THE FOCAL POINT

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CLUB CALENDAR

Next Meeting: July 21 (Saturday), 7:00 p.m. at Villa Rica. **Program:** A covered dish picnic and observing party. Call Leonard and Eugina Abbey at 634-1222 to find out what you can bring.

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.

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THE MORPHOLOGY OF MIRANDA

by Carolyn Collins Petersen

Continued from last month's Focal Point

THE FORMATION OF MIRANDA SURFACE CHARACTERISTICS

DISCUSSION OF POSSIBLE MECHANISMS

The overwhelming question to be asked regarding the observed surface characteristics of Miranda is "How did this satellite form with the surface features that it exhibits?" The answer to that question may lie first in the implied formation history of icy satellites (17), and secondly with one of two models that have been postulated to explain the strange formations we see at Miranda. (8)

Briefly, when an icy satellite accretes, there will be heating at the center, either from the heat of accretion, radiogenic heating, tidal heating, or a combination of the three. Differentiation takes place, and the volume of the satellite grows as different phases of ice melt and move out to the surface. The heavier silicates move to the center of the satellite. Much differentiation make take place before the solidification of the crust, and after the crust is in place, it can be stressed by continued heating and differentiation. Initially, Miranda is assumed to have accreted from materials left over from the formation of the Uranian system, and from some materials left from the solar nebula. These materials would be primarily water ice, carbonaceous rocks, and possibly inclusions of ammonia hydrate, methane clathrate, and/or carbon monoxide clathrates. At the end of accretion, and before the accretionary heat would have dissipated, differentiation would take place. It is assumed that there would be some silicate composition as well. For Miranda, with its low density, the silicate composition is estimated to be 40-60%. In any case, radiogenic heating from the silicates would also aid the differentiation process. If differentiated completely, the early Miranda might have been similar to the Galilean satellites -- icy surface surrounding a silicate core. The surface would most likely have been cratered by incoming debris left over from formation, and there is evidence that irradiation darkening of the clathrates (methane) would have had time to begin. (9, 16)

At this point, the partially (or even wholly-) differentiated Miranda may have been blasted apart, probably by a collision with a large piece of unaccreted debris. Johnson (8) quotes Shoemaker as theorizing that Miranda could have been blasted apart five or more times, each time reassembling itself and beginning the process of differentiation anew.

After the last breakup, then, Miranda was an aggregation of large pieces of rock and ice. These pieces began to reaccrete. Internal heat allowed viscous flow in the interior, and differentiation, as melting ices expanded and moved out toward the crust. At the same time, the heavier, rocky pieces embedded in the surface began to sink toward the core. These motions of rising and sinking caused the newly formed surface to crack along concentric stress lines. In one theory, then, the coronae are thought to be the surface disturbances left behind by the rock masses as they sank toward the center of Miranda. Arguments against this theory center on how large chunks of rock could remain large and intact throughout the repeated cataclysms that broke Miranda apart. At the time of reaccretion, it is more likely that only smaller pieces would have survived breakup. In place of the large rocks, it has been suggested (in a modification to the above theory) (8), that after the final accretionary process, the latest Miranda was a uniform composition of rock and ice. The rocks sank to the core as agglomerates of ice moved to the surface. In this way, the coronae are surface disturbances caused by the rising ice masses. The observed pattern coronal emplacement around Miranda (based on southern hemisphere observations) is very regular, and suggests an internal organization to Miranda similar in the form of a subsurface convection cell.

If this process had continued, a uniform surface, perhaps split by tectonic stresses, would be seen at Miranda. But, something happened to stop the process of differentiation. The satellite cooled, and froze. By this second theory, then, the coronae we see at Miranda are the products of a halted differentiation. What sources of heat would spur differentiation in a newly- or reaccreted Miranda? The typical sources would be radioactive decay (from both long- and short-lived isotopes), gravitational (accretional) energy, and tidal resonances. Johnson (8) states that in conventional theory, radioactive elements found in a planetary body are proportional to the volume of that body. Also, the rate at which a body loses heat is proportional to its surface area. Extrapolating this, the larger body is, the more heat it retains, and the less it loses through its surface. A smaller body would retain less heat, losing its heat more rapidly through its crust. A larger body would have more time to undergo any geologic development. As is seen at Miranda, however, these assumptions do not seem to be the case. Heat was obviously retained long enough to begin the process of differentiation. Some of the heat needed may have been leftover heat of accretion, as well.

