# THE FOCAL POINT

Vol. II, No.I — *The Newsletter of the Atlanta Astronomy Club* — September 1989

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### CLUB CALENDAR

**Next Meeting:** September 15, 8:00 p.m. at Bradley Observatory. **Program:** Fernbank astronomer David Dundee will talk about what we've learned from the Voyager flyby of Neptune.

*Editor:* .......... Steve Gilbreath
*Contributing Editors:* .......... Dr. Ralph Buice, Hal Crawford, Richard Jakiel, Mark Lancaster

**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 $25 annually for a single membership and $30 for a family 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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## AN INTERVIEW WITH CLYDE TOMBAUGH

*This interview with Clyde Tombaugh was conducted by Editor Steve Gilbreath in April, 1989. Although best known for his discovery of the planet Pluto in 1930, Tombaugh has made extensive contributions to astronomy in numerous areas, including work with galactic star clusters and studies in the apparent distribution of extragalactic nebulae, the geologic study of the surfaces of Mars and the moon, and the production of telescope mirrors. Dr. Tombaugh was born in Streator, Illinois on February 4, 1906. He received his A.B. degree from the University of Kansas in 1936, his M.A. in 1939, and a D.Sc. from Arizona State College in Flagstaff in 1960. He retired from New Mexico State University in 1973 as an Emeritus Professor, and currently lives in New Mexico.*

**Focal Point:** Have you always wanted to be an astronomer, or did you consider other occupations at one time?
**Tombaugh:** Yes, I have always wanted to be an astronomer, but at one time I also considered making astronomical telescopes, or being a railroad fireman or engineer.
**Focal Point:** Could you mention a few of the observatories that you have worked in over the years?
**Tombaugh:** Primarily I worked at Lowell Observatory in Flagstaff, Arizona from 1929 to 1943, and at New Mexico State University in Las Cruces, New Mexico from 1955 to 1973. In 1973 I retired from New Mexico State University as an Emeritus Professor.
**Focal Point:** Have you met any noted astronomers that you especially remember for one reason or another?
**Tombaugh:** Oh, I have met well over 100 such astronomers over the years, both in the United States and other countries.
**Focal Point:** If you could use a small telescope for pure pleasure one evening, what would you look at?
**Tombaugh:** If I were using a small telescope, I think I would look at the Moon and Jupiter.
**Focal Point:** Do you consider your work with Pluto to be your most important contribution to astronomy?
**Tombaugh:** No, not necessarily. As by-products of the extensive planet search that was undertaken, I discovered six new star clusters, many clusters of galaxies, and the Pegasus-Perseus super cluster of galaxies in 1937. In addition, I discovered two comets, hundreds of asteroids, and counted at least 29,500 galaxies on my plates. I also established the planetary patrol and study project at New Mexico State University.
**Focal Point:** Are you concerned about the current state of funding for astronomy?
**Tombaugh:** Yes.
**Focal Point:** Do you consider the problem of light pollution to be of great concern, and do you think the problem will get better or worse in the future?
**Tombaugh:** Yes, I am concerned, and it will probably get worse.
**Focal Point:** Do you have any advice for young students today who may be considering a career in astronomy?
**Tombaugh:** Students who are considering a career in astronomy

today must be thorough masters of Physics and Math, have lots of perseverance, and be satisfied with a modest salary.

**Focal Point:** Has the nature of astronomy changed much over the years, or do astronomers just work with more sophisticated technology now?

**Tombaugh:** Some of both, I think.

**Focal Point:** Has the computer made much of an impact in astronomy, and would it have changed some of the things you did if you had had it available years ago?

**Tombaugh:** Yes, it has. The planet search at the Lowell Observatory would not have used a computer because it consisted of a visual scanning of hundreds of large plates. But for theoretical astronomical research, the computer is vital.

**Focal Point:** Have you written any books, or perhaps an autobiography?

**Tombaugh:** As far as books go, I co-authored *Out of the Darkness: the Planet Pluto*, with Dr. Patrich Moore of England. It is 221 pages and richly illustrated. I wrote about 80 per cent of the book. I have written about 40 or more astronomical papers published in such journals as *Sky and Telescope*, *Icarus*, *Astronomical Society of the Pacific*, *Mercury*, and the *Astronomisch Nachrichten* in Germany.

