In This Issue

Planetary Environments, Part 11: Uranus and its Principal Moons

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This is the eleventh article in the *Astrofax* series on planetary environments. The first ten in the series appeared in the previous ten issues of *Astrofax*:

1. *Planetary Environments, Part 1: Introduction* (Volume 31, Issue 2, Summer 2023)
2. *Planetary Environments, Part 2: The Moon* (Volume 31, Issue 3, Fall 2023)
3. *Planetary Environments, Part 3: Mercury* (Volume 31, Issue 4, Winter 2023)
4. *Planetary Environments, Part 4: Venus* (Volume 32, Issue 1, Spring 2024)
5. *Planetary Environments, Part 5: Mars, Part 1* (Volume 32, Issue 2, Summer 2024)
6. *Planetary Environments, Part 6: Mars, Part 2* (Volume 32, Issue 3, Fall 2024)
7. *Planetary Environments, Part 7: Jupiter* (Volume 32, Issue 4, Winter 2024)
8. *Planetary Environments, Part 8: Jupiter's Galilean Moons* (Volume 33, Issue 1, Spring 2025)
9. *Planetary Environments, Part 9: Saturn* (Volume 33, Issue 2, Summer 2025)
10. *Planetary Environments, Part 10: Saturn's Principal Moons* (Volume 33, Issue 3, Fall 2025)

Introduction

This article will discuss Uranus and its five large moons. In order of distance from the planet and with their diameters, they are Miranda (471 km), Ariel (1160 km), Umbriel (1170 km), Titania (1580 km) and Oberon (1520 km). Fig 1, a Voyager-2 event cover for its Uranus encounter, depicts and names the moons. A comparison of the five moons, from Voyager-2 photographs and presented with their proper relative sizes and albedos, is found here. The individual images and some information about the moons are found here.

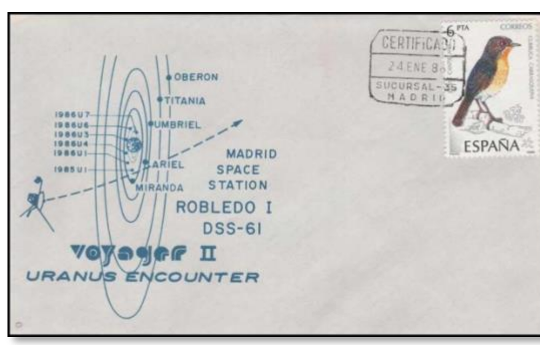

Figure 1. Voyager-2 Uranus encounter event cover, 24 January 1986.

Uranus is so far away (at an average of 19.2 au, it is twice as far from the Sun as Saturn) that it receives almost no solar energy and is very cold. It completes one orbit around the Sun every 84 years. Uranus and Neptune are known as the "ice giants," while Jupiter and Saturn are the "gas giants." This difference is justified because "the bulk compositions of Uranus and Neptune are different from those of Jupiter and Saturn, with ice dominating over gases … Uranus' internal composition must be mostly water, methane and ammonia in order to match the average density of the planet" (Ref 1). Uranus is significantly less dense than Neptune; the two must have different compositions.

Fig 2, the gutter from Australia *Scott* 2740a, shows the Solar System's planets with correct relative sizes (but not correct relative distances among them). The two ice giants are large and similar in size but are dwarfed by the two gas giants. A similar depiction, which also includes the asteroid belt and Pluto, is found in the cachet of Fig 9.

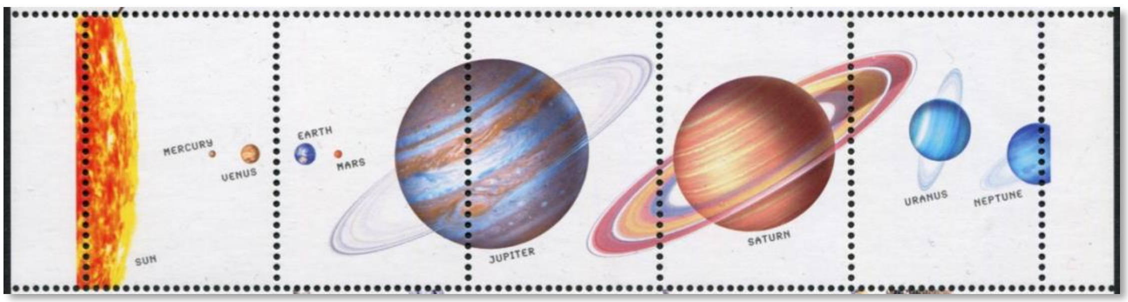

Figure 2. Australia, Sc 2740a gutter, 2007.

