet's interior have ever been made, and theoretical models of the interior have very little hard data to constrain them, However, to many geologists the surface of Venus resembles the young Earth, at an age of perhaps a billion years. At that time, volcanic activity had already begun, but the crust was still relatively thin and the convective processes in the mantle that drive plate tectonic motion were not yet established.

VENUS

In the 1930's, scientists measured the temperature of Venus's upper atmosphere spectroscopically at about 240 K – not much different from Earth's. Taking into account the cloud cover and Venus's nearness to the Sun and assuming that Venus had an atmosphere much like our own, researches believed that Venus might have a surface temperature only 10 K or 20 K higher that Earth's. In the 1950's, radio observations of the planet penetrated the cloud layer and gave the first indication of conditions near the surface. They revealed that the planet has a temperature exceeding 600 K! Almost ever night, the popular conception of Venus changed from that of a lush tropical jungle to an arid, uninhabitable desert.

Since then, spacecraft data have revealed the full extent of the differences between the atmospheres of Venus and Earth. Venus's atmosphere is much more massive than our own, and it extends to a much greater height above the planet's surface. The surface pressure of Venus's atmosphere is about 90 times the pressure at sea level on Earth. This is equivalent to an underwater depth of about 1 km. Unprotected humans cannot dive much below 100 m. The surface temperature is a sizzling 750 K – about twice as hot as a kitchen oven and hot enough to melt lead.

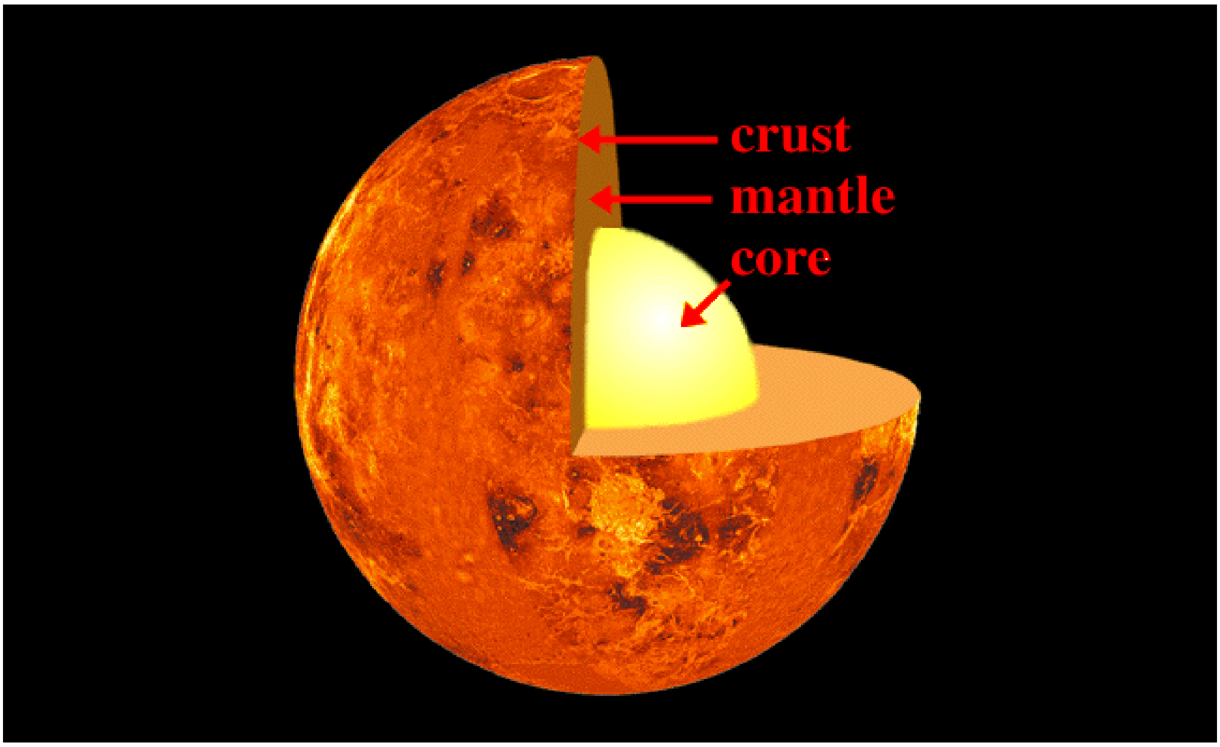
Earth- and space-based observations have allowed astronomers to make accurate measurements of the composition of Venus's atmosphere. The dominant constituent is carbon dioxide, which accounts for 96.5 percent of the total. Almost all the remaining 3.5 percent is nitrogen. There is no sign of the large amount of water vapor that would be expected if a volume of water equivalent to Earth's oceans had once existed on Venus and later evaporated. If Venus started off with Earth-like composition, something has happened to its water-it is now an exceedingly dry place. Even the highly reflective clouds are composed not of water vapor, as on Earth, but of sulfuric acid droplets.