**Focal Point:** What is the most spectacular comet that you have ever seen? Did you see Halley's comet?

**Tombaugh:** Yes, I saw Halley's comet. I have also seen Ikeya-Seki, Arend-Roland, and Bennets Comet. The tail of Arend-Roland was about 40 degrees long. I have also seen several other comets that were almost as spectacular as these.

**Focal Point:** Have you ever participated in an eclipse expedition? Do you have plans for the solar eclipse in 1991?

**Tombaugh:** I observed the July 20, 1963 total eclipse in Alaska. It had a totality of 97 seconds. I have no definite plans for the 1991 eclipse at present.

**Focal Point:** Would you like to take a ride on one of the space shuttles?

**Tombaugh:** I am afraid I am too old now.

**Focal Point:** Do you considered yourself really retired, or are you busier now than you ever were?

**Tombaugh:** From January in 1987 to the present, I have given over 40 lectures from coast to coast in Houston, California, Arizona, New Mexico, Missouri, Illinois, Michigan, Ohio, Tennessee, North and South Carolina, Pennsylvania, Massachusetts, Rhode Island, and Ontario, Canada. I have flown over 34,000 miles, and traveled over 6,000 miles by car. I think I am busier now than I ever was.

## VOYAGER WATCH IN ATLANTA: A SUCCESS!

by G. T. White

The Atlanta Astronomy Club sponsored a Voyager Watch on August 24th and 25th at Fernbank Science Center. These two days marked the closest approach of the Voyager spacecraft to Neptune, and transmitted images of the planet and its moons back to the Jet Propulsion Laboratories in Pasadena, where they were processed and sent by satellite around the world to thousands of eager amateur and professional astronomers.

AAC member Hal Crawford was the coordinator of the event, who admits that he was late coming up with the idea. "I really didn't think I could do it," he said, "after all, before I could sell the idea of a Voyager Watch to Fernbank, I had to find an inexpensive satellite downlink to receive the JPL images." Fortunately, that turned out to be easier than anticipated. Charles Preston, a ham radio operator and the area coordinator for AMSAT (a coalition of amateur radio operators who communicate using satellites) came to the rescue. He had not one but two 2.3 meter dish antennas, a stationary and a mobile, and worked with the Atlanta Astronomy Club and Fernbank Science Center to get his mobile antenna installed on the Fernbank grounds the week of the event. His presence assured that nothing would go wrong during the event, and all minor problems were quickly resolved.

Fernbank technicians continuously recorded all images from Voyager, which will be used to produce an educational tape about the spacecraft's encounters with the outer planets.

Fernbank was also able to receive on loan a couple of television projection units to display the images for the public. The larger unit was mounted in the planetarium, where continuous displays of the raw images of Voyager were on display for the public. The second unit was used in lectures to show the results of Voyager's previous encounters with Jupiter, Saturn and Uranus. Every available television and VCR in the center was tapped to help present the latest information to the hundreds in attendance.

Hal Crawford and Fernbank astronomer Anita Kern produced a two-hour videotape summarizing the images sent back by Voyager through Thursday, which was aired Thursday evening on Prime Cable's DeKalb public access channel.

The Voyager Watch was conducted in conjunction with Fernbank's regular schedule, so visitors were able to see the planetarium show as well as see Neptune directly through the observatory telescope. Hal conducted several lectures to packed classrooms about Voyager's prior encounters, and answered questions regarding the probe's operation.

While there were a few glitches, ranging from poor air conditioning to a finicky microphone, the event could easily be called a success. Over the two days well over 2500 people came out to Fernbank, and most picked up AAC brochures and copies of the latest newsletter. The pictures returned were clear and punctuated with excellent reports and lectures from JPL scientists.

Many thanks are due to the staff of Fernbank Science Center for their support throughout the event. The assistance of AAC members who volunteered their time to make this event a success is also very much appreciated. Between the lunar eclipse the week before and the Voyager Watch, the AAC entertained over 5000 members of the public; Not a bad week at all!

