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Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 46, Number 2, Spring 2004

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. . . plus reports about your ALPO section activities and much, much more.

This month's cover: C/2004 F/4 (Bradfield) Image by Michael Jäger and Gerald Rhemann on 2004 April 22, 2.50 UT, around 70 minutes before sunrise; image with Apo-Tele 180mm/f-3.3; 6x4 seconds. The tail ~1.5 degrees. (Source: http://encke.jpl.nasa.gov/index.html. Visit the ALPO comet page at http://www.lpl.arizona.edu/~rhill/alpo/comet.html)

Journal of the Association of Lunar & Planetary Observers, The Strolling Astronomer

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This publication is the official journal of the Association of Lunar & Planetary Observers (ALPO).

The purpose of this journal is to share observation reports, opinions, and other news from ALPO members with other members and the professional astronomical community.

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Association of Lunar and Planetary Observers (ALPO)

Point of View
Research Amateur Astronomy Indoors

By John W. Westfall, ALPO science editor

The amateur who is trapped indoors by cloudy weather or lacks a high-performance telescope still has plenty of opportunity for meaningful research, thanks to readily available source material on line or on CD-ROMs. Here are some examples (emphasizing the Moon because that's what I'm most familiar with).

First are several on-line collections provided by the Lunar and Planetary Institute (www.lpi.usra.edu): (1) The *Lunar Orbiter Atlas of the Moon* — almost all the Moon at sub-telescopic resolution with a medium solar altitude; (2) The *Apollo Image Atlas* — 70-mm film photographs from all the missions, including orbital views from Apollo 8 and 10-17; and (3) The *Consolidated Lunar Atlas* — The earthside under a range of lighting, one of the most detailed sets of telescopic photographs ever taken (also available as a CD-ROM set).

Several sites offer the Clementine mission images on line, but I prefer to use the CD-ROM set offered by the National Space Science Data Center (nssdc.gsfc.nasa.gov/cgi-bin/shop/web_store.cgi). These cover the entire Moon at 100-meter resolution under noon lighting.

Then there's a wonderful source for research in any area of astronomy — the NASA Astrophysics Data System (adswww.Harvard.edu). It currently lists 975 thousand abstracts, scanned issues of 41 journals, scanned conference proceedings, and Observatory/Society Publications.

So your computer now can serve you as a university-level astronomy research library, but what can you do with it? One example is lunar banded craters, frequently studied and catalogued by amateurs using telescopic

(See *Point of View*, Page 6)

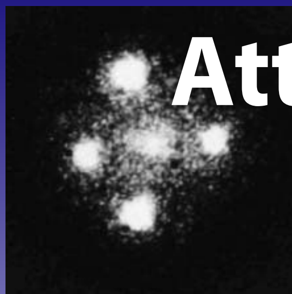

Image credit: NASA and ESA

Inside the ALPO
Member, section and activity news (continued)

AstroCon 2004 Notes

(From Richard Schmude, ALPO executive director

I hope that many of you will be able to attend this important convention. One of the convention highlights is that the banquet will be held on the USS Hornet.

Please be sure to e-mail your name, talk title, abstract and audio/visual equipment needs to me, Richard Schmude, at: Schmude@gdn.edu All abstracts received before June 1 will be forwarded to the AstroCon2004 committee which will then print the abstracts (or the talk titles) for the convention participants. Talks should be 20 minutes long with 10 minutes for question and equipment set-up.

ALPO Membership Online

The ALPO now accepts membership payment by credit card via a special arrangement with the Astronomical League. However, in order to renew by this method you MUST have Internet access. See the inside back cover of this Journal for details.

Our Advertisers

As we all know by now, there is no free lunch. Everything costs money. This Journal and other various activities of the ALPO require funding. One way to help offset the costs of producing and mailing the hardcopy version of this publication is through advertising.

Please show your support of them as they show their support for us.

Report from the ALPO Membership Secretary/Treasurer

by Matthew L. Will

Current Membership

As of April 12, 2004, the ALPO had a total of 617 members. Just a year ago, we had only 410 members. Of course, the popularity of the 2003 Mars apparition and the online purchasing of ALPO memberships via the Astronomical League web site has helped re-establish the high membership count that we had in previous decades. Hopefully, this last great apparition of Saturn and the new naked eye comets visible this spring will continue to generate interest in lunar and planetary astronomy and our organization.

Online Payment

On page 3 of the last issue of the *Strolling Astronomer* (Volume 46, Number 1), the short writeup on online payment is correct. However, it should be noted that the ALPO is being assisted by the Astronomical League in the collection of ALPO dues. Those paying for ALPO memberships in this manner will be billed in their credit cards monthly statements by the Astronomical League and not by the ALPO. The ALPO does not directly accept credit card orders. So, please do not mail your credit card orders directly to the ALPO membership secretary. Your cooperation is greatly appreciated!

THE 2004 Convention - An Expression of Appreciation

I would like to thank John and Beth Westfall for their generous gift of $300 to the A.L.P.O. for sponsoring "ALPO Coffee Breaks" during the first day's ALPO paper sessions. John and Beth deserve credit for promoting the ALPO in this friendly, personable manner at this summer's combined convention of several leading astronomical organizations. Events like these encourage attendees to socialize with other ALPO members and learn more about us – up close and personal, the ALPO way! Thanks again, John and Beth, for sponsoring an outstanding idea.

Interest Areas

Our ALPO members have varied interests in Solar System astronomy across some 30 observing programs that the ALPO volunteer staff manage. Members communicate their interest to the Membership Secretary when applying for membership or renewing, using the interest codes system on the member-

Reminder: Address changes

Unlike regular mail, electronic mail is not forwarded when you change e-mail addresses unless you make special arrangements.

More and more, e-mail notifications to members are bounced back because we are not notified of address changes. Efforts to locate errant members via online search tools have not been successful.

So once again, if you move or change Internet Service Providers and are assigned a new e-mail address, please notify Matt Will at will008@attglobal.net as soon as possible.

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ship applications and renewal forms. Section Coordinators are encouraged to contact this membership secretary for complete listings of prospective observers with interest in topic areas of Solar System astronomy.

Observing Section Reports

Meteors Section

By Robert Lunsford, coordinator

April 19 – As is normally the case, the winter season has provided a lull in meteor observing. Not only were the temperatures too low for comfort (for most of us!) but the actual meteor activity was low.

The normally active Quadrantids suffered from a nearly Full Moon back in early January. Clouds also blocked the view for many potential observers. No major annual showers were predicted for February or March.

Thankfully April, with its warmer nights provides us with the Lyrid meteor shower that occurs close to the New Moon. A report on this shower will appear in an upcoming issue.

Solar Section

By Rick Gossett, acting coordinator

April 12 – After several changes in both staff and procedures, the ALPO Solar Ssection continues to progress. Rik Hill has remained as scientific advisor, and web manager. Kim Hay has completed the section's rotation reports through Carrington Rotation 1997. Copies of the reports are available at kimhay@adan.kingston.net . Kim has also been handling general correspondence.

New observers are encouraged to contact Jamey Jenkins at jenkinsjl@yahoo.com . For new members observing in either white light or h-alpha, help is readily available. The solar section has begun to prepare a new solar observing handbook. This project is headed by Jamey Jenkins. Any observers who would like to participate in this project should contact Jamey or myself at rick2d2@sbcglobal.net .

Visit the ALPO Solar Section on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/solar.html

Mercury Section

By Frank J. Melillo, coordinator

April 12 – I am happy to see some of our work and images from the ALPO Mercury Section published in a new book "Exploring Mercury: The Iron Planet", which was written by Dr. Robert Strom and Dr. Ann Sprague. This book contains all aspects of the planet Mercury, including information about the upcoming spacecraft, Messenger.

NASA is planning to launch the Messenger probe this summer for orbit around Mercury in 2009. My goal in the ALPO Mercury Section is to make the best albedo map possible and compare it with the Messenger images. This spacecraft is capable of producing an albedo map of the surface from a distance, which was not possible from the Mariner 10 space probe. The Messenger camera has a much better resolution and contrasts on any real albedo features while approaching Mercury and which would be similar to the resolution as seen from Earth.

There is a story about Mercury in the April issue of *Discover* magazine. The author, Fred Guterl, *Newsweek* magazine's science editor, interviewed me at my home for nearly three hours! Also, I demonstrated how to find Mercury in the daytime with my Celestron 8-inch telescope. Unfortunately, I failed to find it and I was hoping that I wouldn't disappoint him. Then, I showed him Venus and at least he had a smile on his face! I have received some comments that this article is well-written and it is the first time ever that we have substantial information about Mercury for the public.

Visit the ALPO Mercury Section on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/merc.html

Venus Section

By Julius Benton, coordinator

April 11 – As of this writing, the 2003-2004 Eastern (Evening) apparition of Venus is underway. Venus reached Greatest Elongation East on 2004 March 29 (46°) , and it will pass greatest brilliancy on 2004 May 2 (visual magnitude -4.5), remaining in the evening sky until Inferior Conjunction occurs on 2004 June 8. Venus will re-emerge from the solar glare in late June 2004, a morning object in the eastern sky before sunrise. Sample observations and images from the 2003-2004 Eastern (Evening) Apparition appear on the Venus page of the ALPO website.

Preliminary results from the 2003-2004 Eastern (Evening) Apparition of Venus suggest only limited activity in the atmosphere of the planet from the standpoint of visual observations. It is quite difficult, however,

Inside the ALPO
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in any analysis to differentiate between what constitutes real atmospheric phenomena and what is merely illusory on Venus at visual wavelengths. On the other hand, over 90 ultraviolet CCD images of Venus reveal considerable atmospheric detail. Comparison of images made at roughly the same time and on the same date (simultaneous observations) show similar cloud patterns in the UV, and in a few cases, there is good correspondence with drawings made on the same date using W47 (violet) filters.

A greater level of confidence in our results grows as observers make an effort to do simultaneous observations, and the ALPO Venus Section is stressing combined visual observations and CCD imaging for comparative analysis of resultant data. There is also a definite need for more ultraviolet imaging of Venus simultaneously with visual observations; for example, some observers apparently have a slight visual sensitivity in the near UV range, whereby they report radial dusky features that are so readily apparent on UV photographs and images.

ALPO studies of the Ashen Light, which peaked during the Pioneer Venus Orbiter Project, are still continuing every apparition. Constant monitoring of the planet for the presence of this phenomenon by a large number of observers (ideally participating in a simultaneous observing program) remains important as a means of improving our chances of capturing confirmed dark hemisphere events. Imaging with CCDs and webcams to attempt to capture the faint glow on the dark hemisphere at crescentic phases is an important endeavor that must continue.