Venus's atmospheric patterns are much more evident when examined with equipment capable of detecting ultraviolet radiation. Some of Venus's upper-level clouds absorb this high-frequency radiation, thereby increasing the contrast. The large, fast-moving cloud patterns lie between 50 and 70 km above the surface. Upper-level winds reach speeds of 400 km/hr relative to the planet. Below the clouds, extending down to an altitude of some 30 km, is a layer of haze. Below 30 km, the air is clear.

THE SURFACE OF VENUS

Although the clouds are thick and the surface totally shrouded, we are by no means ignorant of Venus's surface. Radar astronomers have bombarded the planet with radio signals, both from Earth and from the *Pioneer*, *Venera*, and, most recently, *Magellan* spacecraft. Analysis of the radar echoes yields a map of the planet's surface. The altitude of the surface above the average radius of the planet's surface is indicated by the use of color, with red representing the highest elevations, blue the lowest. The planet's surface appears to be mostly smooth, perhaps resembling rolling plains with modest highlands and lowlands. Only two continental-sized features adorn the landscape, and these contain mountains comparable in height to those on Earth. The highest peaks rise some 14 km above the level of the deepest surface depressions.

The elevated "continents" occupy only 8 percent of Venus's total surface area. Although there is no evidence for any large-scale plate tectonic activity on Venus, there is plenty of evidence for volcanism in the recent past. It is likely that the stresses in the crust that led to the large mountain ranges were caused by convective motion within Venus's mantle, the same basic process that drives Earth's plates.