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## LUNAR ECLIPSE BRINGS THOUSANDS TO FERNBANK

August 16 was a date to remember as the most dramatic lunar eclipse of the year impressed thousands of people in the Eastern United States. Possibly the best viewing in the country, however, was at Fernbank Science Center, where approximately 2500 people came out to view the eclipse through the observatory's telescopes. WXIA's 11 Alive news teams were also on hand at Fernbank, where images were not only directed back to the station, but the signal feed was sent to television stations and network affiliates all over the country, as clouds and rainy weather dominated most of the eastern seaboard.

About 15 members of the Atlanta Astronomy Club were on hand to help Fernbank astronomers answer questions, and several telescopes were set up to view the eclipse as it slowly faded to a dark, deep red sphere. AAC President Leonard Abbey was elated as the mercury vapor lamps around the observatory were finally extinguished. "This eclipse was much darker than most of those I have seen. The color varied from blood red at the outer edge of the umbra to a dark burnished copper at the center."

A lunar eclipse is when the earth is aligned between the sun and moon, thus blocking sunlight away from the moon. As totality approaches, various shades of light are refracted through the earth's atmosphere, illuminating our satellite in a variety of dark colors. This coming year there are two eclipses of the moon (the first being on Feb. 20), there can be up to seven in a year.

The weather was the certainly the most capricious aspect of the event, as the clouds and lightning obscured most of the eastern sky until approximately 9:45 pm. As the moon appeared, the crowds in the parking lot burst into applause. The eclipse was already well under way, with about 20 percent of the moon covered with the earth's shadow. About an hour and a half later, the moon disappeared entirely from view, and could barely be made out even in telescopes. This was followed shortly thereafter by clouds which prevented any further seeing that evening.

Most other areas around Atlanta reported far less favorable conditions, however. The weather varied from between heavy thunderstorms around Stone Mountain to low, dark clouds in Marietta. But to the crowds who came out to Fernbank Science Center that evening, few were disappointed.

## THE CASUAL ASTRONOMER: SEPTEMBER 1989

by Hal Crawford

### Voyager 2 Departs for Interstellar Space

After providing stunning views and information to intrigue astronomers for years, Voyager 2 swept past Neptune and headed southward below the plane of the solar ecliptic, toward the constellation Ophiuchus. Anyone wishing to stay up to wait for this event will have to be very patient -- the next close approach to ANY star (in this case, Barnard's Star, a "near" approach of 4.03 light years) will be in the year 8571! Indeed, the probe won't even leave our own system's Oort Cloud until the year 28635!

At a total cost of $865 million (20 cents per American per year of the project), the two Voyager spacecraft visited four planets and at least 56 moons, of which at least 23 of those satellites were discovered. At Neptune alone, Voyager 2 photographed three thin rings of debris and two broader rings, and found at least six new moons, with six "moonlets" hidden in one of the rings.

Pictures from the small spacecraft also revealed a "Great Dark Spot," similar in structure to the Great Red Spot of Jupiter, and easily large enough to engulf the Earth. Also examined were wind speeds of up to 720 miles per hour, ultraviolet auroras, and white, wispy, cirrus-like methane clouds -- visible floating about 50 miles above the haze of hydrocarbons that likely make up most of the planet's atmosphere. Many scientists noted that as solar radiation gradually breaks down methane into acetylene and ethane, it forms a snow-like smog that falls back into the lower atmosphere.

On the moon Triton, volcanos made of ice were observed by Voyager, which appear to eject nitrogen ice and gas up to 25 miles above the moon's surface at speeds of 560 mph. Other ice volcanos appeared to produce ocean-size floods of ice that flow like lava. At 400 degrees below zero, Triton probably beats out even Pluto for being the coldest object in the solar system.

Having completed its "Grand Tour" of the outer planets, Voyager 2 now proceeds into the next phase, the Voyager Interstellar Mission (VIM). The greatest challenge for the scientists and engineers at the Jet Propulsion Laboratories (JPL) in Pasadena is to keep the systems of both Voyagers working until well into the 21st century.