"The ice giant atmospheres are distinct from the gas giants in terms of their driving energy sources, their circulations, and their compositions. Understanding the ice giants will advance our knowledge of fundamental atmospheric processes and of planetary formation and evolution" (Ref 8). To flesh out those atmospheric research priorities, the report then poses the following three questions:

1. *What is the energy source that drives ice giant atmospheric activities?*
2. *What is the pattern of the general circulation of ice giant atmospheres?*
3. *What is the composition of the atmospheres?*

This article can only scratch the surface of those questions. The interested reader is invited to consult the original report.

Some Uranian History

At its brightest, Uranus is barely visible to the naked eye as a blue-green point of light in dark skies. For a long time it was misidentified as a star. The earliest recorded observation of the "star" was made by Hipparchus (Fig 3) in 128 BC (Ref 2). The English astronomer John Flamsteed (Fig 4) observed the "star" in 1690 as did the French astronomer Pierre Charles Le Monnier in the period 1750-1769. William Herschel (Figs 5, 7, 12 and 30) observed Uranus on 13 March 1781 but at first thought that it was a comet, a deduction disputed by other astronomers such

Figure 3. Greece, Sc 835, 1965

Figure 4. Djibouti, No cat #, Flamsteed, 2010.

Figure 5. Great Britain, Sc 2075, FDC, 2002.

Figure 6. Greece, Sc 1054, 1972

as the German Johann Elert Bode, who concluded that "its near-circular orbit was more like a planet's than a comet's."

Herschel acknowledged in 1783 that "by the observation of the most eminent Astronomers in Europe it appears that the new star, which I had the honor of pointing out to them in March 1781, is a Primary Planet of our Solar System" (Ref 2). In this way, "Uranus became the first planet ever discovered using a telescope" (Ref 3). The Benham cachet of the first day cover (FDC) in Fig 5 shows a young William Herschel in the foreground with Uranus in the background. Various names for the new planet were proposed. "In a March 1782 treatise, Bode proposed *Uranus*, the Latinized version of the Greek god of the sky, Ouranos" (Ref 2 and Fig 6). The cachet of the cover in Fig 7 commemorates the 200th anniversary of Herschel's discovery of the planet, and he is depicted in its cancel (as well as in Figs 5, 12 and 30). The Greek goddess of astronomy and the stars, Urania, or Ourania (Fig 8), can also be indirectly related to the planetary name Uranus.

Figure 7. German Democratic Republic (DDR), 1981 200th Anniversary of Wm. Herschel's discovery of Uranus.

Figure 8. Serbia, Sc 467, 2009.

The Discovery of Uranus' Rings

William Herschel described a possible ring around Uranus in 1789, but the definitive discovery was made much later, on 10 March 1977 (nine years before Voyager-2 flew by the planet), by James L. Elliot and colleagues, using the Kuiper Airborne Observatory (Ref 2 and Fig 9). They observed, unexpectedly, that a faraway star dimmed, briefly, "five times at some considerable distance above Uranus' atmosphere, both before and after the planet occulted the star. The dips in brightness indicated that the planet was encircled by five narrow rings. Later Earth-based observations revealed four additional rings" (Ref 1). In 1986, "all nine previously known rings were studied by the Voyager-2 spacecraft [which] showed the Uranian rings to be distinctly different from those at Jupiter and Saturn. The ring system may be relatively young and did not form at the same time as Uranus. Particles that make up the rings may be remnants of a moon that was broken up by a high-velocity impact or torn up by gravitational effects" (Ref 4). Fig 10 depicts the spacecraft above the rings, with the text "Voyager-II & Uranus rings."

Figure 9. Discovery of Uranus' rings, 1977.

Figure 10. Maldives, Sc 2956a, 2008.