It is the ultimate goal of the ALPO Venus Section to attempt to assemble a completely homogeneous mass of accurate, reliable observational data collected over many apparitions, permitting an exhaustive statistical analysis. It is hoped that we might derive enough from painstaking observations and analysis to help provide some answers to questions that continue to perplex us about Venus.

Observations of the atmosphere of Venus are organized into the following routine programs:

- Visual observation and categorization of atmospheric details in dark, twilight, and daylight skies.
- Drawings of atmospheric phenomena.
- Observation of cusps, cusp-caps, and cusp-bands, including defining the morphology and degree of extension of cusps.
- Observation of dark hemisphere phenomena, including monitoring visibility of the Ashen Light.
- Observation of terminator geometry (monitoring any irregularities).
- Studies of Schröter's phase phenomenon.
- Visual photometry and colorimetry of atmospheric features and phenomena.
- Routine photography (including UV photography), CCD imaging, photoelectric photometry, and videography of Venus.
- Observation of rare transits of Venus across the Sun, especially the one on June 8, 2004.
- Simultaneous observations of Venus.

The ALPO Venus Section invites interested readers worldwide to join us in our projects and challenges ahead.

Complete details can be found about all of our observing programs in the ALPO Venus Handbook. Individuals interested in participating in the programs of the ALPO Venus Section are cordially invited to visit the ALPO Venus Section on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/venus.html

Lunar Section:

Lunar Domes

Persons interested in the revived survey are invited to join the Yahoo discussion group on Lunar Domes located at http://groups.yahoo.com/group/lunar-dome/

Visit the ALPO Lunar Dome Survey Section on the World Wide Web at http://www.lunar-dome.com

Lunar Selected Areas

Visit the ALPO Lunar Selected Areas Program on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/lunarstuff/selarea.html

Mars Section

By Dan Troiani, coordinator
Daniel P. Joyce, assistant coordinator

April 20 – Though Mars has slipped to just 4.5 arcseconds, five and a-half-times farther than at the unprecedented opposition of last August, the euphoria (and the workload) has not yet subsided much. With two NASA rovers sending back pictures of historic significance, interest is hardly on the wane. Exciting images are being received from the European Mars Express mission and some recent findings strongly suggest we are on the verge of major changes in our perception of the Red Planet.

There has been, of course, a slackening in the amount of submitted observations, but those that have arrived reveal some surface feature changes of note, yet the familiar pose of the planet has not been lost. No unusual weather phenomena have been reported

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recently. All observers are encouraged to continue watching as long as possible, especially since some have been able to extract considerable detail in recent years using CCD equipment at similar apparent diameters. The anticipated apparition summary is certain to be voluminous!

(Supplemental Report by Richard Schmude, Jr., Acting Assistant Mars Coordinator)

A draft report of the 2003 Mars apparition has been distributed to all Mars section coordinators. Currently, the Mars Section is still working on a map of Mars along with dust storm and cloud activity. The south polar cap appears to have been a little larger than normal and the dust storm that began in December 2003 dissipated by late January.

Don Parker, Frank Melillo and Paul Maxon have all submitted images of Mars in April showing some surface detail. This assistant coordinator also made a few photometric measurements during April and the measurements are consistent with there then being little or no dust activity on Mars.

ALPO Mars Section Coordinator Dan Troiani encourages people to continue watching Mars for as long as possible. If CCD/video equipment can bring out detail on the Jovian moon Ganymede (which is one-third the present angular diameter of Mars), then it can bring out detail on Mars. Keep up the good work.

On another note, if you have not sent in your Mars observations then please DO send them as soon as possible to Dan Troiani, Don Parker or Richard Schmude, Jr.

I am hoping that people with methane band filters will take methane band images of Mars in 2005. This is now important because of the recent discovery of methane in the Martian atmosphere. We may be able to determine the source of the methane.

Minor Planets Section

By Frederick Pilcher, coordinator

April 13 – In the Minor Planets section a larger number of observers are obtaining high quality CCD lightcurves of a larger number of minor planets than ever. As reported in the Minor Planet Bulletin, Volume 31, Number 1, 2004 January-March; and Number 2, 2004 April-June, a total of 28 different people obtained data sufficient to determine reliable rotation periods and amplitudes for 56 different planets, with fragmentary lightcurves of two others.

A major new book is announced as a Book Review: A Practical Guide to Lightcurve Photometry and Analysis, by Brian D. Warner, Bdw Publishing, 2003, ISBN 0-9743849-0-9, paperback, 266 pages, US $30 available at www.MinorPlanetObserver.com. This is just what a novice observer needs to get him started on the path to scientific observations of real value.

Jupiter Section

By Richard W. Schmude, Jr., coordinator

April 5 – Jupiter will be visible in the evening sky until late August. I am hoping that people will try to image Jupiter until this time. One important event that will take place in August will be that oval BA will pass the GRS. This passage is expected to take place on or about Aug. 15.

Please also watch for transits of Ganymede and Europa across Jupiter. I am interested in knowing whether these moons are brighter or dimmer than the belts and zones of Jupiter.

The 2002-03 Jupiter report has been submitted to the JALPO for publication and I am planning to begin writing the 2003-04 Jupiter report this summer. I am hoping to have this report completed by December of this year. Please be sure to send in your 2003-04 observations by Sep. 1, 2004.

Visit the ALPO Jupiter Section on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/jup.html

Saturn Section

By Julius Benton, coordinator

April 11 –Saturn's southern hemisphere and south ring face have been conveniently open for our inspection in recent apparitions. During the current 2003-2004 apparition, Saturn's rings have been inclined -25°, just shy of their maximum tilt of -27° to our line of sight, which occurred during the 2002-2003 apparition. The rings will now gradually “close up,” with Saturn diminishing gradually in brightness, as the next edgewise orientation in 2009 approaches.

With respect to recent apparitions of Saturn, all reports for the 2002-2003 apparition have been received, logged into the ALPO Saturn Section database, and are now undergoing detailed analysis. Observer response during 2002-2003 was excellent, with a considerable number of superb CCD, videographic, and webcam images of Saturn received, along with routine drawings and descriptive reports. The apparition report for the 2002-2003 apparition will appear soon in this Journal.

The current well-observed 2003-2004 apparition will draw to a close as Saturn reaches conjunction with the Sun on 2004 July 08, leaving observers less little time to view the planet to advantage before it is too low in the western sky. Even though our analysis has not yet begun for the 2003-2004 observing season, Saturn's atmosphere has shown some interesting activity over the last 8 months. Over 100 images have been submitted so far, and most have been made with webcams. Samples of

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drawings and images appear on the Saturn page of the ALPO website.

All ALPO Saturn observers will not want to forget that there is a great opportunity this apparition for participation in the Amateur-Professional Cassini Observing Patrol, because Cassini's arrival at Saturn (orbit insertion) occurs on July 1, 2004, followed by the Titan Probe Entry and Orbiter flyby on November 27, 2004. What will be most useful to the professional community will be digital images of Saturn at wavelengths ranging from 400 nm - 1 micron in good seeing using webcams, CCDs, digital dameras, and videocams. This effort began in April 2004 to coincide with when Cassini starts observing Saturn at close range. Use of classical broadband filters (e.g., Johnson system: B, V, R and I) have been recommended, and for telescopes with large apertures (e.g., 30.0 cm. and greater), imaging through a 890-nm narrow band methane filter will also be extremely worthwhile.

The Cassini Team is hoping that ALPO Saturn observers will carefully and systematically patrol the planet every clear night to search for individual features, their motions and morphology, to serve as input to Cassini's imaging system, thereby indicating to Cassini scientists where interesting (large-scale) targets exist. Suspected changes in belt and zone reflectivity (i.e., intensity) and color will be also useful, so visual observers can also play a very useful role by making careful visual numerical relative intensity estimates. The Cassini team also would like to combine ALPO Saturn Section images with data from Hubble Space Telescope and from other professional ground-based observatories (a number of proposals have been submitted).

The ALPO Saturn Section is always eager to enlist new observers, and anyone interested in our programs should contact the ALPO Saturn Section Coordinator on how to get started.

Please contact the ALPO Saturn Section coordinator for more details on how to participate in this very important program.

Further information on ALPO Saturn programs, including observing forms and instructions, can be found on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/sat.html

All are invited to also subscribe to the Saturn e-mail diuscussion group at Saturn-ALPO@yahoogroups.com

Remote Planets Section

By Richard W. Schmude, Jr., coordinator

April 7 – The planets Uranus, Neptune and Pluto will be visible in the early morning hours in May-June. Please be sure to look at the finder charts in *Sky & Telescope* magazine; *Astronomy* magazine may also have good finder charts. Uranus will be in Aquarius and Neptune will be at the edge of Capricornus.

We have already received our first Pluto measurement. I am hoping to receive more Pluto data. The section has now received Pluto data for the last 5+ years.

The 2002 Remote Planets report was sent to the editor in June 2003 and it should be published in the summer of 2004. I will begin writing the 2003 remote planets report in May, 2004; please be sure to send in any 2003 observations as soon as possible. I am planning to send out finder charts for Uranus and Neptune in June 2004; please contact me if you want a finder chart.

Sedna will be at opposition in November; this will be a very challenging object for an amateur but not impossible! Let's see who will be the first amateur to image this object.

Visit the ALPO Remote Planets Section on the World Wide Web at http://www.lpl.arizona.edu/~rhill/alpo/remplan.html

Point of View: Research Amateur Astronomy Indoors

(From Page 1)

observations. I'd guess that, for every banded crater catalogued from Earth, there are ten that can be found on the Clementine images. Likewise with rayed craters. Then how about the association of lunar domes with white patches? The latter are shown excellently on the Clementine images, which can also helpfully distinguish extrusive from intrusive domes. Finally, we do not have accurate depth:diameter measurements for the great majority of lunar craters in the 1-10 km range; the Orbiter images would serve well for depth measurements, while either the Orbiter or the Clementine pictures could be used for measuring crater diameters.

I'm surprised how little use amateurs are making of these sources, which are inexpensive or even free, particularly because they could tie in directly to some current ALPO projects. Check them out and you'll see many opportunities.

ALPO Feature — An Uncommon Appointment: The June 8, 2004 Transit of Venus

By John E. Westfall, ALPO Mercury/Venus Transit Section coordinator

Introduction

In early spring, 2004, the planet Venus dominates the southwestern sky after sunset, reaching greatest elongation on March 29th. Then in April and May it accelerates toward the Sun, and passes through *inferior conjunction* on June 8th, 2004.

This in itself is nothing special — Venus does this every 19 months and usually passes well north or south of the Sun as it does so. But one inferior conjunction in about 40 is exceptional, with Venus crossing the face of the Sun itself, creating a *transit of Venus*.