The third possibility for heating -- tidal resonances -- seems to be not a factor at first glance. Miranda is not now in any resonance with any other satellite of Uranus. However, calculations of past resonances (11), show that Miranda may have passed through several resonances with Ariel and Umbriel since its last formation (approximately 3.5-4 bya). Peale (11), however, maintains that these resonances are unlikely when the tidal effective dissipation (QsubU) of Uranus is significantly large. Another variation on the resonance theory is one advanced by Marcialis and Greenberg, wherein Miranda is warmed during chaotic rotation. (10) They postulate that while the surface temperature of Miranda is quite low (less than 100 degrees K), the active geologic history of the satellite posits definite heating episodes. They state that the low temperature prevents the movement of water, but a methane clathrate, or water-methane mix would have a lower melting point.

The heating required for this mixture would be less, and the heating from radiogenic sources, combined with tidal heating induced by chaotic rotation would be enough to mobilize the materials within the satellite.

Basically, after accretion, anomalously-shaped blocks of material would form an oddly-shaped, chaotically rotating body. Elongation of the satellite could be as little as 0.5%, which would be sufficient for this type of rotation. If the early satellite were in an eccentric orbit, as well, the criteria for chaotic rotation would be satisfied.

Could this type of heating work at the early Miranda? Marcialis and Greenberg put the figures available for Miranda through the equations describing a non-synchronously-rotation satellite, with its body worked by tides, to come up with a heating rate from chaotic rotation of roughly 6 x 10^18 erg s^-1. This is 10^4 times more than that expected from radiogenic heating alone, and ten times per gram more intense than the present tidal heating of Io.

While this might be enough heating for initial melting and differentiation, the chaotic motion is self-damping as eccentricity decreases to conserve angular momentum. However, it would be enough for an initial temperature profile of 70 degrees K at the surface to just over 270 degrees K at the center -- enough to begin the melting of clathrate and water ices. At the end of a million years, this would give (using a thermal diffusivity of 0.15 cm^2 s^-1) a boundary layer of approximately 25 kilometers. This relatively cool layer would have a relaxation time (according to Marcialis and Greenberg) of about 10^6 years for topography of scale = 20 km.

The implications of this chaotic rotation model suggest that had the motion not damped away, the heating might have been enough to completely relax the topography of Miranda, and complete the differentiation process.

This seems to imply that the surface of Miranda froze into place well over 3.5 billion years ago. The heating was not enough to relax the topography completely. Coronal features, as well as current crater populations froze into place. Cratering impacts from orbiting comet nuclei have continued to mark the satellite.

CONCLUSION

The water-ice surface of Miranda has been reworked by both heliocentric and planetocentric cratering. It has been suggested that populations of comets in orbit at Uranus are responsible for ongoing cratering of the satellites. In addition to this "gardening" by impact, Miranda's surface also shows the effects of arrested differentiation -- that is, after its last accretion, Miranda lost its heat source while in the process of differentiation, and froze. Partially differentiated agglomerates froze, possibly midway through the satellite. The resulting surface manifestations of this arrested activity show today as the coronae - - areas considered to be less dense than the surrounding terrains --but which show a wide variety of topological and albedo features. More study of chaotic rotation, formation of icy bodies, and the mechanics of accretion, cataclysm of differentiated bodies, and reaccretion is needed.

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THE CASUAL ASTRONOMER: JULY 1990

by Hal Crawford

GETTING INVOLVED II:

Save Our Space Program!

The last few months have been a trying time for NASA and other elements of the space science community. NASA is bearing the brunt of the crisis. Problems with the Hubble Space Telescope have gone from bad to worse, as flaws going back to the early design stages become apparent. The worse trouble yet to come to light is the mirror system, which is suffering from a severe case of spherical aberration. This severe flaw resulted in a serious degrading of picture quality, limiting the resolution of the 1.5 billion dollar telescope to no greater than that of earth-bound observatories.