Observations of Uranus: Voyager-2 and Space Telescopes

Modern observations of the faraway Uranus are made from Earth or near-Earth space. However, in 1986 Voyager-2 visited the planet. Its 1981 trajectory through the Saturnian system had taken advantage of a rare alignment of the giant planets that permitted it to "slingshot" to Uranus (and eventually Neptune) with a minimal use of fuel (reference). A similar gravity assist would be possible between 2029 and 2034 (Ref 3). Fig 11 symbolizes Voyager-2's epic journey to all four giant planets.

Voyager-2 is the only spacecraft to have visited Uranus. Once there, its trajectory was deflected toward Neptune. To do that, it had to fly to a specific point with a closest approach of 81,500 km above the Uranian cloud tops, which it did on 24 January 1986 (Ref 4 and Figs 1, 12 and 17). The timing of that close encounter was chosen so that the Deep Space Network (DSN) station in Australia could record it. During the flyby, the spacecraft passed only 29,000 km from Miranda, the smallest and innermost Uranian moon then known. That was the closest it had approached any planet or moon up to that point in its mission (reference).

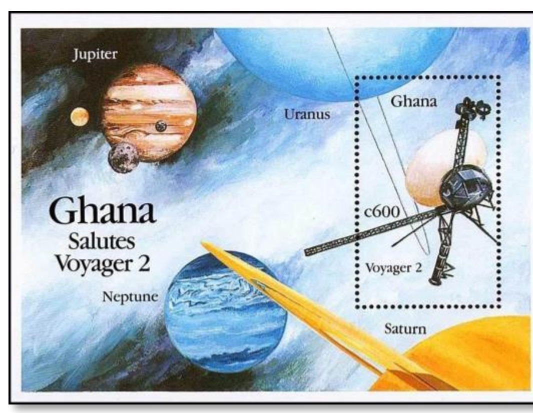

Figure 11. Ghana, Sc 1228, 1990.

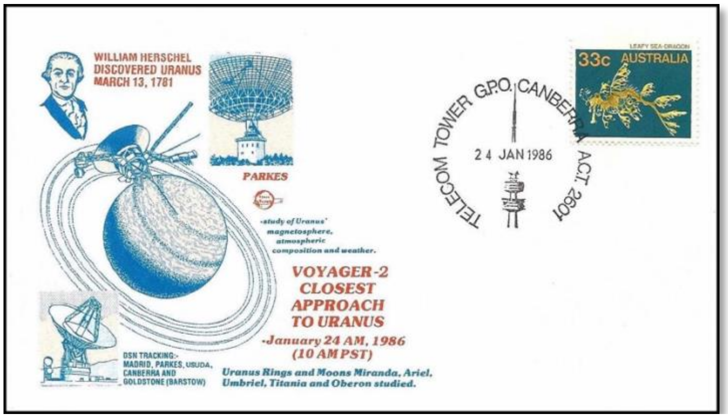

Figure 12. Voyager-2 Uranus encounter, 1986 event cover, SV Cachet.

Voyager-2 studied various aspects of the Uranian system. Fig 13 is a cover issued for the first anniversary of the spacecraft's closest approach to the planet. Its fancy cancel depicts Voyager-2 above Uranus. The cover summarizes the spacecraft's scientific work (translated from German): "4,300 TV images were transmitted to Earth; thin clouds; a small methane content; sunlight only 1/400th that of Earth; 15% helium and 85% hydrogen; aurora borealis; magnetic field 1/10th that of Earth with a 55-degree tilt; rotation period 17 hours; 10 new small moons (15 in total) and 10 rings of dark matter, 1-3 km wide." The term "schwache wolken," translated as "thin clouds," probably refers to the "high layer of haze [that] was detected [by Voyager-2] around the sunlit pole" (Ref 4). The spacecraft's "TV images" were produced by its Imaging Science Subsytem (ISS), made up of "two cameras for visible wavelength imaging" (reference).