Although one of the most rare astronomical phenomena, transits of Venus are very predictable and come in *cycles* of 243 years (e.g., 1761/2004, 1769/2012). For the last five centuries, when one transit takes place, another happens eight years later. Both members of an eight-year pair occur in the same month, which is either June or December.

Our century's two transits are in 2004 and 2012, both in June, which favors observers in the Northern Hemisphere. The last pair was in 1874 and 1882, but that time in December.

Thus our most recent observing experience of a transit of Venus is 122 years old. We have no digital images or photoelectric photometry of a transit of Venus. We do, however, have observers' notes, drawings, and film photographs.

The 2004 transit of Venus lasts slightly over six hours, and of course can be seen only from those areas where the Sun is shining. This means that about a quarter of the world can see the entire transit; another quarter sees only the first part of the transit, and a third quarter can watch only the last part. *Figure 1* shows the portions of the world where the coming event can be seen, and is centered where the Sun will be overhead at mid-transit.

In 2004 the favored longitudes that will see the entire event span most of the Old World, and thus most of mankind. As is always the case with June transits, anyone anywhere in the Arctic, weather permitting, can watch the transit from beginning to end. However, the Sun will set before the transit ends in Australia and easternmost Asia. The eastern Pacific and western part of North America fall in the zone where the entire transit occurs at night. On the other hand, the Sun will rise with the transit already in progress for most of the Americas. About 70 percent of the population of the United States, and most of the population of Canada, should be able to see transit Egress, as shown in *Figure 2*.

For the imaginary geocentric observer, the transit begins at 05:14 Universal Time and ends at 11:26. Local times of transit phenomena will differ by at most 7 minutes from the geocentric times.

Choosing an Observing Location

Advertisements for transit tours and conferences have appeared in astronomy magazines and on the World Wide Web. Also, several astronomical clubs have announced their observing plans. There are plans for live webcasts as well; for the latest information on these, check the following web sites: The Austrian Society for Astronomy and Astrophysics node http://www.venustransit.at (which currently lists 18 webcast sites), Fred Espenak's http://sunearth.gsfc.nasa.gov/eclipse/transit/venus0412.html , the European Southern Observatory's http://vt-2004.org , and the San Francisco Exploratorium's http://www.exploratorium.edu/webcasts .

The Eastern Hemisphere (except for western Africa, eastern Asia, and Australasia) is a desirable destination because the event will be visible there from beginning to end. Residents of the Americas who do not plan intercontinental travel should plan to be in the eastern portions of their continents in order to see at least the transit's Egress phase.

Unlike the case with a total solar eclipse, transit travelers have considerable latitude (and longitude) in choosing an observing site. Expense, convenience, and local politics are obviously important in this choice. One also looks for an area that has a high likelihood of sunshine in June. In the Old World, the Mediterranean Basin, northern Africa, and the Middle East are best. The chances of clear skies in June are better than even for most of the area shown on the North America map, but the real question is what the weather will be like on the actual day of the transit. Observers who can relocate in response to short-term weather forecasts and satellite cloudiness images will have a better chance for clear skies than those at fixed locations. Then, too, the higher the Sun is in the sky during the transit, the better the chance of avoiding clouds (which, due to perspective,

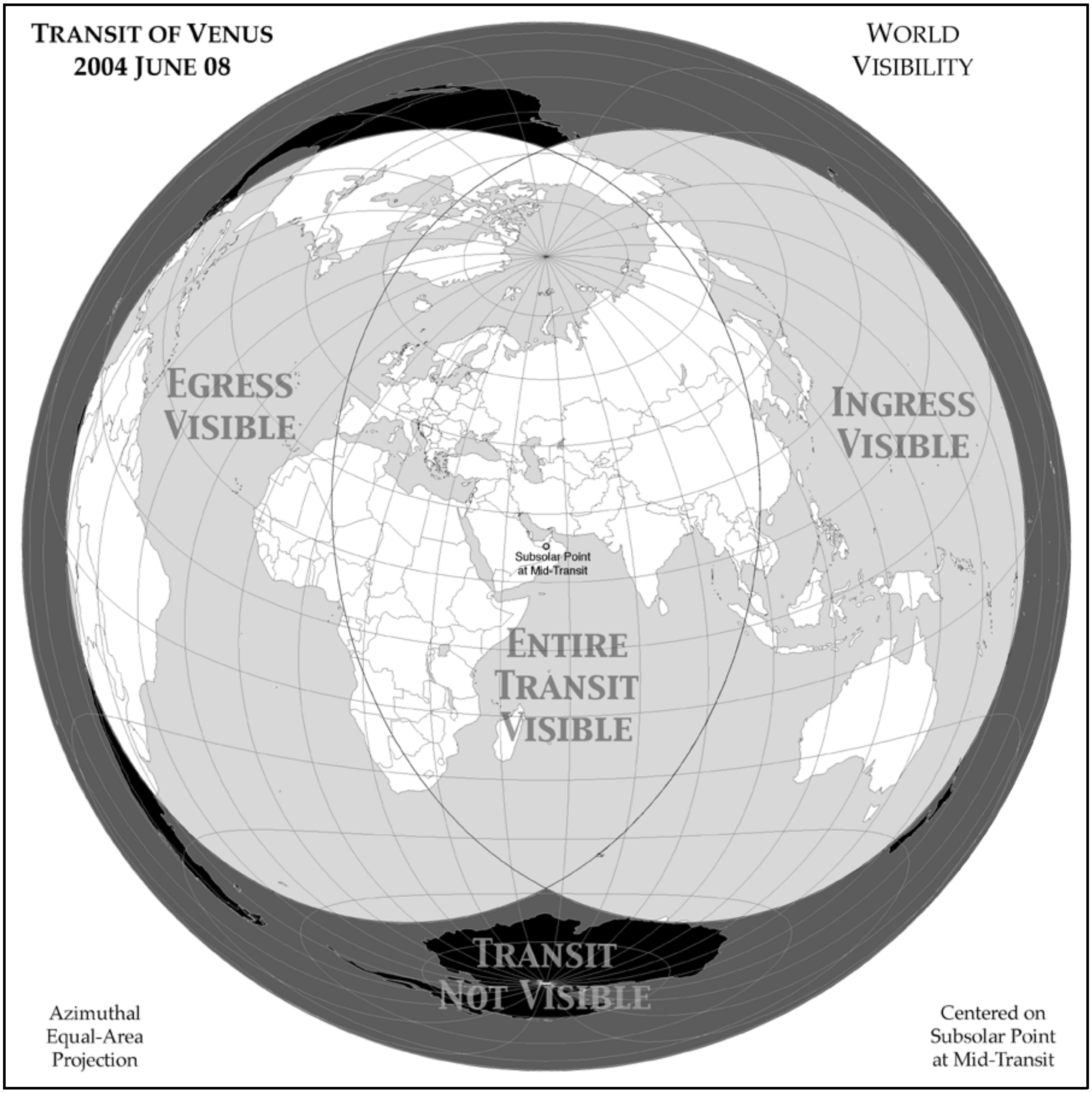


Figure 1. Areas of the world where one can see all, part, or none of the transit of Venus on June 8, 2004. The map is centered on the point where the Sun will be overhead at mid-transit, and the projection shows the areas of the visibility zones in their correct proportions.

tend to bunch near the horizon), and of having better "seeing" (i.e., less atmospheric turbulence due to a shorter path length through our atmosphere).

Transit Phenomena

The chief interest in transits of Venus in the 18th and 19th centuries was timing limb contacts in order to determine the Earth-Sun distance – the astronomical unit (AU). However, even by the time of the 1874/1882 transit pair other methods for finding the scale of the Solar System had become more promising, and by now we know the AU to far greater accuracy than can be determined by transit observations. However, a number of other scientifically significant phenomena are associated with the transits of Venus.

First, near the transit, during the first half of June Venus will be nearer the Sun in our sky than in most other apparitions. At this time, the planet will display a very narrow sunlit crescent, quite likely with its cusps faintly extended beyond 180°, perhaps even forming a complete circle. This phenomenon is caused by scattered light in the planet's atmosphere above its cloudtops, and was the first evidence for an atmosphere of Venus. Observing the cusp extension will be difficult, requiring that either one observe Venus near the horizon in bright evening or morning

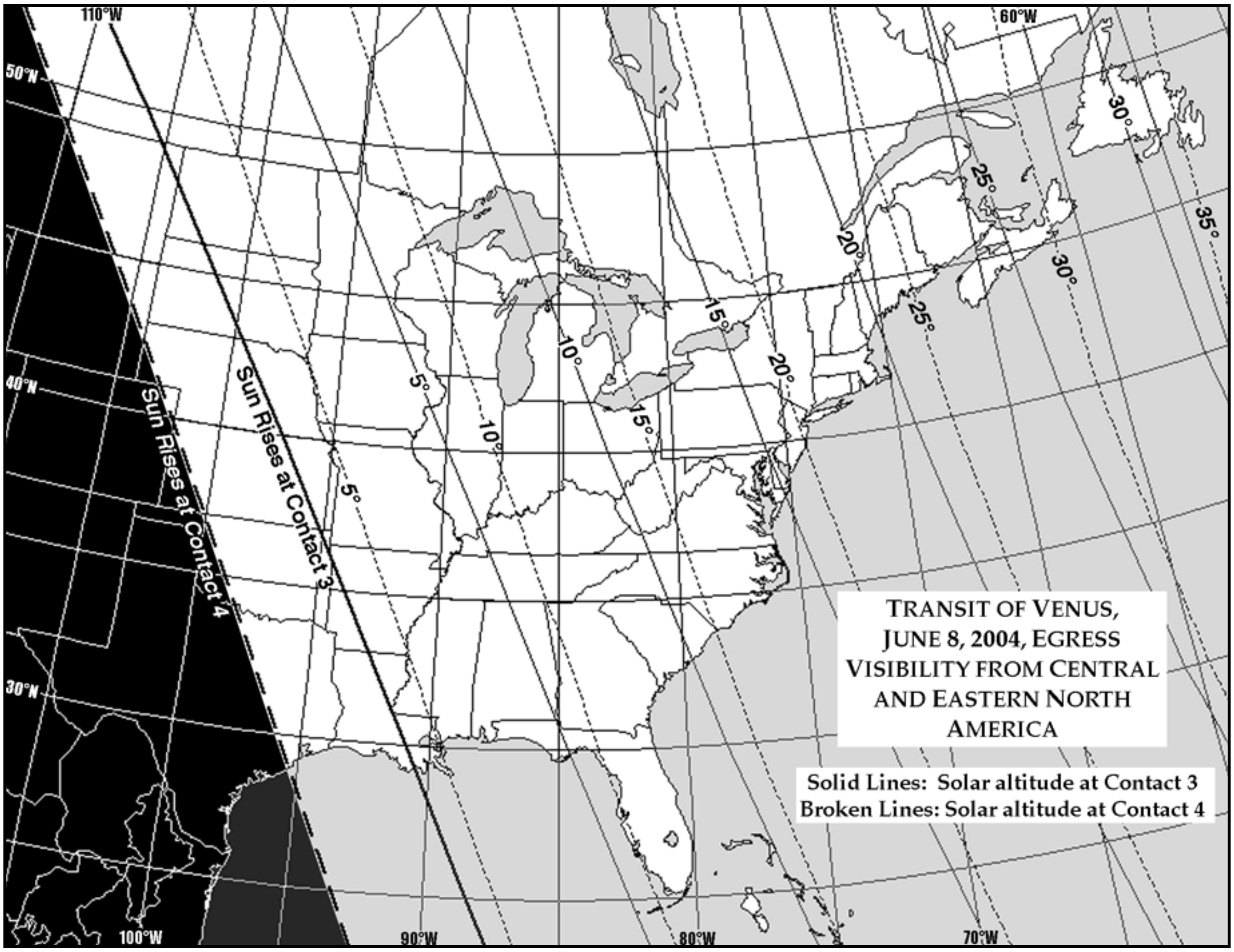


Figure 2. The central and eastern portions of the United States and Canada, showing how high above the horizon the Sun will be at Third Contact (solid lines) and Fourth Contact (broken lines) during the transit of Venus on the morning of June 8, 2004.