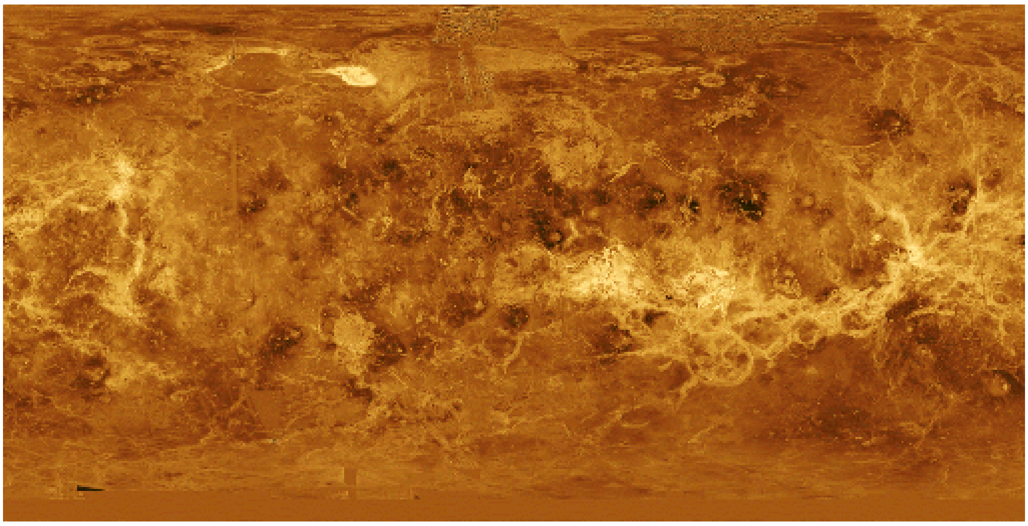


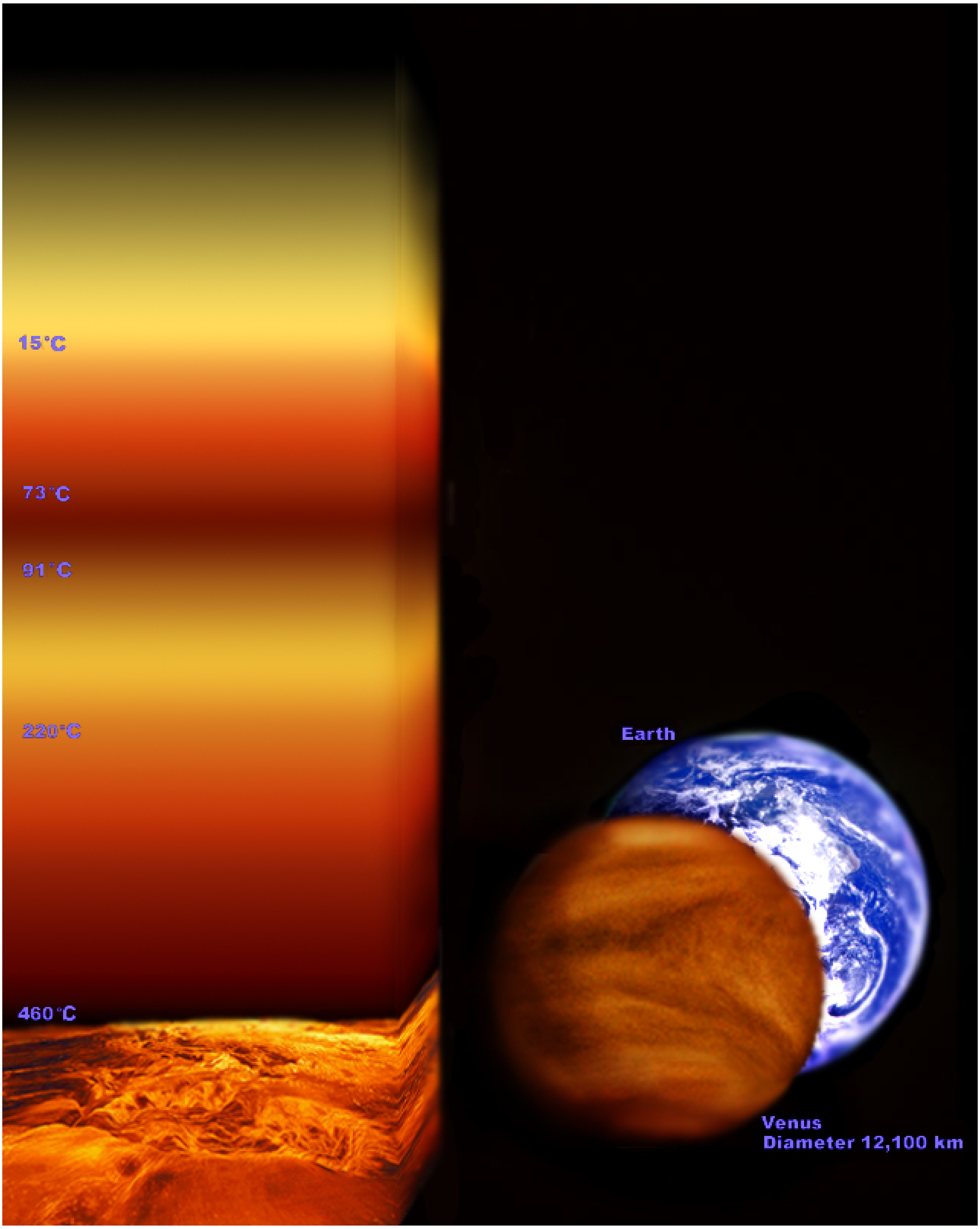
VOLCANISM

Many areas of Venus are now known to have volcanic features. Alpha Region, which lies close to Venus's equator south of Ishtar. A series of seven pancake-shaped lava domes, each about 25 km across, can be seen. They probably formed when lava oozed out of the surface, formed the dome, then withdrew, leaving the crust to crack and subside. Lava domes such as these are found in several locations on Venus. The most common volcanoes on the planet are of the type known as a **shield volcano**. Shield volcanoes on Earth are associated with lava welling up through a "hot spot" in the crust (like the Hawaiin Islands). A characteristic of shield volcanoes is the formation of a *caldera*, or crater, at the summit when the underlying lava withdraws and the surface collapses.

The largest volcanic structures on Venus are huge, roughly circular regions known as **coronae**. Coronae are unique to Venus. They appear to have been caused by upwelling motions in the mantle that never developed into full-fledged convection as on Earth. They generally have volcanoes both in and around them, and closer inspection of the rims usually shows evidence for extensive lava flows into the plains below.

THE IMAGE OF VENUS' LAVA SURFACE




15°C
73°C
91°C
220°C
460°C
Earth
Venus
Diameter 12,100 km

*_THE RUNAWAY GREENHOUSE EFFECT ON VENUS_*

Given the distance of Venus from the Sun, the planet was not expected to be such a pressure cooker. Why is Venus's atmosphere so hot_? And if, as we believe, Venus started off like Earth, why is it now so different_? The answer to the first question is fairly easy : Given the present composition of its atmosphere, Venus is hot because of the *greenhouse effect*. The "greenhouse gases" in Earth's atmosphere, particularly water vapor and carbon dioxide, serve to trap heat from the Sun. By stopping the escape of much of the infrared radiation reradiated from the Earth's surface, these gases increase the planet's equilibrium temperature in much the same way as an extra blanket keeps you warm on a cold night. Continuing the analogy a little further, the more become. Similarly, the more greenhouse gases there are in a planet's atmosphere, the hotter the surface will be.

Venus's dense atmosphere is made up almost entirely of a prime greenhouse gas, carbon dioxide. As illustrated in the picture, the thick carbon dioxide blanket absorbs about 99 percent of all the infrared radiation released from the surface of Venus and is the immediate cause of the planet's sweltering 750 K surface temperature. Thus, we have answered the first question about Venus's temperature: Venus is hot because of the abundance of carbon dioxide in its thick atmosphere. Now let us turn to the second question: Why is Venus's atmosphere so different from Earth's_?

