ARTICLES

SOME RECENT DATA FROM VENUS AND JUPITER: IMPLICATIONS FOR COSMOGONY

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WHAT THIS ARTICLE IS ABOUT

Views of unexplored areas, be they in science or geography, are constructed either from extrapolation of known experiences or from wild fantasy. Earthbound cosmologists have viewed our solar system from both perspectives. With the advent of unmanned probes, results have been obtained which have forced the abandoning of supposed similarities with our own earth as well as causing the destruction of several fantasies. The solar system appears not to be homogeneous in its composition and structure. These results are puzzling in view of a supposed similar source of raw materials. Atmospheric compositions are uniformly hostile to known life forms. Elemental and molecular studies indicate great variance in apparent ages. These results provide little confidence in any naturalistic model of a cosmology for our solar system.

A collection of planetary bodies clustered around a medium-sized star constitutes man's backyard in this vast universe. After millennia of wistful gazing with the naked eye and centuries of squinting through earth-bound telescopes, man in the last two decades has arrived at the grand moment when he can study neighboring worlds in unprecedented detail from comparatively close-up positions.

The era of unmanned planetary missions began in December 1962, when the spacecraft Mariner 2 flew by Venus and measured that planet's surface temperature and the strength of its magnetic field. This initial exploration was followed by more than three dozen missions of varied complexity to other parts of the solar system.[1] As of early 1980, seven American planetary spacecraft were in operation: two Viking landers on the surface of Mars, two Voyagers cruising toward Saturn, the Pioneer 10 vehicle leaving the solar system and carrying a "cosmic greeting card," the Pioneer 11 craft traveling between the orbits of Saturn and Uranus, and a Pioneer-Venus satellite in orbit around Venus.

Most students of the solar system believe that it was formed four to five billion years ago out of a large rotating cloud of gas and small rocky particles named the "presolar nebula." After the sun condensed out, the planets formed at various distances from the sun. The composition of each planet was influenced by the concentration of matter in that portion of the nebula and by the timing of its aggregation. According to this hypothesis, the early-forming planets (i.e., Jupiter and Saturn) scooped up more matter than late-forming ones such as Earth and Mars.[2,3,4]

Currently recognized components of our solar system consist of the sun, nine planets and their thirty-five satellites, numerous comets, thousands of asteroids, plus countless meteoroids. Ninety-seven percent of the solar system's mass is located in the sun, a seething caldron of largely ionized hydrogen.

Nearest to the sun revolve the four small "inner" or "terrestrial" planets, Mercury, Venus, Earth and Mars. All have high densities varying from 3.93-5.52 times that of water. Beyond the orbit of Mars is an asteroid belt 300 million km wide which separates the inner planets from the large, gaseous outer planets, Jupiter, Saturn, Uranus and Neptune. Pluto, the farthest known planet from the sun, is anomalous in that position because it resembles the inner planets in size and density. Some have suggested that Pluto is a runaway satellite of Neptune.

The two gas giants Jupiter and Saturn are surrounded by numerous orbiting moons of various sizes and makeup. Each planet mimics the larger solar system in its form, and indeed, some of Jupiter's moons are of planet size.

There is on the whole a prevailing optimism among scientists that increased knowledge of our solar system will clarify the theories of its origins. But there are still dissenting opinions. For example Carl Sagan writes: "Yet even preliminary reconnaissance of the entire solar system out to Pluto and the more detailed exploration of a few planets ... will not solve the fundamental problem of solar system origins. What we need is to discover other solar systems, perhaps at various stages of their evolution."[5] Prospects of discovering or exploring planetary systems outside the solar system are remote in the foreseeable future.

The reason for this pessimistic view is that the new data from various parts of space necessitated a modification of the theories of the solar system's origin. This article will discuss selected findings of the Pioneer-Venus missions and of the Voyager 1 and 2 missions to Jupiter which have caused this reexamination.

RECENT DATA FROM VENUS

Venus is our nearest planetary neighbor in space, a mere one hundred and twenty-day journey from Earth by modern spaceships. It closely resembles Earth in size and density; hence, according to the "presolar nebula" theory, one would infer similarities in planetary makeup. Though it receives almost twice as much solar radiant energy as does Earth, it actually absorbs only about the same amount of solar energy, due to its highly reflective cloud cover.[2,6]

Despite these similarities, observed conditions on Venus are singularly unique in the solar system. Its surface is uniformly hot, in the vicinity of

750 K. Its heavy atmosphere is composed largely of carbon dioxide, creating a surface atmospheric pressure of nearly 100 times that on Earth. Conditions on Venus are so inhospitable that none of the half a dozen Soviet spacecraft survived more than a few hours after making a soft landing on the planet.