twilight, or, while taking *extreme* care to avoid accidentally getting the unfiltered Sun in one's field of view, using tube extensions or sunshades to observe Venus near the Sun in full daylight.

When the transit itself takes place, the beginning of the planet's entry onto the Sun's disk is called *First Contact*, the start of *Ingress* (see *Figure 3*). *Second Contact* takes place when Venus completes Ingress. *Third Contact* occurs when Venus starts to leave the Sun's disk, the beginning of *Egress*, which ends at *Fourth Contact*, when the planet completely leaves the Sun, ending the transit. Venus crosses the Sun's southeast limb during Ingress (First Contact will be at position angle 116°, 26 degrees south of celestial east), and then travels southwestward to the Sun's southwest limb (Fourth Contact will be at position angle 216°, 36 degrees west of celestial south). Ingress and Egress will each take about 20 minutes.

The Universal Times on June 8, 2004 that the four contacts are predicted to occur at are listed in Table 1 for some locations worldwide ("—" means that Venus will be below the place's horizon at the time).

The notorious "black drop" effect occurs near Second and Third Contacts, when the limbs of Venus and the Sun gradually separate (Second Contact) or merge (Third Contact). Thus, the contact timings made by observers even at the same site can differ by tens of seconds. A series of drawings of the black drop is shown in *Figure 4*.

The literature sometimes blames the black-drop effect on Venus's atmosphere. However, the same phenomenon occurs during transits of airless Mercury. Actually, the black drop is simply due to solar limb darkening and to the inevitable blurring of any telescope's image due to diffraction and atmospheric seeing.

The one real phenomenon that is unique to transits of Venus is the "ring of light" or *aureole* that appears on the limb of Venus, silhouetted against the sky during Ingress and Egress. It has also been seen on the

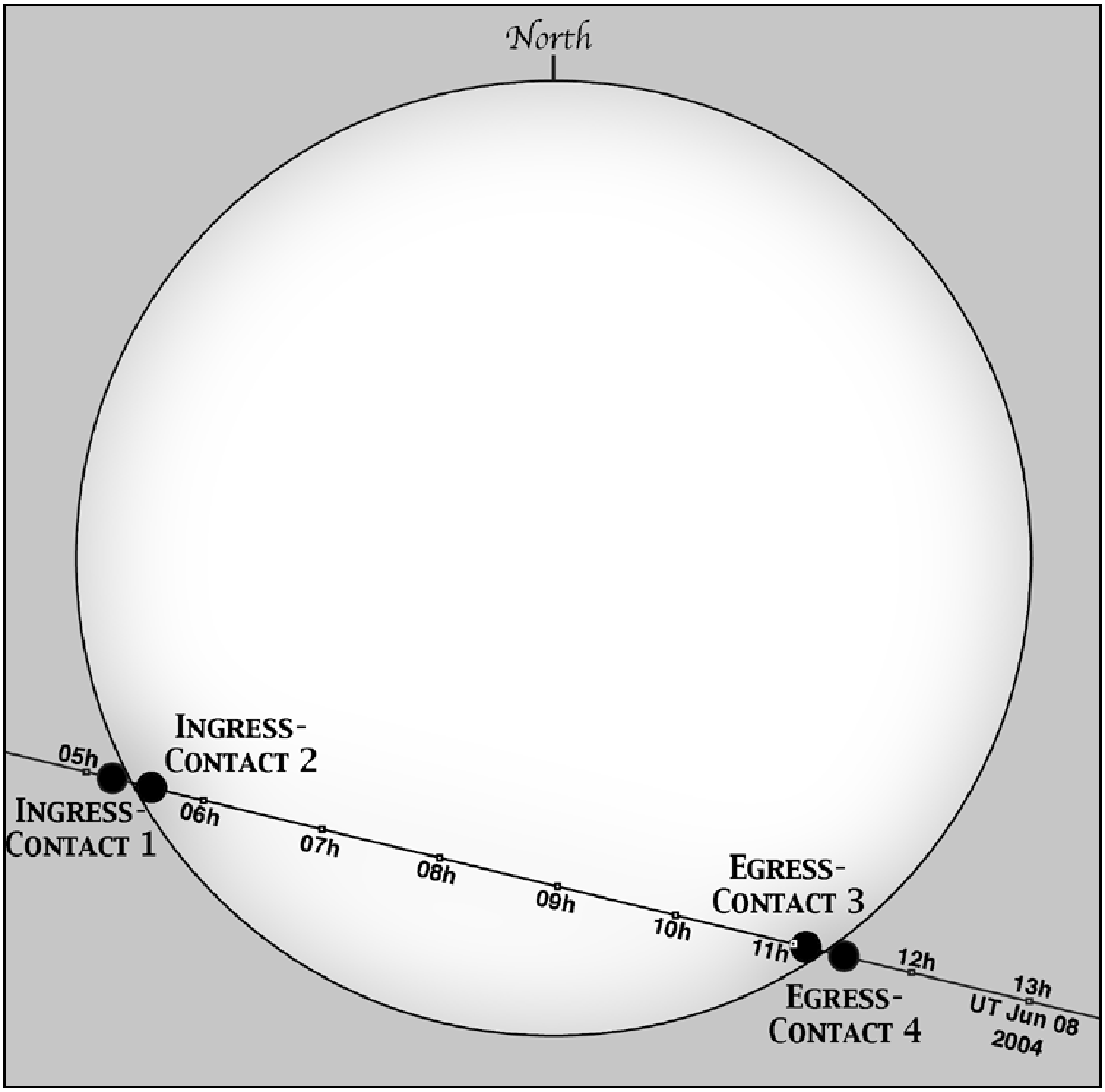


Figure 3. The apparent path of Venus across the Sun's disk on June 8, 2004. The two bodies are drawn to scale, and celestial north is at the top. Besides the four contacts, the path of the planet is shown at 1-hour intervals for a geocentric observer. Depending where on the Earth one is, the apparent position of Venus may differ from the geocentric path by up to one-third its apparent diameter.

Sun's disk, but near its limb, due to the phenomenon of solar limb darkening. If we are lucky enough to have Venus cross a sunspot, probably for the first time in post-telescopic history, we might see the aureole against the spot's umbra. The "ring of light" is caused by refraction of sunlight in Venus's upper atmosphere. It is far brighter than the cusp extension mentioned earlier, but has never been photographed; all we know of it comes from written descriptions and drawings (see *Figure 5*). Thus, obtaining photographs and electronic images of the aureole should be one of the highest priorities for the 2004 transit.

Some historical observers of transits of Venus have reported anomalous phenomena, such as deformations of the planet's limb, areas or points of light within the dark hemisphere of Venus, or a halo of light, much wider than the aureole, around the planet when fully on the disk of the Sun. Such phenomena are almost certainly due to contrast effects and light scattering within our atmosphere, or are intrinsic to one's telescope, eyepiece, filter, or eye itself.

Observing the Transit of Venus

Observing a transit of Venus involves looking at the Sun, so you should take every safety precaution that