A simple test of the assembled mirror system would have immediately revealed the defect. NASA engineers dismissed the testing as too expensive, although it turned out that Defense Department facilities could have found the defect. Some engineers that I have spoken with who have worked closely with the mirror contractors believe that the problem was likely caused by leaving off a minus sign when entering data into a computer program, which controlled the glass-grinding machine.

Although the telescope is far from useless, the blunder is frustrating to the space community. Considering that the telescope lay in storage for years before finally being placed into orbit by the space shuttle, it is irritating to think that no one thought to test the completed system before shipping it off. Harvard University astronomer Clifford Stoll (who wrote "The Cuckoo's Egg," about a case of computer espionage) probably said it best: "This is one of the worst things to happen to astronomy since the pope strung up Galileo."

Back on earth, there is no shortage of problems in store for astronomy. All a certain Arizona university wants to do is put up an observatory on Mt. Graham. The problem is, there is an endangered species of red squirrel who happen to live on the mountain. Enter a bunch of generally confused environmentalists and other weirdos, and you have chaos. In spite of US Forestry Service environmental reports that the observatory would have minimal impact on the wildlife there, members of the Sierra Club and Earth First! demand that any form of development on the mountain, even for the benefit of science, is asking for trouble.

We are talking about some myopic people here. Earth First! members have a reputation for being more of violent terrorists than of true, concerned environmentalists (earlier this year, two members were seriously injured when the bomb they were carrying in their car, detonated accidently).

It's more than understandable if someone wants a factory or commercial development on Mt. Graham. But before any attention was made by the astronomy community to build anything on the mountain, squirrels there were freely hunted. No one cared about the wildlife before. Since the brouhaha started, land requirements for the observatory were voluntarily severely reduced, but this does not appease the environmental community.

Naturally, dumb things have happened over this issue. The Secretary of the Interior, no genius this man, stated something to the effect that "a bunch of squirrels shouldn't get in the way of progress." This has only enraged the environmentalist community.

The whole issue is stupid. No one wants the extinction of any species, but building an observatory is not going to threaten the existence of these animals. In fact, it will more than likely help the environmentalists' cause in the long run, since any further development of the mountain can only hurt the operation of the observatory. The last thing astronomers need is development, which ultimately spells out to more light pollution. But don't try to explain that to the idiots.

The point of the Mt. Graham issue is that the environmentalists are now trying to legislate away the observatory in Congress. Despite strong support from many forward-thinking congressmen, the lobbying is intense, and the voting could be close. I would like to urge all AAC members to write to their representative in Congress and tell them about the value of observatories, and why Mt. Graham must be built. After all, we know better than anyone else.

Speaking of writing to Congress, there is a contest taking place that is sponsored by the magazine *NASA Tech Briefs* and the National Space Society. The contest is to write a letter to your representative or senator, explaining why he or she should support the President's Space Exploration Initiative, presented by President Bush earlier this year. The initiative consists of committing the U.S. to landing astronauts on Mars by 2019. To establish this goal, the President has requested $1 billion in the fiscal year 1991 budget. Congress of course has to appropriate the money. And that's where you can come in.

All you need to do is write a letter of 500 words or less to the politicians of your choice, outlining your reasons for the Initiative. Then send a copy to the National Space Society. List your age and daytime telephone number. Make sure your entry gets in before the deadline of August 15, 1990.

The prizes this year are:

Children's Category (16 and under): 1 grand prize of a week-long stay at the United States Space Camp in Huntsville, Alabama or in the Space Coast area of Florida.

Adult's Category: One grand prize winner will attend the three-day adult session at the U.S. Space Camp in Huntsville. The second prize winner will attend a space shuttle launch at the Kennedy Space Center in Florida. This prize includes a guided tour of the launch area.

Send your entry to:

Lori Garver, Executive Director
National Space Society
922 Pennsylvania Avenue., SE
Washington, DC 20003

To write to United States Senators:

Senator Sam Nunn (or Wyche Fowler)
United States Senate
Washington, DC 20510

To write to Members of the US House of Representatives:

The Honorable Ben Jones (or whoever)
U.S. House of Representatives
Washington, DC 20515

Good luck!

THE FOCAL POINT

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