Venus is continually veiled by an unbroken, pale-yellow cloud cover that appears to be featureless at visible wavelengths. In the ultraviolet region these clouds display a complex pattern of bright and dark swirls. Both the clouds and the planet rotate in the retrograde direction. The upper clouds rotate with a period of about four days, driven by 360 km/hr winds at the equator, while the planet itself moves at the much slower rate of one rotation in 243 Earth days. Venus' slow rotation is thought to be the reason why there is no detectable magnetic field around the planet.

In December 1978 the Venusian atmosphere was extensively analyzed by five Pioneer Venus probes during their short plunges on various trajectories through it. Using radar, the Pioneer "bus" orbiter has produced a complete topological map of Venus. Initial results of these experiments have been published recently.[4,7]

The Pioneer Venus space probes discovered that the cloud cover enveloping Venus has three distinct layers, extending vertically from 48 to 70 km above its surface. The upper cloud region contains droplets of an 85% aqueous solution of sulfuric acid. There are liquid droplets and solids of various sizes with uncertain chemical composition in the middle and lower clouds. Below the clouds a thin haze of sulfur dioxide and sulfuric acid extends from 48 km to 32 km. There is no particulate matter in the lower 32 km of the Venusian atmosphere, but visible light is so sharply bent here that looking straight down at the planet from orbit, one could see nothing but an empty sky.

These probes also made extensive measurements on the chemical composition and isotopic distribution of the gaseous components of the Venusian atmosphere using ion and neutral mass spectrometers and gas chromatographs.

Interaction between components of the upper atmosphere and the solar wind produces numerous ionic species. Of the 11 ions detected, the most abundant above 200 km are O^+ and some C^+, N^+, H^+ and He^+, whereas at the 150 km level the O_2^+ is the dominant species with minor amounts of NO^+, CO^+ and CO_2^+.[8]

As for neutral molecules and atoms, helium is the highest detectable substance, being found as far away as 700 km from the planet. Carbon dioxide appears at 450 km and becomes the dominant species below 200 km. The atmospheric composition at 150 km above the surface is seen in Table 1.

TABLE 1*

Component	Particles/cm^3
Carbon dioxide	1.1×10^9
Carbon monoxide	2.4×10^8
Molecular nitrogen (N_2)	2.1×10^8
Atomic oxygen (O)	6.6×10^8
Helium	2.0×10^6

*Data taken from Endnote 9.

In addition to these, measurable quantities of sulfur dioxide were found at the 70 km level. The composition of the lower portion of the Venusian atmosphere (25-54 km above the surface) is seen in Table 2.

TABLE 2*

Component	Approximate percent of total
Carbon dioxide	96.4
Nitrogen	3.4
Water	0.14
Molecular oxygen (O_2)	?
Argon	67×10^{-4}
Carbon monoxide	20×10^{-4}
Neon	4.3×10^{-4}
Sulfur dioxide	185×10^{-4}

*Data taken from Endnote 10.

Currently available data analyses do not permit the unequivocal identification of molecular oxygen. Its presence in measurable quantities would be a surprise to scientists who assume that most planets are surrounded by a reducing atmosphere resulting from outgassing processes from the planet's interior. Photodissociation of water and the subsequent escape of hydrogen could conceivably give rise to oxygen on Venus, were it not for the low rate of hydrogen escape, $10^7/cm^2$ sec. This has prompted the conclusion that "if Venus ever possessed a large amount of water, it cannot have lost it by escape mechanisms known to be operating now."[11]

A major surprise was the finding of 2-300 times as much ^{20}Ne and ^{36}Ar in the lower atmosphere of Venus than on Earth.[12,13,14] These particular isotopes of inert gases are not decay products of radioactive elements, and as such they are assumed to have been present since the formation of the planet. At the same time, the abundance of elements lighter than argon, such as ^{14}N or ^{12}C, are about the same in Venusian atmosphere as in our own. These data necessitated a departure from previous thinking, causing scientists to conclude that "primordial" noble gas abundances do not give adequate estimates of other volatiles in a planetary atmosphere.[12]

On the basis of low levels of primordial noble gas concentrations in our atmosphere, evolutionary theorists suggested that the original atmosphere of Earth was lost, followed by outgassing of a secondary atmosphere from the interior of the planet. This widely accepted notion will have to be reevaluated in the light of the findings above. Earlier studies of the atmosphere of Mars by the Viking probes showed that both the ^{36}Ar to ^{40}Ar ratio and the total abundance of argon are significantly lower there than in Earth's atmosphere, even though the abundances of other gaseous components, such as nitrogen, are comparable. A straightforward application of the "solar nebula" hypothesis would have predicted similar argon concentrations for both planets, since they were supposed to have been condensed out of the same nebula at close proximity.

