THE FOCAL POINT

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CLUB CALENDAR

Next Meeting: June 23 (Saturday), 7:00 p.m. at the Monastery of the Holy Ghost near Conyers.
Program: A covered dish dinner and observing party. See the Program Preview on page 4 for more information.

Editor: .... Steve Gilbreath
Contributing Editors: .... Dr. Ralph Buice, Hal Crawford

The Focal Point is published monthly during the academic year by the Atlanta Astronomy Club, Inc. The AAC is a non-profit organization dedicated to the advancement of amateur astronomy. Meetings are held the third Friday of each month (except the second Friday in December) at the Bradley Observatory on the Agnes Scott campus. Dues are $35 annually for a family membership and $25 for a student membership and include a subscription to **Sky & Telescope** magazine and use of the club observatory in Villa Rica.

Submissions: Article submissions are welcome, and may be delivered to the editor for consideration. Articles on computer floppy disk are encouraged.

OFFICER'S PHONE NUMBERS

Leonard Abbey	*President*	634-1222
Eugenia Abbey	*Program Chrm*	634-1222
Richard Jakiel	*Observing Chrm*	473-9873
Steve Gilbreath	*Corresponding Sec*	634-7466
Bud Rosser	*Recording Sec*	879-0304
Hal Crawford	*Treasurer*	320-9156

THE MORPHOLOGY OF MIRANDA

by Carolyn Collins Petersen

INTRODUCTION

The Uranian system of major satellites, Ariel, Umbriel, Titania, Oberon and Miranda, provides new insights into the structures and evolution of small, icy bodies orbiting the gas giants of the outer solar system. Until the January, 1986 Voyager 2 encounter with Uranus, however, information regarding these satellites was limited to what observers could deduce from ground-based tests. (Limitations were due to atmospheric viewing conditions, the great distance between Uranus and Earth, and the fact that reflected light from Uranus tends to obscure the satellites.)

Subsequent to the Voyager encounter, these moons have been confirmed as small, icy bodies, their radii ranging between 236-762 kilometers. Their densities range between 1.35-1.7 g cm-3. (Table 1) All are in synchronous rotation with Uranus; their distances from Uranus range from 583,400 km (Oberon) to 129,900 km (Miranda).

Table 1: Radii and Densities of the Uranian Satellites (Ref. 6)

Satellite	Radius (km)	G x Mass (km^3 s-2)	Density (g cm-3)
Miranda	236 +- 3	5.0 +- 1.5	1.35 +- 0.39
Ariel	579 +- 2	90 +- 16	1.66 +- 0.30
Umbriel	586 +- 5	85 +- 16	1.51 +- 0.28
Titania	790 +- 4	232 +- 12	1.68 +- 0.09
Oberon	762 +- 4	195 +- 11	1.58 +- 0.10

Voyager imaging reveals cratered terrain on all five satellites, and each shows varying degrees of tectonic deformation and resurfacing. In the early 1980's, observers obtained results from near-infrared spectrophotometry, confirming that the surfaces of the five Uranian satellites are composed mainly of water ice. (Ref. 1,2) Voyager observations confirmed and refined these results, and have spurred further study regarding methane clathrates on the surfaces of at least three of these satellites. (1,2,5,7,8,9,11) However, Voyager imaging also showed the surfaces of the five to be darker than expected for surfaces composed of water ice (5, 8, 13).

Pre-Voyager data suggested albedos for Ariel, Umbriel, Titania and Oberon to be in the 20 to 30% range. (2) (Geometric albedo information for Miranda was difficult to obtain, due to the satellite's proximity to Uranus.) Voyager data shows the albedo range for the five to be 20-40 percent, with some localized variations -- most notably at Miranda. It had been suggested that this darkening of the satellites was caused by a carbon-rich, soot-like coating of material, presumably swept up by the satellites as they orbited Uranus. More recently, however, theories center on irradiation of the surfaces by ultraviolet radiation or energetic electrons found in the Uranian magnetosphere. (5, 8, 9, 13, 16) Specifically, these theories center on the inclusion of clathrates, or at the very least, methane or other carbon-compound contaminants in the water ice. Irradiation of these compounds would produce the surface darkening seen at the Uranian satellites.

As mentioned above, each of the satellites shows evidence of cratering and tectonic activity. Oberon shows the least activity, with only a few fault features splitting its surface. Its surface does appear to be nearly saturated with old crater remains, indicating little activity in the past four billion years (since the last heavy bombardment period).

Titania's surface shows more recent bombardment activity with associated bright rays radiating out from the craters, as well as evidence of global tectonics. Umbriel is very dark, and shows overwhelming evidence of large craters, created during the late heavy bombardment.