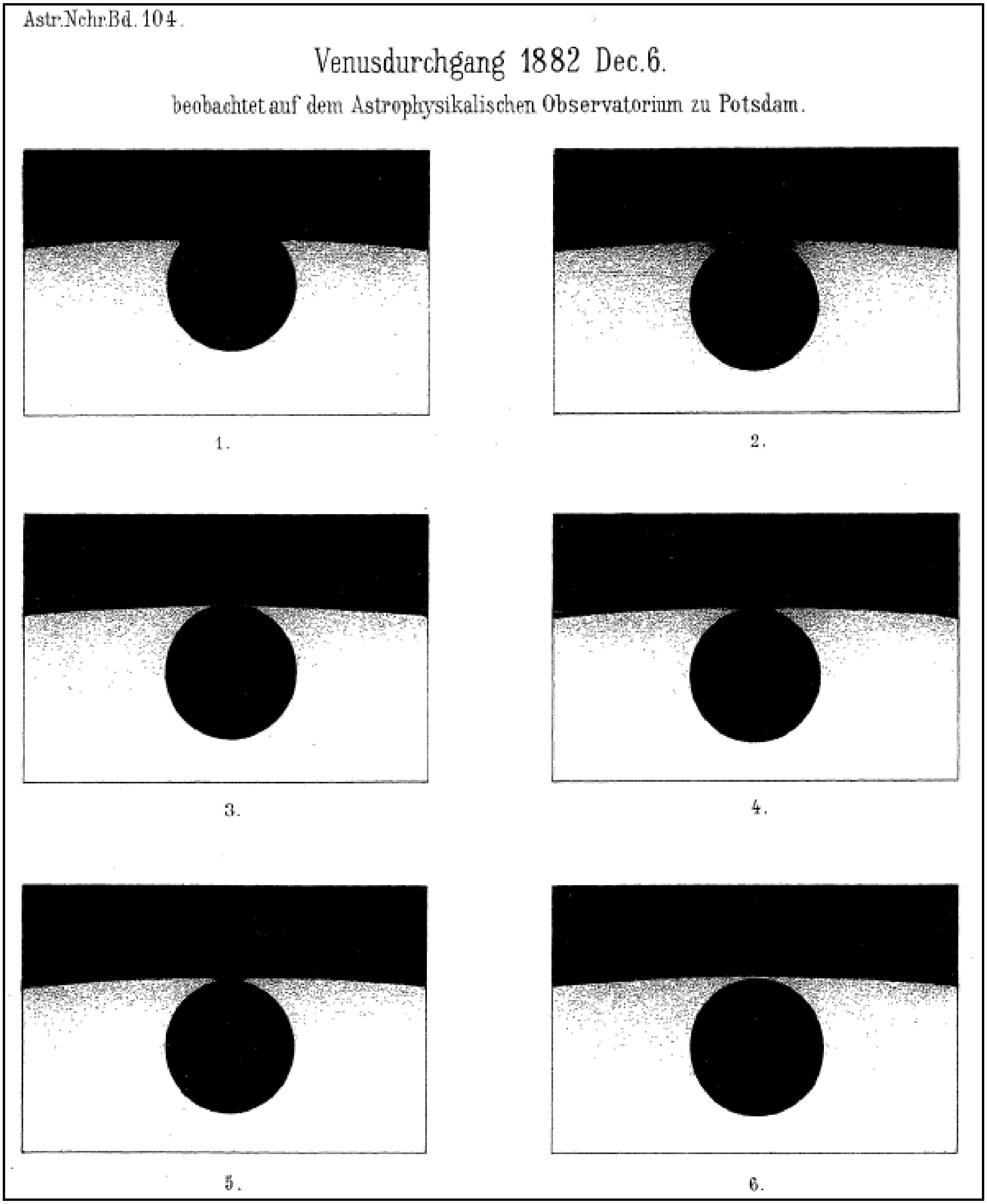


Figure 4. The development and disappearance of the black drop during the Ingress of Venus onto the Sun's disk during the transit of December 6, 1882. Only 3.3 minutes elapsed between the first and last sketch, drawn by Hermann Carl Vogel, using the 29.8-cm (11.7-in) refractor of the Potsdam Astrophysical Observatory, Germany, at 120X with a solar eyepiece. [*Astronomische Nachrichten* 105 (1883), f.p. 258].

you would use for a solar eclipse or sunspot observation when watching or imaging the transit. The two safe methods are either:

1. A full-aperture *safe* solar filter placed securely over the *front* end of one's instrument (be it eye, camera, binoculars, or telescope). Do not look

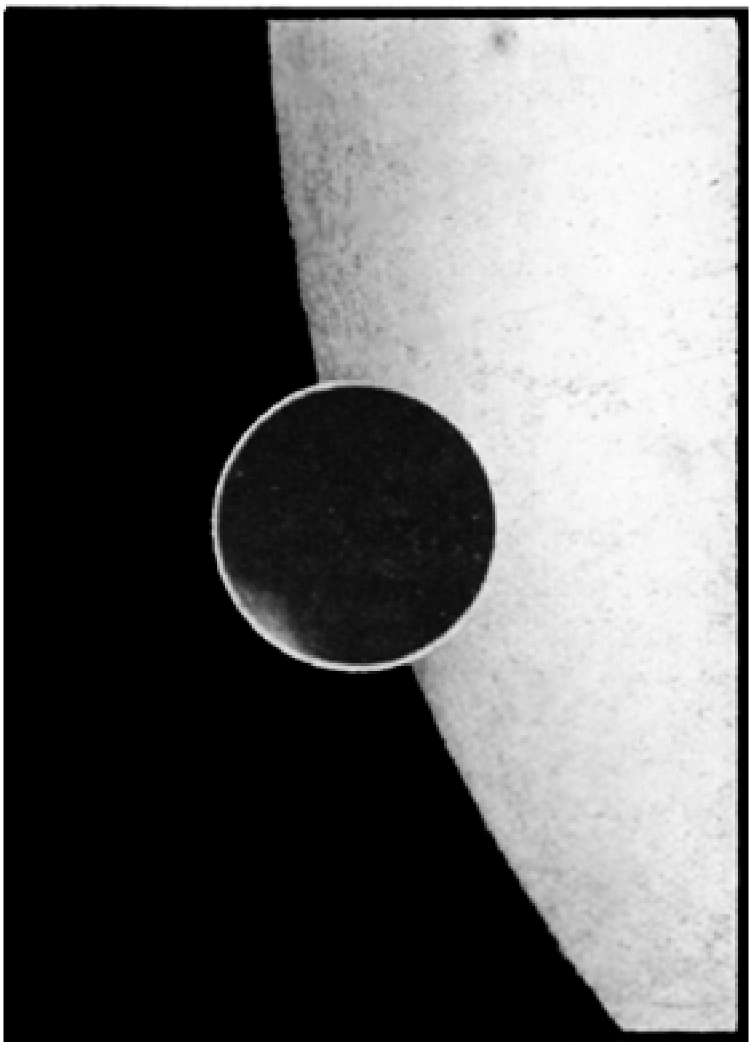


Figure 5. Another view of Ingress during the 1882 transit of Venus, this one showing the "ring of light" around the planet. This phenomenon is visible both against the sky and the outermost portions of the Sun's photosphere, and shows a brightening on the lower left limb of Venus. Drawing by Samuel Pierpont Langley with the 13-inch (33-cm) refractor of Allegheny Observatory, Pennsylvania, stopped down to 6 inches aperture, at 244X with a polarizing solar eyepiece. [*Monthly Notices of the Royal Astronomical Society* 43 (1884), f.p. 73]

through binoculars or a telescope wearing filters over your eyes rather than over the instrument aperture itself and also avoid eyepiece filters which can overheat and shatter without warning. Make sure that there are no scratches or holes in the filter, which if small will reduce contrast, or if large will pose a danger. Small defects can be painted over (e.g., with "whiteout") but large ones will require replacing the filter. Also, when putting a filter over the aperture of your telescope, tilt it a degree or so away from being perpendicular to your optical axis to prevent a "ghost" image caused by the highly reflective rear of the filter.

2. Eyepiece projection. This is normally fairly safe, but as the transit lasts over six hours, either your eyepiece, your secondary mirror, or both, may overheat. At the least, this could degrade the image, but also might destroy your secondary or your eyepiece (or hurt your eye if next to an overheated eyepiece). To avoid this problem, cap your telescope, or turn it away from the Sun, when you are not actually viewing.

There has been some debate whether Venus can be seen against the Sun simply with one's eyes — safely filtered of course. Actually, there are numerous reports from the last transit, in 1882, of many people doing just this. The writer has confirmed this by viewing the sun's image reflected in a mirror with a black spot the same apparent size as Venus during transit (about 1 arc-minute).

However, you may want to use some additional optical equipment, particularly if you make a special trip to see the event.

You can comfortably watch the event with binoculars — if *both* lenses are securely filtered. However, if you want a chance of seeing or recording the black drop or the aureole, you will need a telescope. Here, our most recent observational experience comes from the transits of 1874 and 1882! Most of the telescopes used by the 19th-century expeditions were of 3 to 8 inches aperture, with 5- and 6-inch clock-driven refractors the most popular. Observers also used Newtonian reflectors, particularly if they lived in the visibility zone and observed from home or an existing observatory.

Special Projects

1. Observing Venus off the Photosphere. The possibility of observing Venus's cusp extension during the days before and after the transit has already been described. In addition, on the day of the transit itself, Venus may possibly be seen off the Sun's photosphere (the surface visible in white light) both before First Contact and after Fourth Contact. Actually, with a Hydrogen-alpha filters, the planet might be seen perhaps as much as, say, a half-hour before First Contact or after Fourth Contact, silhouetted against a prominence or the Sun's chromosphere.

2. Visual Timing of Transit Contacts. This was the most popular form of observation during past transits because contact time differences among

Table 1: Contact Predictions for June 8 Transit of Venus

Place	1st Contact	2nd Contact	3rd Contact	4th Contact
Geocentric	05:13.5	05:32.8	11:06.6	11:25.9
Chicago, IL, USA	—	—	11:05.3	11:25.2
Fairbanks, AK, USA	05:13.9	05:33.7	—	—
Houston, TX, USA	—	—	—	11:26.3
New York, NY, USA	—	—	11:05.9	11:25.7
Halifax, NS, Canada	—	—	11:05.7	11:25.4
Mérida, Mexico	—	—	—	11:27.6
São Paulo, Brazil	—	—	11:13.2	11:32.2
Athens, Greece	05:19.6	05:39.4	11:04.3	11:23.4
London, United Kingdom	05:19.9	05:39.6	11:04.1	11:23.5
Paris, France	05:20.0	05:39.8	11:04.3	11:23.6
Berlin, Germany	05:19.7	05:39.4	11:03.5	11:22.8
Moscow, Russia	05:18.8	05:38.3	11:02.1	11:21.4
Cairo, Egypt	05:19.7	05:39.0	11:04.6	11:23.6
Nairobi, Kenya	05:18.6	05:37.5	11:07.2	11:25.9
Pretoria, Republic of South Africa	05:17.4	05:36.3	11:10.0	11:28.6
Tehran, Iran	05:18.5	05:37.6	11:02.8	11:21.8
New Delhi, India	05:16.2	05:35.1	11:01.6	11:20.7
Beijing, People's Republic of China	05:13.2	05:32.3	10:59.4	11:18.9
Manila, Philippines	05:11.1	05:29.9	—	—
Tokyo, Japan	05:11.3	05:30.4	—	—
Alice Springs, Australia	05:08.5	05:27.0	—	---

the widely separated observing stations could be "reduced" to calculate the Earth-Sun distance. Today contact timings no longer serve their original purpose because we know this value from space-probe radio ranging to about 3 meters accuracy! Nonetheless, there are plans to conduct such timings as an educational exercise, by comparing observers' timings to see how closely their results compare with predicted times and with the modern value of the solar parallax. Second and Third Contacts are the best to time, with Second Contact considered as the moment during Ingress when the "filament" between Venus and the Sun's limb breaks; when the two limbs are first clearly separated. Likewise, Third Contact is taken to be the moment when the filament forms again during Egress. These moments should be timed to one-second precision in Universal Time (UT), with the time standard either a shortwave time signal (e.g., WWV) or a GPS signal. One such project is being coordinated by the European Southern Observatory (see their website: http://vt-2004.org).

3. Recording the Appearance of Venus During the Transit. There are several means of recording the appearance of Venus during the transit (or even before or after it — see above), especially for the critical Ingress and Egress phases.