To account for the actual findings, theorists suggested that perhaps nitrogen was somehow more effectively bound in the interior of Mars than was argon during the formation of the planet. When argon outgassed, it was swept away by an energetic "early" solar wind. By the time the Martian nitrogen was released into the atmosphere, this energetic solar wind had subsided.

This same scenario should also apply to Venus, which, like Mars, possesses only a weak magnetic field, permitting in theory the close approach of the hypothetical, early energetic solar winds. The prediction was that the argon content of Venus would be similar to that of Mars. The actual results were totally unexpected. Compared to Mars, Venus showed an increase in primordial argon content. More recently a new concept has been proposed, postulating that perhaps the temperature of the solar nebula was fairly even during planet formation. This permits the existence of an increase in noble gas concentration toward its center.[15] However, this proposal does not predict the uniform ^{12}C and ^{14}N abundances observed in the atmospheres of Venus, Earth and Mars. There is no known basis upon which we would expect a gradient of noble gases to exist in the absence of the same gradient among other gases.

Another perplexing problem is the extremely hot temperature near the surface of Venus. The obvious explanation that the heavy atmosphere of carbon dioxide, water vapor and sulfur dioxide prevent the loss of absorbed radiant solar energies, a "greenhouse" effect, does not appear sufficient to explain the 750 K surface temperatures. Additional sources of energy are needed. One intriguing proposal suggests that compounds with high bond energies would form high in the atmosphere under the influence of sunlight, then would drift downward and decompose near the surface, releasing their chemical energies. In this way, a portion of the sun's energy would reach the Venusian surface in a chemical form. This decomposition energy is one possible cause of the faint glow observed in the lower atmosphere.[16]

The surface of Venus has been mapped by radar from the Pioneer Venus orbiter. A variety of surface features can be seen: volcanoes, plateaus, mountain ranges, craters and great valleys. The craters, however, are few in number and are very shallow perhaps due to a surface softened by heat. A chain of volcanic prominences running north-south for thousands of miles has been seen, some reaching 4 km above the surrounding terrain. The most prominent mountain on Venus is Maxwell, towering alone 12 km above the surrounding region.

Venus lacks the equivalent of Earth's great ocean basins which account for 70% of our planet's surface. As a result, tectonic forces that gave rise to the Venusian mountains are not yet understood. Horizontal movements of crustal plates which are thought to be responsible for plateaus and mountains on Earth also explain the appearance of the corresponding basins.

RECENT DATA FROM JUPITER

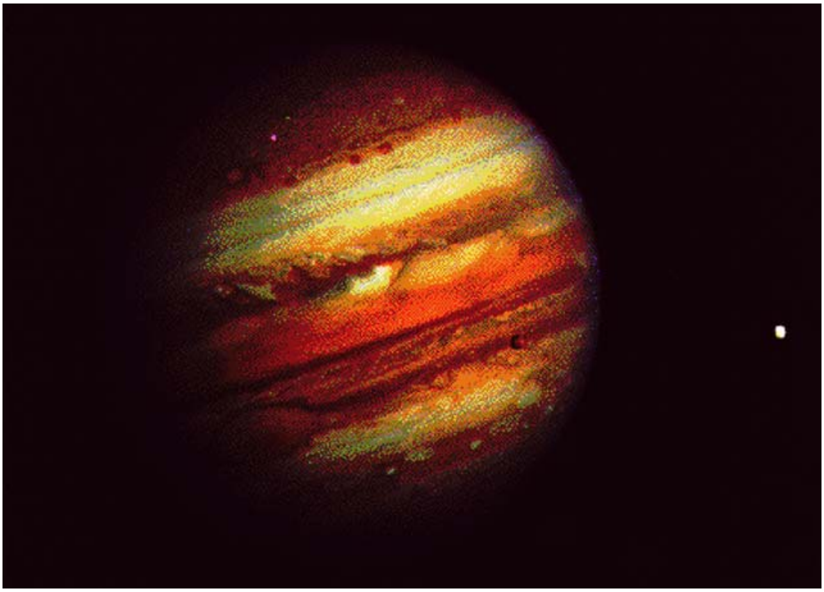
Beyond the orbit of Mars and the asteroid belt, 800 million km from the sun, is Jupiter. Three hundred times more massive than Earth, Jupiter contains about two-thirds of the planetary mass of the solar system. Its elemental composition is thought to resemble that of the sun, but its structure is neither that of a star nor that of an inner planet. It is one-and-one third times as dense as water, presumably composed mostly of gas and liquid with possibly a small solid core of comparatively dense material.[17]