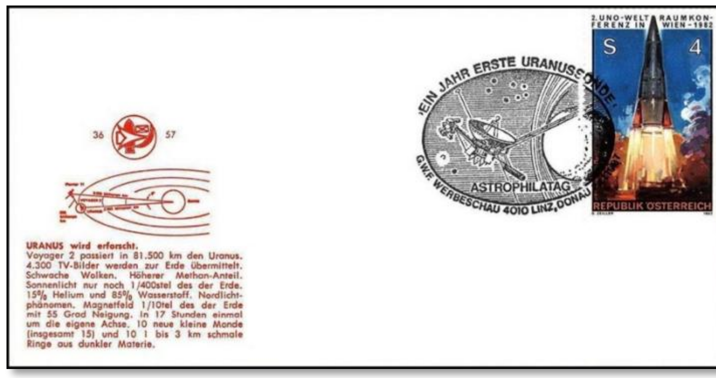

Figure 13. Voyager-2 event cover, 1st Anniversary of Uranus encounter, 1987.

The Voyager-2 true-color images show Uranus as a bland pale whitish-blue disk as illustrated in Figs 14 and 19. Only subtle variations in color and extremely faint cloud features were detectable in those images even after extensive processing. That muted appearance was due to high altitude haze obscuring the lower clouds (Refs 2 and 4), whose counterparts are readily visible at Jupiter and Saturn. Enhancements and more recent observations in various wavelengths have been used to bring out the Uranian details in false color images. Some depictions of Uranus on stamps and elsewhere may be too blue, possibly for dramatic effect. One example is found in Fig 15. The atmospheres of both Uranus and Neptune are

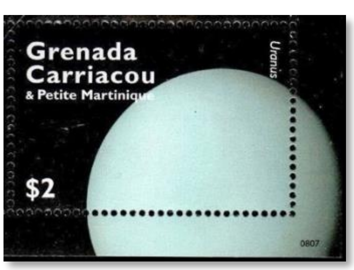

Figure 14. Grenada, Sc 2707f, 2008.

Figure 15. US, Sc 2575, 1991.

composed mostly of hydrogen and helium with small amounts of methane, which causes the blue tint of the Uranian atmosphere since it absorbs red light. Neptune is “bluer” than Uranus. The methane effect is probably at work there as well, with another unknown physical process intensifying it (Ref 3).

Fig 16 is a good example of the variability of depictions of Uranus in postage stamps. It features “Uranus and Voyager-2” but the planet is shown with a huge yellow patch. The authors are unaware of any enhancement or spectral band that would result in such an image of Uranus, so it is best thought of as an artist’s depiction. It includes what looks like a single solid ring rather than the multiple rings that exist.

Figure 16. Marshall Islands, Sc 930b, 2008.

Most planets of the solar system rotate on an axis that is roughly perpendicular to the plane of their orbits, but the Uranian axis of rotation is approximately in its orbital plane: it spins nearly on its side, tilted at 97.8 degrees from the vertical. (Ref 1). When Voyager-2 flew by Uranus in 1986, the north pole was in darkness, and the Sun was almost directly overhead at the south pole. Forty-two years later, the situation was reversed. The consequent major impact on the planet’s climate is poorly understood. Earth’s axial tilt of only 23.5 degrees is known to be a major factor in our seasons. Despite Uranus’ being “tipped on its side,” its atmospheric wind currents still line up approximately parallel to its equator, like those of the other giant planets (which are *not* tipped on their sides). “Apparently, rotation of the planet itself and *not* the distribution of absorbed sunlight controls the [wind patterns and] cloud patterns” (Ref 1). Adding to the conundrum is the observation that Uranus radiates less heat than the other planets. Recently, scientists at the University of Houston “analyzed decades of readings from spacecraft and computer models to find that Uranus emits 12.5% more internal heat than the amount of heat it receives from the Sun. However, that amount is still far less than the internal heat of other outer solar system planets like Jupiter, Saturn and Neptune, which emit 100% more heat than they get from the Sun” (reference). This fact may explain why Uranus has fewer storms than the other giant planets.

Fig 17 features another event cover for Voyager-2’s closest encounter with Uranus. Its cachet depicts the spacecraft above a false-color image of the planet. That image has been inverted and copied from this original, which is a computer-enhanced composite of three images from Voyager-2. The small dark rings are shadows of dust particles on the spacecraft’s optical system. A bright “streak,” like an Earthly jet streak, is seen in the blue part of the image.