Ariel shows evidence of geologically recent tectonic and volcanic activity. It is the brightest of the five satellites, and has the least-cratered surface. Presumably this is evidence of recent resurfacing activity. (8)

The smallest of the five -- Miranda -- shows the most variation in surface characteristics and terrains -- with some unusual results. The rest of this paper is devoted to discussion of those characteristics and their evolution. (It should be stressed that data concerning the surfaces of the Uranian satellites covers only fractions of those satellites. Due to time and trajectory constraints on the Voyager 2 spacecraft, as well as Uranus' 98% obliquity, and the Uranian axial tilt, no more than half of each satellite was photographed during the encounter.)

MIRANDA

Miranda orbits Uranus at a distance of 129,900 kilometers, in synchronous rotation with its primary. Its radius, as given in Table 1, is roughly 236 kilometers (diameter 500 km), and its density is roughly 1.35 g/m^-3. As mentioned above, water ice has been detected on the surface of Miranda, seemingly covered or 'frosted' with a dark layer of what is presumed to be carbonaceous material. (As mentioned above, Brown and Clark (1) found a reflectance spectrum for Miranda in the 1.62 - 2.47 micron range, with deep absorption at 2.0 micron. This matches the shape and wavelength of minimum reflectance by water frost.)

Just under 60% of Miranda's terrain was photographed by Voyager, and what is seen in the photographs demonstrates a clear global dichotomy. Plescia, (and others) have divided the terrain of Miranda into two distinct units: cratered terrain and coronae. (12) Masursky, et. al. have arrived at a nomenclature for specific areas on the Mirandan surface. (Proceedings of the 18th Lunar and Planetary Conference, which Plescia has adopted, and is used here.)

Cratered Terrain

The cratered terrain seems to be underlying surface upon which the more striking coronae formations are overlaid. (The coronae themselves show cratering as well.) It is the oldest geologic unit on the satellite. In some places -- notably in the anti-Uranian hemisphere, the surface has appeared to reach cratering saturation, with craters lying rim-to-rim. In other areas, there are fewer craters spread out amidst a smooth intercrater surface. With a limit of resolution of 500 m, Voyager images show crater sizes ranging from 500 m to 50 km in diameter.

Within this range of crater sizes, the morphology varies from well-defined craters to very degraded and ancient formations. Plescia observes that the larger craters are more degraded, while the smaller ones are less degraded. Ejecta deposits are observed near some craters -- with craters up to 15 km diameter showing dark ejecta deposits. Craters less than 3 km diameter have bright ejecta deposits. Larger craters do not show ejecta deposits. No craters are observed to have central peaks or pits.

The craters on Miranda have been divided into 2 types -- Population I and Population II (13) (also known as heliocentric and planetocentric bombardments, respectively). Population I craters range in diameter from 50-100 km. They are thought to date back to the post-accretional period (4 x 10^9 years ago), when the satellite was actively sweeping up the debris left over from the formation of the solar system (4.5 bya). Population II craters are typically smaller than 50 km, and were created by impacts of smaller pieces of debris left over from the formation of Uranus and its satellites. Johnson, et al, (8) state that these two bombardment periods probably overlapped, but that the planetocentric bombardment ended later. This overlap and offset of periods may provide a clue to the differing densities of cratering found on different parts of the satellite. The high cratering density on the anti-Uranian hemisphere indicates heavy bombardment in the past; the frequencies of various crater sizes within that area may provide some understanding of the two different bombardment rates. Crater frequencies in the anti-Uranian hemisphere may also reflect the fact that the area is in equilibrium (craters are formed as rapidly as they are destroyed).

Within the cratered areas, fault scarps and grabens split the surface. The most spectacular of these is a feature called Verona Chasma. It is estimated to be between 10-12 km deep, and could stretch across as much as 50-60 km of cratered terrain.

A severely degraded crater field lies centered about longitude 175, latitude -55. A number of grabens seem to terminate in this area, while others continue through the area, showing less topography. Plescia speculates that it may be a highly-degraded impact basin, similar to the palimpsest formations found on the Galilean satellite Ganymede. This implies viscous relaxation in the ice surface, with implications of some sort of heating mechanism.

Within the craters, and along fault scarps, streaks of bright and dark material stand out. In many craters, the bright material occurs as a ring, just below the rim of the crater, leading to speculation that a layer of bright material underlies the darker surface at a shallow depth. At impact, this material would be exposed, and would splash out as ejecta.

Coronae

The Mirandan Coronae have sparked intense speculation regarding their formation, and their implications for the formation of Miranda itself.

These areas, first dubbed "chevron", "ovoids", and "trapezoids" by various members of the Voyager team, exhibit highly unusual terrain types. They are circular to rectangular in shape, showing a complex morphology and high-contrast albedo markings. Within their boundaries, they show complex tectonic structures, and two of the coronae show extreme topographical relief. Johnson, et al., (8) describe them as locally parallel belts of ridges, grooves and scarps that abut one another at odd angles. Exposed bright material lies alongside dark material parallel to and within the escarpments, and in fresh craters within the coronae. These areas are cut by huge fracture zones, which extend through the cratered plains, presumably around the satellite. In one coronal area, there may be evidence for eruptive flows of ice, burying nearby scarps and ridges, and piling up behind other flow fronts. Clearly, these coronae are evidence of some sort of past tectonic activity. That this activity occurred in a satellite as small as Miranda is but one part of the mystery of the formation of these areas.