   - Basic Documentation — What will be particularly useful will be records of transit phenomena — visibility off the photosphere, the aureole, the black drop, and any anomalous appearances. Whatever the form of one's observational record, its scientific value depends on adequate documentation. What is needed for *all* forms of observation is: observer's name and postal address (and email address if applicable); latitude and longitude of observing site (to 0°.01 or one arc-minute); description of instrument (eye, or aperture and magnification of telescope or binoculars); description of filter used (or of projection method, when you should give the diameter of the projected disk); atmospheric transparency (on a 0-5 scale, with 5 best and 0 worst); seeing, on a scale from 0 (worst) to 10 (perfect); and Universal Time of each remark, drawing, or image, accurate to one second if possible.

- Visual Observation — Visual observations can take the form of remarks (including contact timings) or drawings. Refer to celestial directions using either the words “north, “south,” “preceding” (the direction of drift with one’s drive turned off), or “following” (the opposite of preceding); or as celestial position angle (measured from 0° for celestial north counterclockwise through celestial east, south, and west to 360°). In referring to directions, correct for the reversal that occurs if you used a right-angle viewer for direct visual observation. With projection the Sun’s disk will normally be reversed, but will be correct with the use of a right-angle viewer. The orientation of drawings should be clearly indicated.

- Still Photography — Film or digital still photographs taken with a suitably filtered telephoto lens, say of 200-mm focal length or greater, should show Venus while in transit. The camera can be mounted on an ordinary tripod because the exposure will be very short. However, you will need a telescope to capture the contacts, the black drop, or the aureole, along with a suitable full-aperture filter or with projection. The duration of the exposure can be judged at the time of the transit with a digital camera, but for a film camera, the exposure should be found previously by photographing the Sun with the same optical arrangement. Remember that the delicate aureole will probably require a longer exposure than for the Sun’s photosphere.

  Even with a safe filter, the Sun’s image will be so bright that you can use a higher-quality medium-speed film or digital camera sensitivity setting (e.g., ISO 50-100). The exposure may still be so short that a clock drive will not be necessary to prevent blurring. Still, a clock-driven equatorial mounting will be a great asset in tracking Venus during the six hour-long transit, although the planet’s motion will make it necessary to make occasional adjustments.

- CCD Imaging — Recording the transit, particularly Ingress and Egress, with a CCD camera will allow photometry of the aureole and the black drop. This is because you can use flat frames and dark frames to correct the raw image for background noise and variations of sensitivity among the camera’s photosites. For those traveling to view the transit, a disadvantage of a CCD camera is that it must be connected to a computer. Another limitation is that most CCD cameras take monochrome (grey-scale) images, and for color images one must take three images in succession through different color filters.

- Video — The disadvantage of taking still photographs or images is that there always is an interval between successive images, which may be a minute or more when making colored CCD images. Thus you may miss rapidly changing events during Ingress or Egress. Video allows continuous coverage at a typical frame rate of 30 frames per second. Admittedly, analog-video frames are “noisy,” and several must be “stacked” to obtain an acceptable image. Results are definitely better with a digital video (dv) camera, or by connecting an analog-format camera to a digital-format recorder.

- Webcams — Webcams provide a stream of digital images, thus also supplying continuous coverage. Webcams were used to obtain excellent images of the May, 2003, transit of Mercury, so this medium has great potential for the 2004 transit of Venus. As with CCD cameras, Webcams need to be attached to computers.

- Stacking Images — This process uses a computer to register and combine anywhere from a few to several thousand individual digital images, with either manual or automatic selection of the best images to use. The stacking process is done anytime after the images themselves are acquired. It is possible to stack digital still-camera or CCD images, but stacking is most effective when using the many images provided by video cameras or webcams. The final result is typically far better in resolution and contrast than even the best individual frames. However, the gain in spatial resolution is had at the expense of time resolution because one necessarily stacks images taken over a range of time. As Venus will be moving in relation to the Sun by about one arc-second every 20 seconds, it would be wise to stack no more than a few seconds’ worth of images at a time.

General Comments on Photography and Imaging

Small-scale views that show Venus’s position in relation to the Sun’s limb or to sunspots or other solar features will provide an interesting and visually striking record of the transit. Multiple exposures, perhaps combined with computer image processing, will give a record of the planet’s track across the face of the Sun.

Larger-scale views of Venus in relation to the Sun’s limb, taken simultaneous at widely separated stations, can be combined to give a three-dimensional view of the transit.

For transit photographs or images to be of scientific value in recording the aureole and the black drop, a large image scale is necessary, so that Venus covers a significant portion of the frame. With moderate-size telescopes this will require either afocal imaging at high magnification or imaging directly on the film or chip with eyepiece projection or a Barlow lens.

Computer processing can be done with all forms of imaging. Film photographs can be scanned and converted to digital images, and analog videos converted to digital with an analog-to-video "frame grabber." Digital video, digital still-camera, CCD, and webcam images are digital to start with. Common enhancement techniques include contrast stretching and sharpening. Computer enhancement should be done cautiously because it can create "artifacts," such as a false light ring around the planet, or a bright spot on its dark hemisphere. Certainly, the observer should retain copies of all digital images in their unenhanced ("raw") form, and should document all enhanced images with comments on the types of enhancements used.

Besides the basic and specialized documentation already described, all still photographs and images, as well as video or webcam images, should be documented with the Universal Time of exposure, exposure time (shutter setting), and effective focal length of the optical system. Naturally, it is important to note if the photographs or images are reversed.

Submitting Observations

If you observe the 2004 Venus transit, your efforts will have permanent value only if they are communicated. The ALPO welcomes all forms of observation — written notes, drawings, photographs, or electronic images – which, along with their documentation, should be sent to:

John Westfall
ALPO Mercury/Venus Transit Coordinator
P.O. Box 2447
Antioch, CA 94531-2447
(Email: johnwestfall@comcast.net)

Sources

Several recent books on transits are:

Eli Maor. *June 8, 2004: Venus in Transit*. (2000)

Michael Maunder and Patrick Moore. *Transit: When Planets Cross The Sun*. (1999)

David Sellers. *The Transit of Venus*. (2001)

William Sheehan and John Westfall. *The Transits of Venus*. (2004)

There are many websites related to the coming transit. A small selection of them follows; most have links to other sites.

Transit Circumstances. —

http://www.chocky.demon.co.uk/oas/venus.html

http://aa.usno.navy.mil/data/docs/Venus.2004.pdf

http://sunearth.gsfc.nasa.gov/eclipse/transit/venus0412.html

http://www.lunar-occultations.com/iota/2004venus/2004venus.htm

http://home.cc.umanitoba.ca/~jander/transit/transit/transitmenu.htm

Lists of Web Links. —

http://www.transitofvenus.org/links.htm

http://www.venustransit.at

Observing Projects. —

http://vt-2004.org

http://didaktik.physik.uni-essen.de/~backhaus/VenusProject.htm

http://www.astronomie.info/projectvenus

http://www.transitofvenus.co.za

ALPO Feature — Observations of Venus During the 1999-2000 Western (Morning) Apparition

By Julius L. Benton, Jr., ALPO Venus Section coordinator
Peer Review by John Westfall

Abstract

This report summarizes the results of an analysis of photo-visual observations submitted to the ALPO Venus Section by observers in Germany, Italy, and the United States throughout the 1999-2000 Western (Morning) Apparition. Data resources and types of telescopes (plus accessories) employed in making those observations are discussed, and comparative studies deal with observers, instruments, and visual and photographic data. The report includes illustrations and a statistical investigation of the categories of features in the atmosphere of Venus, including cusps, cusp-caps, and cusp-bands, seen or suspected at visual wavelengths, both in integrated light and with color filters. Terminator irregularities and the apparent phase are discussed, as well as coverage based on results from continued monitoring of the dark hemisphere of Venus for the Ashen Light.

Introduction

A collection of 143 drawings, photographs, and CCD images of Venus was contributed to the ALPO Venus Section during the 1999-2000 Western (Morning) Apparition. Geocentric phenomena in Universal Time (UT) for the 1999-2000 apparition are given in *Table 1*, while *Figure 1* illustrates the distribution of observations by month during the observing season.

Observational coverage of Venus throughout the 1999-2000 Western (Morning) Apparition was quite good, with several individuals initiating their observing programs right after Inferior Conjunction (which occurred on 1999 August 20) and continuing up to about three weeks prior to Superior Conjunction, which occurred on 2000 June 11. Consistent coverage of Venus throughout any apparition is extremely important, and it has been a welcome recurring practice by Venus observers in recent years. The "observing season," or observation period, ranged from 1999 August 20 to 2000 May 20, with almost three-fourths of the observations (73.4%) submitted for the period from 1999 September through December. During this span, Venus passed through greatest brilliancy, dichotomy, and maximum elongation from the Sun.

Ten (10) individuals contributed visual and photographic observations of Venus during the 1999-2000 Western (Morning) Apparition, and *Table 2* gives their observing sites, number of observations, and instruments used.

Table 1: Geocentric Phenomena for the 1999-2000 Western (Morning) Apparition of Venus

Inferior Conjunction	1999	Aug 20^d 12^h UT
Initial Observation		Aug 20 18
Dichotomy (predicted)		Oct 30 00^h 43^m 12^s UT
Greatest Elongation West (46.0°)		Oct 31 00
Greatest Brilliancy (m_v = -4.6)		Sep 26 15
Final Observation	2000	May 20 11
Superior Conjunction		Jun 11 11

Apparent Diameter (observed range):
57".9 (1999 Aug 20) - 9".7 (2000 May 20)
*Phase Coefficient, **k** (observed range):*
0.010 (1999 Aug 20) - 0.994 (2000 May 20)

Figure 2 shows the distribution of observers and contributed observations by nation of origin for the 1999-2000 Western (Morning) Apparition. Four-fifths of the individuals participating in ALPO Venus observing programs (80%) resided in the United States and accounted for a little less than three-fourths (72%) of the total observations received. Thus, during 1999-2000, as in recent previous apparitions, international participation in our programs continued, thus supporting our efforts to improve global cooperation among lunar and planetary observers.