The most substantial concern is electrical power -- used to operate the radios, computers, and scientific instruments. The Voyager spacecraft are each equipped with radioisotope thermoelectric generators (RTGs), which directly convert the heat from the radioactive decay of plutonium into electricity. Current predictions indicate that the RTGs can keep the spacecraft operational until around 2025.

The next concern is making certain that the communication link between Earth and spacecraft is not lost. Two options are possible to maintain communications -- build larger tracking stations to communicate with, or instruct the Voyagers to send data at a slower data rate to minimize communication distortion. Voyager 2's primary receiver broke down shortly after launch, so there is a chance that the secondary receiver could fail as well. This would mean that Voyager 2 would be unable to send scientific data, although engineering-based telemetry could still be performed. Current estimates indicate that with no breakdown in radio equipment and with 70 meter tracking stations, we have the capability to communicate with the Voyager probes until the year 2030.

There is also the question of how much hydrazine fuel is left on board the spacecraft. The fuel has two purposes for Voyager: to adjust the craft's trajectory for planetary flyby's; and to maintain attitude control so that the antenna constantly points toward Earth. In the new VIM era, there will be no need to make any trajectory corrections. All remaining fuel will be used only for attitude control. Engineers speculate that there should be enough fuel to control Voyager until 2025, and possibly longer.

Finally, there is the problem of the spacecraft being able to continuously track on the Sun. As the Voyagers move further and further out into interstellar space, they will eventually fail to be able to lock onto the Sun, and the probes will turn away from Earth-point and begin to tumble out of control. Current estimates of the Sun-sensing equipment indicate that this should not be a major concern until the year 2030.

Why do want to keep a couple of inter-planetary explorers alive, anyway -- since they have already completed their primary mission? Because valuable information about the universe can still be retrieved, that's why.

First of all, the Voyagers can proceed to use their field and particles instruments (magnetometer, cosmic ray, plasma, and low-energy charged particle instruments; as well as the planetary radio astronomy and plasma wave receivers). These instruments would be used to sample the interstellar environment, and search for the farthest reach of the Sun's magnetic field (called the solar heliopause). Having reached this point, the probes can go on to analyze the interstellar wind (a stream of charged particles flowing out from the stars).

This basic mission has other opportunities -- the continued study of galaxies, binary stars, and pulsars, all of which can be examined by the ultraviolet spectrometer. UV wavelengths can't be observed from Earth because of the screening effects of the ozone layer, and no other spacecraft currently in operation has the capability to match the Voyagers in far-UV wavelengths. Information obtained at these wavelengths will reveal much about our universe, since the most energetic astronomical phenomena radiate most of their energy in the ultraviolet.

Imaging will no longer be a serious consideration for the Voyager spacecraft, due to the technical requirements involved and the high probability of failure in comparison to cost. Also canceled due to the high monetary and engineering cost were experiments using the infrared interferometer and spectrometer, photopolarimeter, and radio science instruments.

It will take decades to realize the full potential of what the Voyager spacecraft have to offer in terms of new information concerning interstellar space. But the mere fact that the two interplanetary probes are still very much alive and kicking and ready to provide even more data about our universe should be considered the Voyager Project's greatest triumph.

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## WATER AND THE MARTIAN SURFACE MORPHOLOGY

by Carolyn Collins Petersen

In recent years, the search for an understanding of a variety of Martian surface features has centered around such topics as impact cratering, volcanism, tectonism, and aeolian (wind-driven) processes. Individually, as well as collectively, these processes explain many of the Martian surface features we see, as well as give us a look at the history of the Red Planet. These processes, however, do not always take into account the role that water has played in shaping certain terrains that we see on Mars. Recent research has shown water to be an important element, despite the fact that we find no traces of liquid water on the Martian surface. This apparent lack of water is one facet of the Mars water "problem" that should be solved in order to gain a complete understanding of the planet.

Beginning in the mid-1960's, the first Mars-exploration spacecraft reached the Red Planet (see fig. 1), surveying the Martian southern hemisphere. The photographic evidence from the early missions revealed the surface of Mars to be dry, barren, and riddled with craters. Subsequent missions studied the northern latitudes of Mars, finding less cratering, but evidence of volcanism and fracturing. Upon closer study, some of the features mapped by the spacecraft appeared to be fluvial features -- features that, on Earth, would indicate the presence of flowing water, and associated erosional artifacts. What these spacecraft did not find was concrete evidence of flowing water on Mars. It had been known from Earth observations that there was no water flowing across the surface of Mars, but the discovery of flow channels presented a new problem to researchers: it seemed that there had been water on the surface in the past. How long ago did that water exist, and where did it go? To answer these questions, we should look at the current water situation on Mars.