The initial stages of atmospheric development on Venus probably took place in more or less the same way as just described fro our own planet. At some time in the past, Venus may well have had an atmosphere similar to Earth's primitive secondary atmosphere, containing water, carbon dioxide, sulfur dioxide, and nitrogen-rich compounds. What happened on Venus to cause such a major divergence from subsequent events on our own planet_?

On Earth, much of the secondary atmosphere became part of the surface of the planet. If all the dissolved or chemically combined carbon dioxide were released back into Earth's present-day atmosphere, its new composition would be 98 percent carbon dioxide and 2 percent nitrogen, and it would have a pressure about 70 times its current value. In other words, apart from the presence of oxygen and water, Earth's atmosphere would look a lot like Venus's. The real difference between Earth and Venus, then, is that Venus's greenhouse gases never left the atmosphere.

When Venus's secondary atmosphere appeared, the temperature was higher that on Earth, simply because Venus is closer to the Sun. The exact temperature is uncertain, however. If it was already so high that the oceans never condensed, the out gassed water vapor and carbon dioxide would have remained in the atmosphere, and the full greenhouse effect would have gone into operation immediately. If oceans did form and most of the greenhouse gases left the atmosphere, the temperature must still have been sufficiently high that a process known as the **runaway greenhouse effect** came into play.

To understand the runaway greenhouse effect, imagine that we took Earth from its present orbit and placed it in Venus's orbit. At its new distance from the Sun, the amount of sunlight hitting the Earth's surface would be almost twice its present level, so the planet would warm up. More water would evaporate from the oceans, leading to an increase in atmospheric water vapor. At the same time, the ability of both the oceans and surface rocks to hold carbon dioxide would diminish, allowing more carbon dioxide to enter the atmosphere. The greenhouse heating would increase, and the planet would warm still further, leading to a further increase in atmospheric greenhouse gases, and so on. Once started, then, the process would "run away", eventually leading to the complete evaporation of the oceans, restoring all the original greenhouse gases to the atmosphere. Although the details are quite complex, basically the same thing would have happened on Venus long ago, leading to the planetary inferno we see today.

The greenhouse effect on Venus was even more extreme in the past, when the atmosphere also contained water vapor. By intensifying the blanketing effect of the carbon dioxide, the water vapor helped the surface of Venus reach temperatures perhaps twice as hot as at present. At those high temperatures, the water vapor was able to rise high into the planet's upper atmosphere---so high, in fact, that it was broken up by solar ultraviolet radiation into its components, hydrogen and oxygen. The light hydrogen rapidly escaped, the reactive oxygen quickly combined with other atmospheric gases, and all water on Venus was lost forever.

DICTIONARY

Obliquity : Also called: obliquity of the ecliptic. Astronomy. ex : The angle between the plane of the earth's orbit & that of the celestial equator, equal to approximately 23^o $27^{'}$ at present.
Eccentricity : The degree of displacement of the geometric centre of a part from the true centre, esp. of the axis of rotation of a wheel.
Seismic : Relating to or caused by earthquakes or artifically produced earth tremors.
Spectroscopy : The science and practise of using spectrometers and spectroscopes and of analysing spectra, the methods employed depending on the radiation being examined. The technniques are widely used in chemical analysis and in in studies of the properties of atoms, molecules, ions ,etc.
Ultraviolet (Astronomy) : the study of radiation from celestial sources in the wavelenght range 25 to 350 nanometres.
Frequency : Physics. The number of times that a periodic function or vibration repeats itself in a specified time, often 1 second. It's usually measured in hertz.
Penetrate : To find or force a way into or through (something); pierce; enter.
Collapse : To fall down or cave in suddenly
Infrared : The part of electromagnetic spectrum with a longer wavelength than light but a shorter wavelength than radio waves; radiation with wavelength between 0.8 micrometers and 1 millimetre.
Equilibrium : Chemical. The condition existing when a chemical reaction and it's reverse reaction takes place at equal rates.
Abundance : Chemical. The extend to which an element occurs in the earth's crust or some other specified environment; expressed in parts per million or as a percentage.
Primitive : Biology. Of, releating to, or resembling an early stage in the evolutionary development of a particular group of organism.
Divergence : The scalar product of the operator & a vector function.
Subsequent : Occuring after; succeeding.
Diminish : To make or become smaller, fewer, or less.
Inferno : Hell; the infernal region.

MY SOURCES

ASTRONOMY a beginner's guide to the universe

Evren CD_ROM

www.space.com www.nasa.gov

My astronomy teachers : Müge Genc, Talat Saygaç, Sinan Ali

COLLINS english dictionary

Grolier International Americana Encyclopedia

Istanbul University Astronomy Department