The types of telescopes employed to perform observations of Venus in 1999-2000 are shown graphically in *Figure 3*. It can be seen that the majority (91.6%) of all observations were made with telescopes ≥15.2 cm. (6.0 in.) in aperture. Classical designs (e.g., refractors and Newtonians) were used in slightly more than half (59.4%) of the observations, while the remaining percentage (40.6%) of Venus reports was generated using Schmidt-Cassegrains or Maksutovs. During 1999-2000, almost all of the observations (98.1%) were gathered in twilight sky conditions, with the remaining percentage occurring under dark skies. A few observers followed Venus after sunrise into

Table 2: ALPO Venus Observers During the 1999-2000 Western (Morning) Apparition

Observer and Observing Site	No. of Observations	Telescope(s) Used*
Benton, Julius L., Jr.; Wilmington Island, GA	38	15.2-cm (6.0-in) REF
Boisclair, Norman J.; South Glens Falls, NY	11	8.9-cm (3.5-in) MAK
	1	50.8-cm (20.0-in) NEW
Bradbury, Mark; Indianapolis, IN	1	8.0-cm (3.1-in) REF
Crandall, Ed; Winston-Salem, NC	25	25.4-cm (10.0-in) NEW
Cudnik, Brian; Weimar, TX	5	35.6-cm (14.0-in) SCT
Frassati, Mario; Crescentino, Italy	11	20.3-cm (8.0-in) SCT
Haas, Walter H.; Las Cruces, NM	19	31.8-cm (12.5-in) NEW
Melillo, Frank J.; Holtsville, NY	2	20.3-cm (8.0-in) SCT
Niechoy, Detlev; Göttingen, Germany	29	20.3-cm (8.0-in) SCT
Parker, Donald C.; Coral Gables, FL	1	40.6-cm (16.0-in) NEW
Total Number of Observers	10	
Total Number of Observations	143	
MAK = Maksutov, NEW = Newtonian, REF = Refractor, SCT = Schmidt-Cassegrain		

broad daylight in an attempt to minimize the effects of overwhelming glare associated with the planet. Also, viewing Venus higher in the sky helped reduce the effects of atmospheric dispersion and image distortion near the horizon, at least until solar heating by late morning caused image deterioration.

The ALPO Venus Section Coordinator expresses his sincere thanks to the 10 individuals mentioned in this report for their perseverance during early morning hours to study the planet and submit observations during 1999-2000. Readers interested in finding our more about the ALPO Venus programs are urged to join the ALPO and become regular contributors to our observational pursuits in forthcoming apparitions.

Observations of Venusian Atmospheric Details

The customary methods for carrying out visual studies of the vague and elusive "markings" in the atmosphere of Venus are outlined in detail in *The Venus Handbook*. Readers who have access to earlier issues of this Journal may also find it of benefit to consult to previous apparition reports for a historical perspective on ALPO studies of Venus.

Most of the observations utilized in this analysis were made at visual wavelengths, although Melillo contributed two images of Venus taken in ultraviolet (UV) light. Several examples of these observations in the form of drawings, photographs, and images appear in this report to assist the reader in interpreting the phenomena reported in the atmosphere of Venus in 1999-2000.

The photo-visual data for the 1999-2000 apparition represented all of the usual categories of dusky and bright markings in the atmosphere of Venus, with the exception of radial dusky features, as described in the literature referenced previously in the report. *Figure 4* illustrates the frequency in which the specific forms of markings were seen or suspected. Most observations referred to more than just one category of marking or feature, and thus totals exceeding 100% are expected. Readers should realize that there is an inherent subjectivity that exists when visual observers attempt to try to describe the highly elusive atmospheric markings of Venus, and this unavoidably affected the data in *Figure 4*. Yet, it is believed that conclusions deduced from these data are at least reasonable.

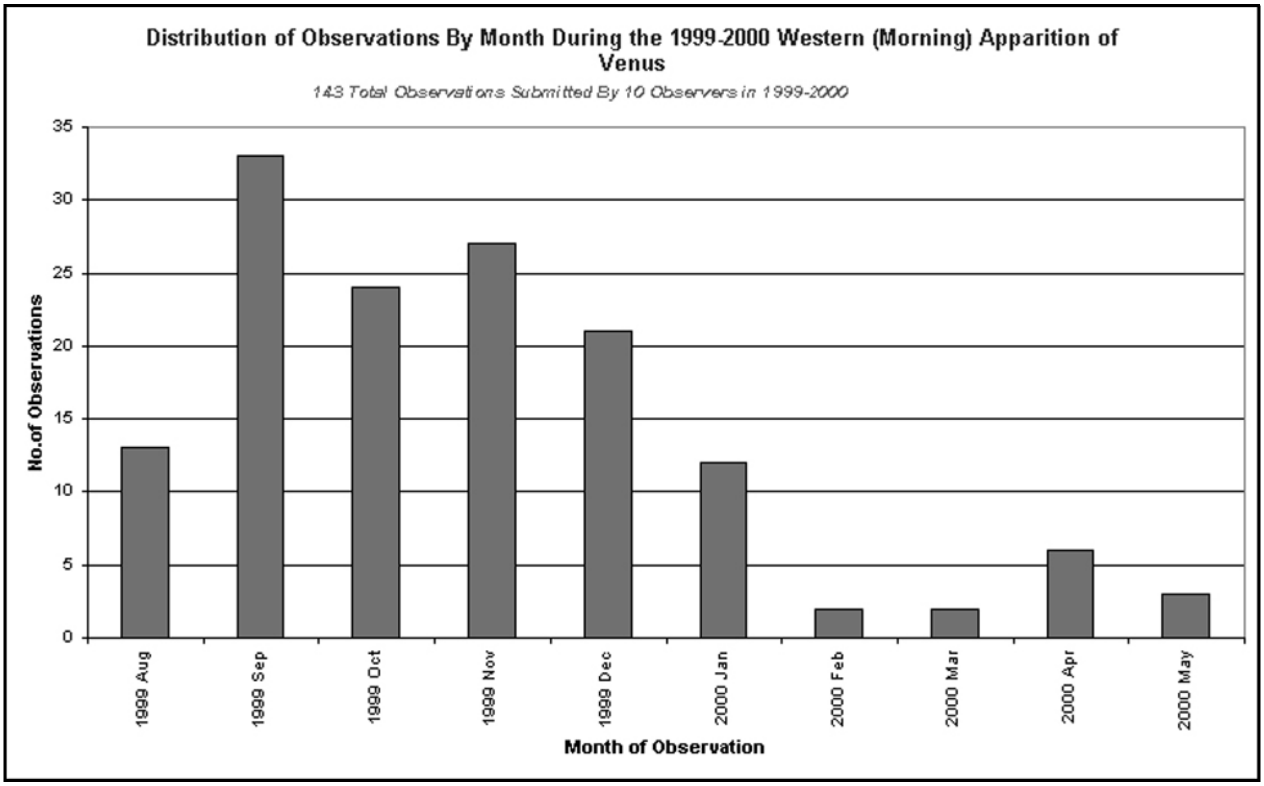


Figure 1. Number of observations by month, 1999-2000 Western (Morning) Apparition of Venus.

The dusky markings in the atmosphere of Venus are notoriously hard to detect visually, a characteristic of the planet that is mostly independent of the experience of the observer. Using color filters and variable-density polarizers helps emphasize subtle cloud phenomena on Venus at visual wavelengths, but the ALPO Venus Section strongly encourages observers to attempt regular UV photography. The morphology of features revealed at UV wavelengths is typically different from what is seen in visual regions of the spectrum, particularly radial dusky patterns.

Figure 4 shows that about a third (35.4%) of the observations of Venus in 1999-2000 referred to a

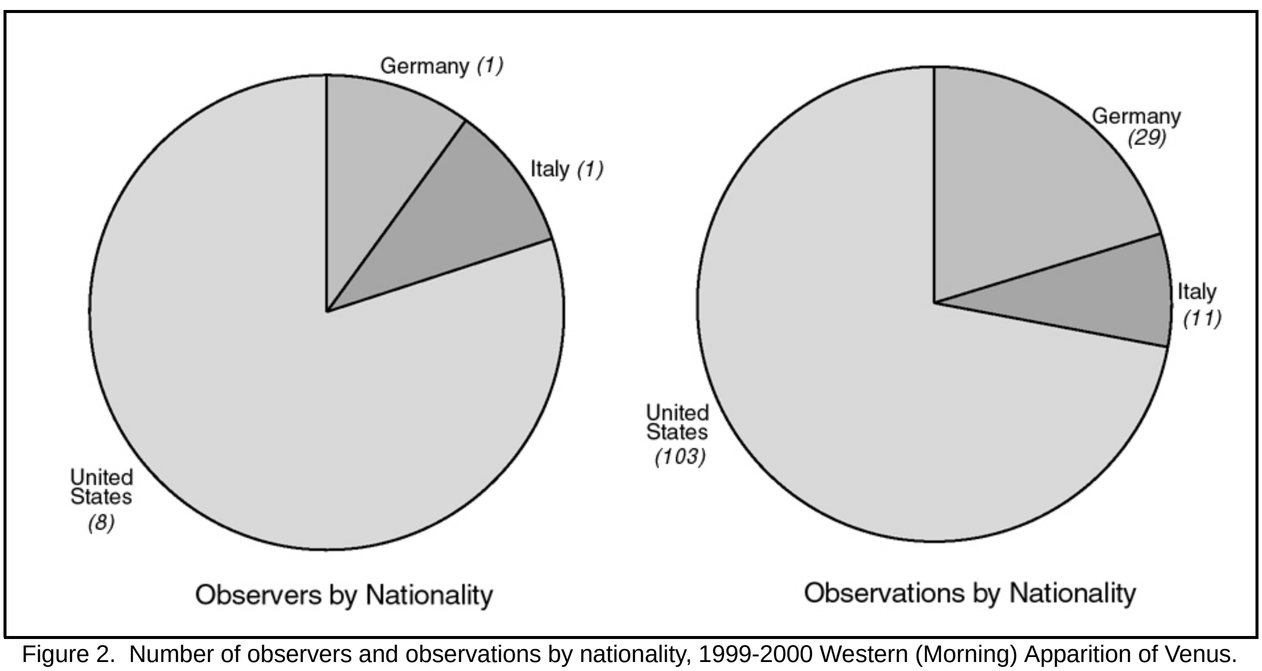


Figure 2. Number of observers and observations by nationality, 1999-2000 Western (Morning) Apparition of Venus.

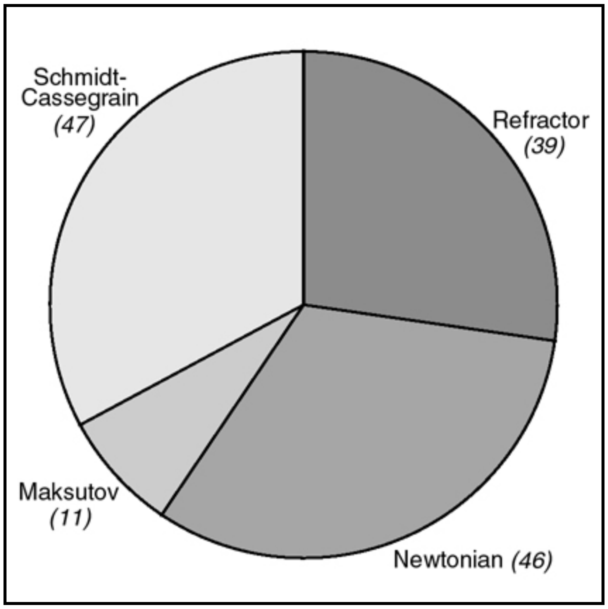


Figure 3. Number of observations by optical design of telescope, 1999-2000 Western (Morning) Apparition of Venus.

brilliant disc completely devoid of markings. When dusky features were seen or suspected, most fell in the categories of "Amorphous Dusky Markings" (53.1%), "Irregular Dusky Markings" (16.8%), and "Banded Dusky Markings" (14.2%). There were no sightings of "Radial Dusky Markings" during the 1999-2000 Western (Morning) Apparition.