Careful reduction of data from the Mariner and Viking spacecraft showed that the Martian atmosphere maintains an average water vapor content of .03 percent. (See figure 2) Because of the low atmospheric pressure of 6 millibars (see figure 3), liquid water is unstable, and would evaporate or freeze on (or under) the surface. Under conditions of low atmospheric pressure and temperature -- both of which apply to Mars, the only forms of water that are allowed are water vapor and water in the solid state (ice).

CHRONOLOGY OF MARS EXPLORATION SPACECRAFT

| Year | Name | Purpose | Country |
|---|---|---|---|
| 1965 | Mariner 4 | flyby | U.S. |
| 1969 | Mariner 6 | flyby | U.S. |
| 1969 | Mariner 7 | flyby | U.S. |
| 1971 | Mars 2 | orbiter | U.S.S.R |
| 1973 | Mars 5 | orbiter | U.S.S.R. |
| 1976-80 | Viking 1 | orbiter/lander | U.S. |
| 1976-80 | Viking 2 | orbiter/lander | U.S. |

(Fig. 1)

MARTIAN ATMOSPHERIC COMPOSITION

| | |
|---|---|
| $CO_2$ | 95.3% |
| Nitrogen | 2.7% |
| Argon | 1.6% |
| Oxygen | .15% |
| Water | 0.03% |
| Neon | 0.0003% |

(Fig. 2)

MARS CHARACTERISTICS

| | |
|---|---|
| Martian year | 687 days |
| Martian day | 24 hrs, 37 min. |
| Polar tilt | 25 degrees |
| Atmospheric pressure | 6 millibars |
| Surface gravity | .38 Earth gravity |
| Diameter | 6794 km |
| 2 polar caps, $CO_2$ and $H_2O$ | |
| Temperature range (mean) | -150 C to -50C |

(Fig. 3)

Water vapor has been measured in the atmosphere, with higher concentrations around the poles, and over areas known as "oases". The polar concentrations have been found to run in a seasonal cycle (6, 11, 18). In Viking year 1976-77, the Mars atmospheric water detector (MAWD) recorded a full cycle of $H_2O$ vapor activity on the planet. The data was then compared with Mariner data and earth-based observations. Basically, the data showed a high abundance of water vapor over the north polar cap in Martian midsummer. According to Jakosky (10), the column abundance "varies from nearly zero to about 100 precipitable micrometers, depending on location and release...". This 100 pr/m abundance seems to occur over the north polar cap in midsummer -- implying temperatures of at least 205K (freezing/melting point of water on Mars).

A possible explanation for this (6, 11, 18) is that the north polar cap is composed of a residual water cap, mixed or overlaid with a $CO_2$ cap. As temperatures rise, the cap first loses its $CO_2$, and water vapor is released. The peak abundances appear over the dark polar collar, as well as over the retreating edge of the cap. The vapor circulates through the atmosphere, and in one suggested mechanism, is trapped at the cooler south pole (which acts as a vapor sink). According to Jakosky (conversation), there is no evidence to suggest that this north-to-south transport of water vapor is unidirectional -- it is possible that either pole can be the source of vapor in the atmosphere, depending on the time of year and the position of Mars in its orbital cycle.

The southern pole, at northern hemisphere summer, seems to be a source of the dust storms that can cover the Martian surface. During a storm, particles of water adhere to particles of dust, thus creating another transport mechanism for water in the atmosphere. The polar regions clear first during these storms, with the dust and water precipitating out onto the poles.