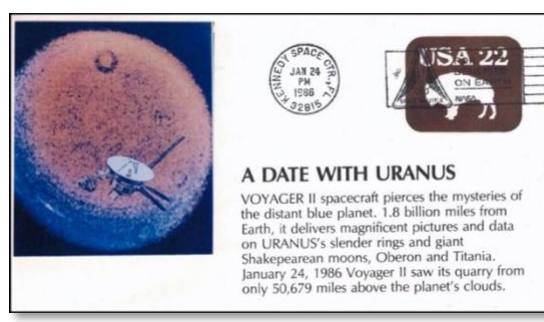

Figure 17. Voyager-2 event cover, Uranus encounter, 1986.

The Outer Planet Atmospheres Legacy (OPAL) program uses the Hubble Space Telescope (HST) to make yearly observations of the giant planets. The goal is to fill in temporal gaps among other programs. OPAL studies long-term trends tied to seasonal or other evolutionary cycles (including storm activity, wind field variability, and changes in aerosols) in the highly dynamic atmospheres of the giant planets. Fig 18 includes a false-color image of Uranus from 1998, produced by the HST's Near-Infrared Camera and Multi-Object Spectrometer (NICMOS). The bright spots are high cold clouds (roughly analogous to cirrus clouds in Earth's atmosphere) above small transient (with lifetimes of up to a few months) storms in the Uranian atmosphere. Such storms are described in Ref 5. Those cold clouds and the banded cloud structure do not appear in ordinary visible light images of the planet. Further details about this image are found here. Other images of Uranus in various wavelengths and enhancements are found here.

Figure 18. China, Postal Card, Uranus, 2003.

OPAL has documented some long-term Uranian atmospheric changes. For example, a 25 October 2021 image "highlights the planet's bright northern polar "hood." It's springtime in the northern hemisphere on Uranus, meaning the north pole of the planet is pointed toward the Sun, and because of the dramatic tilt of the planet's axis, nearly 90 degrees, that's a stark change. The spring's increase in ultraviolet radiation absorbed from the Sun alters the concentration of methane gas and haze particles in the planet's atmosphere, which in turn causes the polar region to brighten" (reference). In other words, "Uranus exhibits dynamic clouds as it approaches equinox, including rapidly changing bright features" (reference). A much more complete discussion of the planet's climate and its significant seasonal variability is found here.

Voyager-2 saw a dynamically inactive Uranus in 1986. However, as the years passed the storm activity picked up. "Later observations from the ground or by the HST made in the 1990s and the 2000s revealed bright clouds in the northern (winter) hemisphere. In 2006 a dark spot similar to the Great Dark Spot on Neptune was detected." (reference).

On average, Uranus radiates the same amount of energy as an ideal, perfectly absorbing surface at a temperature of 59.1 K (-214 °C) (Ref 1). This value is very close to the original Voyager-2 measurement (60 K, -213 °C) (Ref 4). Ref 2 includes a graphic with the hypothesized composition and structure of the Uranian atmosphere. It shows a temperature sounding whose shape is similar to that of Earth's troposphere and stratosphere. Fig 19 shows a souvenir sheet of one stamp (SS1) from a prestige booklet issued by Türkyie. It includes the values of various physical characteristics of Uranus, including the "average [cloud top] temperature," which is given in its text as -178 °C. That value is in good agreement with what one reads from the graphic

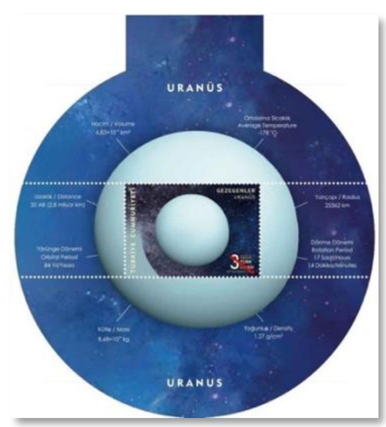

Figure 19. Türkiye, Sc 3725g, 2020.

mentioned above. The average Uranian atmospheric temperature decreases with altitude to a minimum value of around 55 K (-218 °C). It can even, locally, get as cold as 49 K (-223 °C). This is the coldest atmospheric temperature of all the planets of the solar system (Ref 2). Interestingly, "Voyager-2 found that the pole-to-pole variation in those temperatures was small – less than 1 K (1 °C) – despite one pole's facing the Sun at the time of the flyby, with the other in darkness. This lack of global variation is thought to be related to the efficient horizontal heat transfer and large heat-storage capacity of the deep atmosphere" of Uranus (Ref 1).