Jupiter is surrounded by zones of clouds of alternating light and dark appearance, all oriented parallel to its equator. Infrared measurements by two Pioneer spacecraft reveal that the dark belts are warmer than the light zones. Chemically, the upper atmosphere of Jupiter is made up of hydrogen, helium, ammonia, methane, water and hydrogen sulfide, all colorless substances. Nevertheless, highly colored organic and inorganic compounds and free radicals are believed to form in the upper atmosphere under the influence of the sun's ultraviolet radiation, giving rise to the colored bands that are observed.

In the southern hemisphere is the "Great Red Spot," a 30-40,000 km by 14,000 km reddish vortex, observed by earth-based telescopes to fade and reappear periodically over the past several centuries. It appears to be a gigantic cyclonic disturbance of the atmosphere, hovering over a postulated sea of liquid hydrogen.

Voyager measurements focused on the composition, structure and dynamics of Jupiter's atmosphere, on magnetic field properties, and on the comparative geologies of the Galilean satellites.

The Voyager craft found the dynamics of Jupiter's atmosphere very complex. What appeared from a distance to be a rather stable, multicolored, banded cloud system turned out to be, upon closer inspection, a dynamic system of fast-moving streams, vortices and turbulence undergoing noticeable changes in rotational and lateral motion within hours. Besides the Great Red Spot, a host of light and dark colored spots were observed.



Jupiter, its Great Red Spot, and two of its four largest satellites are visible in this photograph taken February 5, 1979, by Voyager 1. The innermost large satellite, Io, can be seen against Jupiter's disk. Io is distinguished by its bright, brown-yellow surface. At the right of the photograph is the satellite Europa. Picture courtesy of the National Aeronautics and Space Administration.

Some spots were seen to overtake or roll around one another before separating. In view of such turbulence, it is surprising that the Great Red Spot has remained essentially intact for at least the three centuries it has been observed. This unexpected, complex motion invalidates all existing atmospheric circulation models for Jupiter.

Infrared spectroscopy of Jupiter's atmosphere revealed the presence of a wide variety of gases: hydrogen, methane, ethylene, ethane, deuterated methane, ammonia, phosphorus trihydride, water, and germanium tetrahydride. It also showed that the atmosphere above the Great Red Spot is measurably cooler when compared to the areas surrounding it.[18]

Pictures taken on Jupiter's night side showed a vast glowing arc over the planet. Huge flashes of light were seen above the cloud tops, each estimated at 10 billion joules of electrical energy. They resemble the "super-bolts," seen occasionally above Earth's tropical regions.

Another discovery was a thin flat equatorial ring of particles surrounding Jupiter. Some 30 km thick and 6000 km wide, this ring system appears to reach down to the cloud tops.[18,19] It consists of particles about 10-100 meters across.

Jupiter's rotation period of just under 10 hours makes it the fastest rotating planet in the solar system, and it is therefore expected to have an intense magnetic field as observed. According to current theories, this magnetic field requires that the planet's interior be a rotating, electrically conductive fluid. Scientists postulate that underneath a 25,000 km deep surface layer of liquid molecular hydrogen, there exists yet another 25,000 km layer of hydrogen in an atomic, liquid, metallic state. This latter layer surrounds the core. This unusual metallic state of hydrogen is brought about by an estimated pressure of three million Earth atmospheres and a temperature near 11,000 K.[20]

Jupiter has two distinguishable magnetic fields, an inner one which directs particles along a magnetic equator, and an outer field that fans far into space along the rotational equatorial plane of the planet. The inner magnetosphere extends to about 1,400,000 km while the outer field reaches to six and a half million km into space. Both magnetic fields are tilted 11° to the planet's axis of rotation. The strength of the magnetic field at Jupiter's cloud tops ranges from 2-15 G, compared to 0.5 G at Earth's surface. Jupiter's strong magnetic field accelerates electrons and protons to energies thousands of times higher than those observed in the Earth's magnetic belts. The radiation intensities are comparable to those following a nuclear explosion in our upper atmosphere.[21]

Voyager 1 discovered that the inner magnetosphere forms a "flux tube" between Jupiter and one of its moons, Io. Charged particles of oxygen and sulfur flow along this "tube" at the rate of about $10^{10}/cm^2$ sec, generating a current of about 5×10^6 A.[22]

More than a dozen satellites orbit around Jupiter. The four largest rival the smaller planets in size and are often referred to as the "Galilean satellites." The Voyager missions examined extensively their surface structures. Some of the findings are given in Table 3.