Another possible source for Martian atmospheric water seems to lie in "oases" -- areas outside of the polar caps where higher-than-average amounts of water vapor have been observed. Their existence has been inferred by remote sensing, and visual evidence: overlying fogs and vapors. Two areas under study are the Solis Lacus (25 S, 90 W), and Noachis-Hellespontus (30 S, 310 W). These areas are discussed by Clifford (6), who suggests that soil moisture, possibly in the form of subsurface ice, could extend very close to the surface. As the temperature rises, this ice melts and sublimates, causing a sudden burst of localized vapors and condensation. (The data supporting these observations was taken during the Viking year 76-77.) Clifford suggests that there is a global sub-permafrost groundwater system that is activated by seasonal temperature variations.

**Surface Water**

While there is no evidence for liquid surface water, the existence of a subsurface permafrost layer on Mars has been inferred from the Viking data and models created from that data. This layer figures prominently in theories concerning the formation of some flow features seen on the surface. Other flow features seem to imply the presence of rain at some point in

Mars' past. To answer the questions raised above, a brief look at Mars' geologic history is in order.

Rossbacher (16) describes the geomorphic evolution of Mars in terms of four "regimes": (after formation)

1) Impact cratering (4.5-3.5 billion years ago) which ended with the end of the Late Heavy Bombardment (3.5 billion years ago) (also some early volcanism).

2) Commencement of fluvial and aeolian processing of the surface (3.5-2.5 billion years ago) which modified the older cratered terrain. This period was characterized by maximum atmospheric density, internal heating and partial differentiation, and tectonically-induced stresses in the crust.

3) A period of increased volcanic and tectonic activity (2.5 billion years ago - 800 million years ago).

4) The current regime, characterized by aeolian processes varying in intensity with the obliquity cycle of Mars.

The presence of surface water falls across the two center regimes, and could be affected by the obliquity cycle as well.

At the end of the cratering period, outgassing associated with that cratering, as well as from volcanism, would have formed a much denser atmosphere than we see today. This would have supported water precipitation, as well as pooling of water on the surface. Some areas of the surface show evidence of dendritic channels -- i.e. runoff channels formed by a slower, gentler flow of water -- such as might be generated by rainfall. These channels show tributaries, and start small, increasing in size downstream (Carr, 2). The terran analog for these channels can be seen in river valleys. Where valleys on Earth show a mature formation, indicating continued flow activity over long periods of time, the channels on Mars are not well- formed, indicating cessation of flow during early stages of channel network formation. (Greeley)

At some point, the climate of Mars changed. This change could have been induced by a reduction in the outgassing, or by changes in the obliquity of the Martian orbit. The net result was a cooling of the atmosphere, and a reduction of atmospheric pressure. The surface froze, water escaped underground to form the permafrost, or condensed at the poles, or sublimated into space. At that point (2.5 billion years ago), surface water was found (as today), as vapors, or ices.

Also at this point we see the formation of the other major feature of Martian water activity -- outflow channels. Prominent examples of these channels are found in the Chryse and Tharsis regions in the Martian mid-latitudes. They seem to be associated with the volcanic region in which Olympus Mons lies -- the Tharsis Uplift. This region is a result of volcanic and tectonic processes -- processes which also produced the Valles Marineris, and the associated chaotic and fretted terrain (Noctis Labyrinthus, Alba

Patera, Kasei Vallis, etc.).

These outflow channels differ from the valley networks (runoff channels) in that they are larger, and seem to arise full-grown from a variety of source regions and chaotic terrain. The terran analog most often mentioned (Lucchitta, Masursky, et al), is the Washington scablands -- an area where a prehistoric catastrophic flood created a channeled terrain much like those seen on Mars. (The origin of this flood was the melting of an ice dam, which released ice and water flows onto lower-altitude areas.)

Martian outflow channels seem to fall into two types:

1) Unconfined, which scour broad swaths of terrain; low depth/width rations.

2) Confined, where we see erosion restricted to discrete channels; high depth/width ratios.

We see outflow channels running through older, cratered terrain. Typically, these channels are sparse east of Chryse, where many of the unconfined channels are found (Amazonia-Memnis). Confined channels are mostly found northwest of Elysium, and a few are seen in Hellas. Carr (2) finds that outflow channels occur in regions of 1500-2100 craters greater than 1 km/10^6 km^2. Finding these channels in these regions supports the contention that they are older features as well (less than 3.5 billion years).