Zonal winds (parallel to the equator) blowing in the planet's upper atmosphere have been calculated by the tracking of various cloud features. Unusually, Uranus rotates in what we would call an east to west direction on Earth (opposite to our planet's direction of rotation) and its winds are several times stronger than those of Earth – up to 720 km/h prograde (in the direction of rotation) at Uranus' mid-latitudes, and up to 400 km/h retrograde (opposite the direction of rotation) at the equator. "Neptune's equatorial winds are also retrograde, but those of Jupiter and Saturn are prograde. No satisfactory theory exists to explain these differences" (Ref 1). Uranus' cloud bands align with the winds and so also are parallel to the planet's equator. The Uranian winds are described in more detail in Ref 7, and here.

As stated in the cachet of the cover in Fig 12, one of the goals of the Voyager-2 mission was to study the magnetosphere of Uranus. It also made measurements of the planet's magnetic field and radiation belts. Such space weather science for Uranus is treated in many sources (including Refs 1, 2 and 7) in much more detail than is possible here. In related work, the spacecraft found that "Uranus has relatively well-developed aurorae, which are seen as bright arcs around both magnetic poles" (Ref 6). In its ultraviolet astronomy section, Ref 7 discusses the planet's auroras and presents two images in which they are visible.

Space telescopes have provided much of our recent knowledge about Uranus. Some results from the HST were described above. The James Webb Space Telescope (JWST) has studied the solar system as well as objects in deep space. A JWST image of Uranus, from 6 February 2023, is found here. The SS1 in Fig 20 depicts both space telescopes, though not in the context of observations of our solar system. Fig 21, an illegal stamp, depicts the HST in the foreground and "Uranus" in the background. The

Figure 20. Central Africa, Bl 3282, 2023.

Figure 21. Djibouti, No cat #, HST & Uranus, 2007.

authors are not aware of any philatelic items, legal or illegal, that depict, or at least refer to, both the JWST and Uranus.

The Five Principal Uranian Moons

"Uranus has 29 known moons. While most of the satellites orbiting other planets take their names from Greek or Roman mythology, Uranus' moons are unique in being named for characters from the works of William Shakespeare and Alexander Pope" (reference).

William Herschel (Figs 5, 7, 12 and 30) discovered Uranus' two largest moons, Titania and Oberon, in 1787. "Two more major moons, Ariel and Umbriel, were discovered by the English astronomer William Lassell in 1851" (Ref 1). His 1200 mm (48-inch) telescope (built in 1855 and installed in Malta) is illustrated in Fig 22. The names of those four moons were proposed by Walter Herschel's son, the astronomer John Herschel. The last major moon, "Miranda, was detected photographically by the Dutch American astronomer Gerard Kuiper in 1948" (Ref 1). His name was eventually given to the "C-144 Kuiper Airborne Observatory" (Fig 9) whose cachet also includes a "cutaway of [the] Kuiper Observatory."

Figure 22. Malta, Sc 1366, 2009.

"Virtually all of what is known about the distinctive surface characters of Uranus' major moons comes from Voyager-2, which sped past them in a few hours and imaged only their sunlit southern hemispheres" (Ref 1). The moons have no detectable atmospheres and no magnetic fields. Voyager-2's infrared interferometer spectrometer (IRIS) measured sunlit "summer" surface temperatures of close to 86 K (-187 °C) at Miranda and 84 K (-189 °C) at Ariel (Ref 10). Ref 9 models a winter minimum to summer maximum polar surface temperature range of 25 to 90 K (-248 °C to -183 °C) through a full Uranian year for Umbriel. At the moon's equator, the corresponding range is from 39 to 81 K (-234 °C to -192 °C). For Titania, polar summer surface temperatures may reach as high as 85-90 K (-188 °C to -183 °C) (reference).

"Water ice shows up in the surface spectra of the five major moons. Because the reflectivities of the moons are lower than that of pure ice, the obvious implication is that their surfaces consist of dirty water ice. The composition of the dark component is unknown" (Ref 1). The densities of the four largest moons (1.4 - 1.7 g/cm^3) are consistent with a composition of roughly half ice and half rock. Miranda is less dense (1.2 g/cm^3) so has a higher ice-to-rock ratio (Ref 1). On all the moons, the ice may include ammonia and carbon dioxide (Ref 2).