TABLE 3

Satellite	Mean Distance from Jupiter (km)	Density (g/cm^3)	Mass (Moons=1)
Io	350,200	3.53	1.21
Europa	559,500	3.55	0.66
Ganymede	998,600	1.93	2.03
Callisto	1,808,600	1.79	1.45

Io is the innermost Galilean satellite, featuring a mottled surface of orange, red, yellow and white, pock-marked with jet-black pits. It is surprising that no impact craters were found on Io, for most planetary bodies devoid of atmosphere are covered with these. Instead, eight active volcanoes were discovered spewing matter 70-300 km into space. The cause of volcanism is suspected to be a gravitational tug of war over Io between Jupiter on the one hand and Europa plus Ganymede on the other. As Io moves in a slightly eccentric orbit (caused by Europa and Ganymede), tidal bulges on its surface are "pumped" in and out by Jupiter, heating it to temperatures required for volcanism to occur.

Europa appears almost white, reflecting light nearly ten times better than Earth's moon. Its surface is criss-crossed by stripes and bands, tens of kilometers wide, and some extending thousands of kilometers in length. They appear to be filled fractures in the satellite's icy crust. This moon's surface is under a thick mantle of ice which effectively obscures most topographic features.

Ganymede and Callisto have numerous similar features. Both have large areas of dark and bright colors and both are pock-marked with numerous craters, although Callisto's surface has a greater number of these. One of Callisto's hemispheres is dominated by a system of concentric rings of grooves. Ganymede's surface is also covered with ridges and troughs that appear as grooves, except these run in random directions. The grooves on both moons are thought to be caused by tectonic forces.[23]

IMPLICATIONS FOR THEORIES OF THE SOLAR SYSTEM'S ORIGIN

The massive amount of new data reveals that the solar system is a much more complex, heterogeneous collection of planets, moons and interacting forces than previously suspected. Venus is a vastly different planetary body than the Earth and Mars. Jupiter and its four Galilean moons also form a complex and possibly unique subsystem.

It is not difficult to perceive that the "presolar or solar nebula" hypothesis neither predicts nor explains many of the recent findings. The very idea of planets condensing out of a cloud of gas and dust is not a secure one. Moreover, it is not at all obvious how planets of such widely diverse properties as Earth and Venus could have condensed out of the same rotating cloud at comparatively close distances to each other. The problem is further compounded when we note the variance in density and apparent composition of Europa and Ganymede, which are theorized to have formed, again at very close range, from the same primordial matter. Since 1644, when Descartes published his vortex theory in *Principia Philosophie*, more than 20 major hypotheses have been advanced to explain the intricacies of the solar system. These are, according to one author, "a record of the versatility of the human mind."[2] Another writer summed it up this way:

> *Each new fact seemed to add to the complexity of the problem. It is clear that the solar system did not originate in a simple manner, in spite of the fact that many of the theories which have attempted to explain it are framed in simple terms. If a theory of the origin of the solar system is to*

be truly complete, it must explain all the facts. This is still extremely difficult, not only because all the known facts amount to such a large and bewildering sum of data, but because many vital facts are not yet known.[23]

Thus we note the frustration of the theorists who attempt to formulate coherent theories of origins in terms of purely natural forces and without invoking the handiwork of a Creator. Yet they press on, convinced that eventually all the data will fall into place.

Creationists observe the orderly orbits of the planets around the sun, the strange admixture of similarities and diversities among the components of the solar system and find harmony between these and their concept of the Creator described in the Bible. Although they too are unaware of the undiscovered aspects of the solar system, given the choice between uniformity and non-uniformity, they would tend to predict that Saturn, Uranus and Neptune will turn out to be quite different from what was seen in the Jovian system. The Creator they know does not use the "assembly line" approach to creation, but rather He is an artist who does variations on a theme.

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