The formation of outflow channels involves volcanism and subsurface ices with catastrophic results. In a series of papers, Lucchitta and Masursky (12, 14) each postulate the following scenario:

Channels fringe the Chryse Basin, seeming to spring from areas of chaotic terrain (Ares, Tiu, Simud Valles). We see jumbled terrain, giving rise to an outflow channel that may flow for hundreds or thousands of kilometers, and then stop. These may have formed when a layer of permafrost near the surface was melted by a nearby heat source. This melting would continue until underground ice dams were breached, releasing a slurry of water and ice. Alternatively, the melting could have undermined overlying rock, which would collapse, releasing the underground water to the surface. This slurry reached the surface, and flowing rapidly, carved the outflow channels we see today. It is probable that the water for this flow was released from more than one source, collecting underground until the final catastrophic release. The source of heat for this melting would have been the volcanic processes involved in the Tharsis region.

At the end of the outflow area, the water could have pooled, if the atmospheric conditions permitted. However, pooling of water into lakes is a much more tentative conclusion, and not fully supported by the mass of visual evidence that we see for dendritic, and outflow channels. However, conditions described in a JPL press release (9-2-86) (describing a paper by Parker, Schneeberger, Pieri and Saunders) point to the following scenario: Outflow channels have been seen to empty into what appear to be featureless plains. The authors examined these plains for evidence of delta-like deposits, indicating a shallow pooling of water. They found several sites which support the idea of pooling -- Cydonia Mensae and Acidalia Planitia. Erosional artifacts similar to island groups and knobs produced by wave-like actions seem to point to the existence of broad shallow pools.

Major questions regarding the form of water flow remain. Lucchitta (12) postulates that the outflow channels were not necessarily formed by liquid water. By comparing the erosional characteristics of these channels with those formed on Earth by the flow of ice-streams and glaciers, a plausible case can be made for the flow of ice on Mars. However, ice flows are typically very slow on Earth, and would be much slower on Mars.

One possible scenario involves the same under-surface liquefaction described above. The liquid mixes with the regolith to form a mudflow. As it reached the surface of Mars (and cooler temperatures), the flow would become ice-charged -- water-laden ice. This mixture would flow along, dropping debris and carving out the channel. As it flowed, friction would have generated heat along the edges of the flow, further liquifying the flow, and adding acceleration to the mass.

This scenario would explain why some areas resemble U-shaped glacier valleys, why we see terracing in other areas, and why some areas show the effects of highly-accelerated catastrophic flooding.

At the end of the flow, the water is presumed to have frozen into the surface, or condensed into the atmosphere, only to precipitate out at the poles. The end of this period of Martian history (800 million years ago) marks the end of free-flowing and catastrophic surface flow of water on the planet. The current regime of cyclic vaporization of water dates from that point.

The characterization of Mars as a dead planet is probably not accurate. While we have seen no evidence of current tectonism or volcanism, there does appear to be interaction between the atmosphere and the planet. The CO2 cycle on Mars is one proof of this; the vaporization of water into the atmosphere, and its subsequent precipitation onto the caps (and at points in the regolith) point to the active involvement of water in the daily and yearly cycles of replenishment and change on the planet. While the likelihood of surficial water flow on Mars is very small, we have seen that there are mechanisms for release of subsurface water: subsurface heating and liquefaction, as well as the vaporization process.

Future studies of the Martian water "problem" will concentrate on the locations of water masses under the surface, as well as a clearer understanding of the atmospheric mechanisms which release and trap (circulate) the water around the globe.

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## VILLA RICA NOTES

by Steve Gilbreath

Once again here's a report on our observing site in Villa Rica. First, and foremost is the news that a tornado touched down not far from our observatory about two weeks ago. Over 85 trees were destroyed and the power pole near the warm up shed was uprooted. We're pretty lucky no other damage was done. Thanks to the Barbers, the pole has been replaced, however at this time there is no electric power to run the observatory; we must find an electrician to hook it up. If you know of someone who can help, please have them contact Leonard Abbey.

It's time for the annual lock change at Villa Rica. On September 30, all the locks will be changed. You can get the new combinations at the September meeting or by calling one of the officers.

THE FOCAL POINT

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