A surprising result is that "the large moons of Uranus and Neptune are possible ocean worlds" (Ref 8). This idea is supported by recent (2023) research which is summarized here. It uses a reanalysis of Voyager-2's data along with computer modeling to suggest that the four largest moons of Uranus may be able to retain enough heat caused by internal radioactive decay that there could exist salty or briny oceans between their icy crusts and cores (Miranda was found to be too small to retain the required heat). This hypothesis is supported by telescopic evidence that at least one of the moons, Ariel, has material that flowed onto its surface, perhaps from icy volcanos, relatively recently (reference). Ref 8 goes so far as to state that "the five classical Uranian satellites and Neptune's moon Triton may be ocean worlds that display evidence for recent geologic resurfacing, including cryovolcanic activity and high internal heat." "Because of the very low temperatures expected for the outer solar system, the erupting fluid was probably a water-ammonia mixture with a melting point well below that of pure water ice. Brightness differences could indicate differences in the composition of the erupting fluid or in the history of the surface" (Ref 1).

Umbriel is the darkest of the five principal moons. "It reflects only 16 percent of the light that strikes its surface … The process by which Umbriel's ancient cratered surface was darkened remains a mystery … Images taken by Voyager-2 in 1986 revealed a curious bright ring about 140 km in diameter on the moon's dark surface. It is unclear what created the distinctive ring, although it may be frost deposits associated with an impact crater" (reference). The SpeX is a medium-resolution 0.7-5.3 µm spectrograph at NASA's Infrared Telescope Facility (IRTF) on Mauna Kea (reference). Ref 9 builds on IRTF/SpeX observations of the principal Uranian moons in the early 2000s and hypothesizes that Umbriel's "frost" deposits are composed of CO_2 ice, and that similar deposits may exist on Ariel, Titania and Oberon (but not on Miranda and the smaller moons). It also notes that "transport of CO_2 on airless icy satellites has been actively observed by the Cassini spacecraft on the Saturnian satellites Rhea and Dione." Given the large seasonal surface temperature swings on the Uranian moons, as mentioned above, a corresponding seasonal CO_2 transport might exist on Umbriel, Ariel, Titania and Oberon. Basically, some CO_2 may seasonally "sublimate and migrate to the opposite pole and to the equatorial regions, giving rise to a type of carbon cycle" (reference), with atmospheric concentrations of CO_2 remaining below the current limits of detectability.

Umbriel and Uranus are depicted in Fig 23. The moon is shown to be very dark and includes the bright "frost" ring mentioned above. Fig 24 is a minisheet of four (MS4) issued in 2016 for the 30th anniversary of Voyager-2's encounter with Uranus. The left margin shows the spacecraft above Uranus, whose rings are emphasized in the drawing. Stamp 'b' of the MS4 features Voyager-2 above Umbriel with the text "Umbriel flyby – 325,000 km." In this depiction, the moon is not as dark as in Fig 23. Yet another stamp (Fig 25) depicts Voyager-2 above Umbriel and Uranus, with the text "Voyager-2: Umbriel." In this case, most of the moon is drawn in light tones of yellow and red, which does not match what we know about the dark nature of this moon.

Figure 23, Liberia, no cat #, 2024.

Figure 24. Ghana, Sc 2909, 2016.

Figure 25. St. Vincent, Sc 2792a, 2000.

As outlined above, Ariel has been used as a model in at least one study of possible recent geologic resurfacing of the principal Uranian moons. Stamp 'd' in the MS4 of Fig 24 depicts Voyager-2 and Ariel with the text "Ariel flyby – 127,000 km)." Fig 26 also features Ariel, with the text "Voyager-2" and "Ariel, moon of Uranus." Those depictions of the moon can be compared with the actual Voyager-2 image of Ariel (e.g. here).