Arden Corona has been referred to as the "banded ovoid" (Smith, et al). Its length is unknown, since it stretches over the horizon, but its width is about 300 km. It has a roughly rectangular shape, with rounded edges and dark parallel bands. These albedo bands are outward-facing fault scarps that appear to form a "step terrain" down into a steep trough which continues as cratered terrain. The inner core of Arden has sharp edges, appears topographically smooth, and exhibits a mottled albedo pattern.

Inverness Corona, sometimes referred to in the literature as "the trapezoid", lies in the sub-Uranian hemisphere and is roughly 200 km on a side. Located between the south pole along longitude 330, this area is characterized by the familiar-looking "chevron" shape at its center. Within the corona, the surface is dominated by parallel grooves only a few kilometers apart. Inverness is bounded on three sides by a complex series of faults. This corona exhibits four distinct areas as distinguished by tectonic patterns and albedo:

* boundary area
* bright chevron
* 2 grooved areas on either side of the chevron

The narrowly-grooved areas also exhibit block faults. Elsinore Corona is roughly 100 km wide, and was described at first by Smith et al. as a "ridged ovoid", similar in shape to a racetrack. Elsinore has interior and boundary areas characterized by different morphologies, with ridges and troughs forming a complicated pattern in variable relief. It is similar to Arden Corona. Only a narrow part of this corona was observed, but the thin slice of the interior does show evidence of volcanic vents. Material from these vents appears to have flowed across the surface of the corona.

Crater frequencies across the coronae vary, with Arden Corona showing a somewhat higher crater frequency than the others. The interior seems to have a nominally higher cratering frequency than the exterior. This could indicate an older surface area than the other coronae, but not as old as the 'inter-coronal' cratered terrain.

Inverness Corona shows a lower crater frequency at its boundary areas, and higher rate in the grooved areas on either side of the chevron, which showed a fairly high cratering rate. These areas would be older than the boundary areas, which show less cratering.

Elsinore Corona exhibits only a few craters, but this is due largely to the fact that only a small portion of the Corona was observed. Thus, any cratering statistics may not accurately reflect the age of area as accurately as on other areas of Miranda. However, the craters seen, particularly in the marginal area, may postdate the formation of the ridges and troughs that form the margin of Elsinore, and suggest that the margin is younger than the interior. (12).

Generally, judging from cratering rates, each of the interiors of the coronae seem to be older than the marginal areas. If this is true, then the coronae may have formed from the outside inwards.

(concluded in next month's Focal Point)

PROGRAM PREVIEW

Observing Party, Saturday, June 23
(Rain date: June 30)

For June we have a special treat in store: an observing party and picnic at the Monastery of the Holy Ghost near Conyers! If you've visited the Monastery you already know its serenity and quiet grandeur. The sanctuary takes you back to the cathedrals of the Middle Ages. The monks operate a Gift Shop and a Green-house along with their dairy farm. (The latter is not open to the public.)

We will picnic under the trees by the lake where picnic tables and benches are provided. Be sure to bring extra bread for the ducks! We will use a portion of the parking area in front for telescopes.

Dinner begins at 7 p.m. There will be no business meeting. The Monastery will provide 1 extra long (300 ft.) extension cord as there is no power supply in the parking area. Everyone is requested to bring their longest cord (marked with your name) for additional electrical access.

It's worth it to come early. The Gift Shop and Greenhouse both close at 4:30. (The monks are known for their bread as well as potted herbs, bonsai and other plants.) Vespers are sung from 5:35-6 p.m. The last service of the day is Compline (also sung) from 8:15 - 8:30, after which the sanctuary is closed.

Please bring the following:

* A covered dish. Call the Abbeys at 634-1222 and let them know what you plan to bring.

* $2.00 per person in your party to cover the cost of fried chicken and ham. Children under 5 years are free.

* Family and friends. Let the Abbeys know how many are coming when you call.

* Telescopes, binoculars and other observing equipment.

* Folding chairs and lounges.

* EXTRA EXTENSION CORDS.

The address is 2625 Highway 212. From Atlanta take I-20 east, exiting at the second exit past I-285, exit 37, Panola Rd. Turn right and go south. At the third traffic light (not counting blinking lights) turn left onto Brown's Mill Rd. (Georgia 212). After 9 miles you'll see the Monastery on your left.

Call the Abbeys, 634-1222 if uncertain about the weather. If it rains on both June 23 and June 30, we cancel for this month.

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First Class Delivery

W. Tom Buchanan
105 Carriage Station Circle
Roswell, GA. 30075

Article submissions and address corrections to:
Steve Gilbreath, Editor
1410-C Druid Valley Dr.
Atlanta, Ga. 30329

AAC membership renewals to:
Hal Crawford, Treasurer
1690 Oak Grove Rd.
Decatur, Ga. 30033