The upper right margin of St. Vincent *Scott* 2793, an MS6 issued in 2000, depicts a moon that is labeled "Ariel". The MS6 treats almost exclusively Saturn and its moons and was included in Article 10 of this series and will not be repeated here in its entirety. However, a portion of the margin of that MS6, rotated 100 degrees to the left, is included here as Fig 27. If we compare it with Fig 28, a Voyager-2 image of Miranda (e.g. from this page), we find an almost perfect match. The moon is Miranda, not Ariel! Another stamp, in Fig 29, features an artist's depiction of Uranus with a single white ring as the planet might be seen from Miranda. The text says "Voyager-2" and "Uranus and Miranda." This stamp is also interesting because we can trace the design to its source. The original image is found here (the stamp design has flipped it horizontally), where we learn that the image is a "montage of Voyager-2 photographs taken in January 1986 that simulates a view of Uranus and rings as if seen over the horizon of Miranda, one of the satellites of Uranus." Fig 30 includes an artist's drawing of the "Satellite Miranda." Part of Uranus and its rings is in the background and William Herschel is in the foreground. The "Mariner Mark II" spacecraft is also depicted. It was a forerunner of the Cassini-Huygens (C-H) spacecraft. Mariner Mark II was never built, and C-H explored Saturn (see Part 9 of this series of articles for details) rather than Uranus, so that is an error in the design of this stamp.

Figure 26. Ghana, Sc 1226c, 1990.

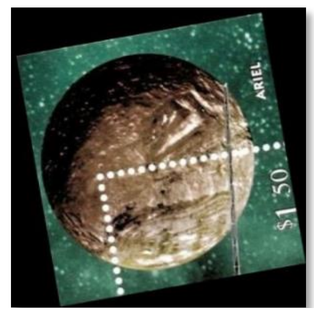

Figure 27. St. Vincent, Sc 2793, 2000.

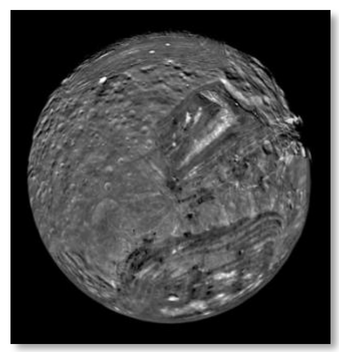

Figure 28. Voyager-2 image of Miranda.

Figure 29. Ghana, Sc 1226h, 1990.

Figure 30. Central Africa, Sc. 844, 1988.

Fig 31 (stamp 'd' and a portion of the left margin of an MS6 issued by St. Vincent) includes a bright artistic depiction of Titania, with the moon identified in text. It can be compared with the Voyager-2 photo of Titania (e.g. here). This is the only stamp known to the authors to depict Titania. Figs 1 and 17 include the names "Oberon" and "Titania" in their text. They are the only philatelic items known to the authors to refer to the moon Oberon.

Figure 31. St. Vincent, Sc 2792d, 2000.

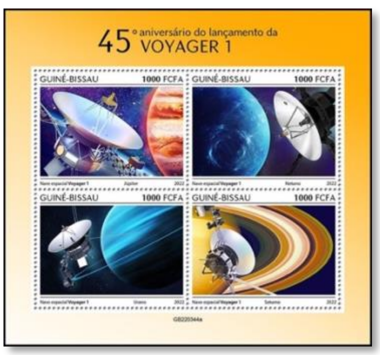

Figure 32. Guinea Bissau, Yt 10334-10337, 2022.

Voyager-1 flew by the gas giants but did not visit the ice giants. Fig 32 features an MS4 issued by Guinea-Bissau for the 45th anniversary of the launch of Voyager-1. The four stamps illustrate a Voyager spacecraft along with each of the four giant planets. The text in stamp 'c' says "Voyager-1 spacecraft" and "Uranus" while the corresponding stamp 'b' text says "Voyager-1 spacecraft" and "Neptune." Only Voyager-2 visited the two ice giants, so the text on those two stamps is in error. Corresponding text in stamps 'a' and 'd' could be OK since both Voyagers did visit Jupiter and Saturn.

Conclusion

Uranus and its moons are a fascinating scientific challenge. Recent advances in studies of the Uranian system have come from reanalysis of Voyager-2 observations and significant remote sensing work using data from Earth-based and near-Earth platforms. Many different spacecraft missions to revisit the planet and its moons have been proposed. A list is found here. So far, nothing has developed any further. Such missions would be expensive and take a long time to come to fruition.

The next article in this series will feature Neptune and its principal moons.

Other References

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