Terminator shading was apparent during much of the 1999-2000 observing season, reported in 64.8% of the observations, as shown in *Figure 4*. The terminator shading usually extended from one cusp region to the other, and the shading seemed to lighten (i.e., take on a higher intensity) as one progressed from the region of the terminator toward the bright limb of the planet. This gradual variance in brightness ended in the Bright Limb Band in most accounts. No photographs in 1999-2000 showed any hint of terminator shading, but it is apparent in Melillo's two UV images taken in 1999 November and December.

The mean relative intensity for all of the dusky features on Venus in 1999-2000 ranged from 8.5 to 8.8. The ALPO Scale of Conspicuousness (which runs sequentially from 0.0 for "definitely not seen" up to 10.0 for "certainly seen") was also used regularly during 1999-2000. On this scale, the dusky markings in *Figure 4* had a mean conspicuousness of ~3.0 during the apparition, which suggests that these features fell within the range from very indistinct impressions to fairly good indications of their actual presence on Venus.

Figure 4 also shows that "Bright Spots or Regions," exclusive of the cusp areas, were seen or suspected in

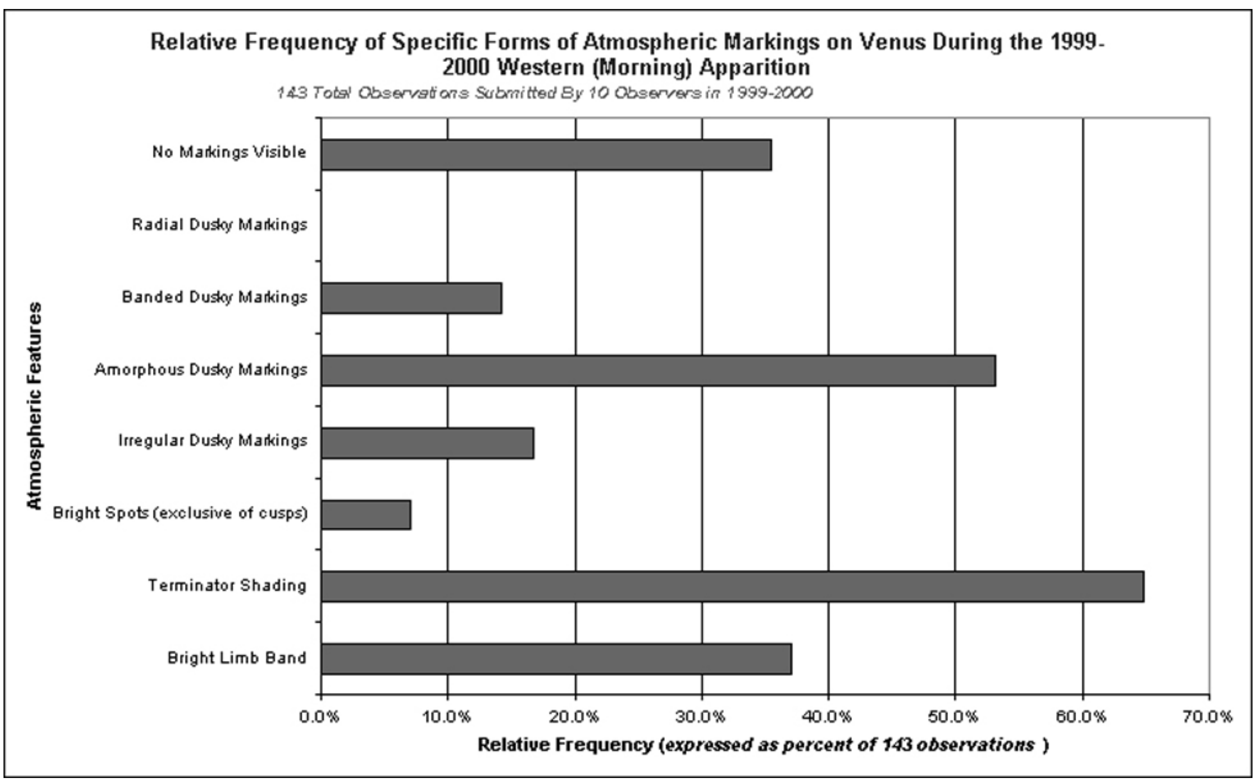


Figure 4. Relative frequencies of forms of atmospheric markings, 1999-2000 Western (Morning) Apparition of Venus.

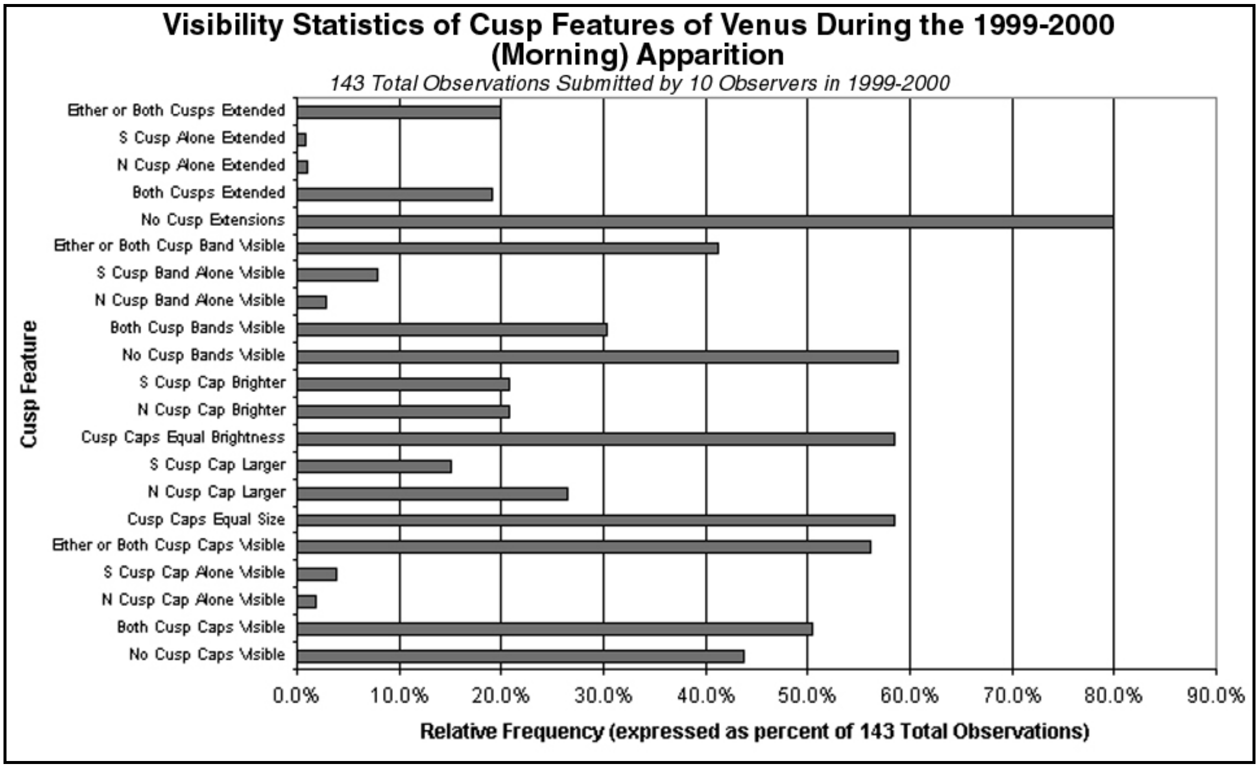


Figure 5. Visibility statistics of cusp features, 1999-2000 Western (Morning) Apparition of Venus.

only 7.1% of the submitted observations. It is standard practice for observers to call attention to such bright areas by sketching in dotted lines around such features in drawings made at visual wavelengths.

Observers regularly used color filter techniques during the 1999-2000 Western (Morning) Apparition, and when results were compared with studies in Integrated Light, it was clear that color filters and variable-density polarizers helped improve the visibility of elusive atmospheric phenomena on Venus.

The Bright Limb Band

Figure 4 shows that 37.1% of the submitted observations in 1999-2000 referred to a “Bright Limb Band” on Venus’ illuminated hemisphere. When the Bright Limb Band was reported, it appeared as a continuous, brilliant arc extending from cusp to cusp 61.5% of the time, and interrupted or only partially visible along the limb of Venus in 38.5% of the positive reports. The mean numerical intensity of the Bright Limb Band was 9.8, becoming more obvious when color filters or variable-density polarizers were employed. Despite the dazzling brilliance of this feature to visual observers, it was not readily apparent in any photographs or images of Venus submitted in 1999-2000.

Terminator Irregularities

The terminator is the geometric curve that divides the sunlit and dark hemispheres of Venus. Observers described an irregular or asymmetric terminator in only 13.3% of the observations in 1999-2000. Amorphous, banded, and irregular dusky atmospheric markings appeared to blend with the shading along the terminator, possibly contributing to reported deformities. Filter techniques enhanced the visibility of terminator irregularities and dusky atmospheric features closely associated with it during the 1999-2000 Western (Morning) Apparition. Because of irradiation, bright features adjacent to the terminator may occasionally look like bulges, and dark features may look like dusky hollows.

Cusps, Cusp-Caps, and Cusp-Bands

In general, when the *phase coefficient* (the fraction of the disc that is illuminated), **k**, lies between 0.1 and 0.8, features on Venus having the most contrast and prominence are repeatedly sighted at or near the planet's cusps. These cusp-caps are sometimes bordered by what are described as dark, usually diffuse, cusp-bands. *Figure 5* shows the visibility statistics for Venusian cusp features in 1999-2000.

When the northern and southern cusp-caps of Venus were observed in 1999-2000, *Figure 5* illustrates that these features were equal in size 58.5% of the time

Note: Unless otherwise indicated, the drawings and CCD images that follow are oriented with celestial south at the top and celestial west at the left, which is the normal inverted view when observing objects near the meridian with an astronomical telescope in the Earth's Northern Hemisphere. Seeing was reported in, or has been converted to, the standard ALPO scale, ranging from 0.0 for the worst possible condition to 10.0 for perfect seeing. Transparency is on the ALPO Scale, ranging from 0 for worst to 5 for perfect.

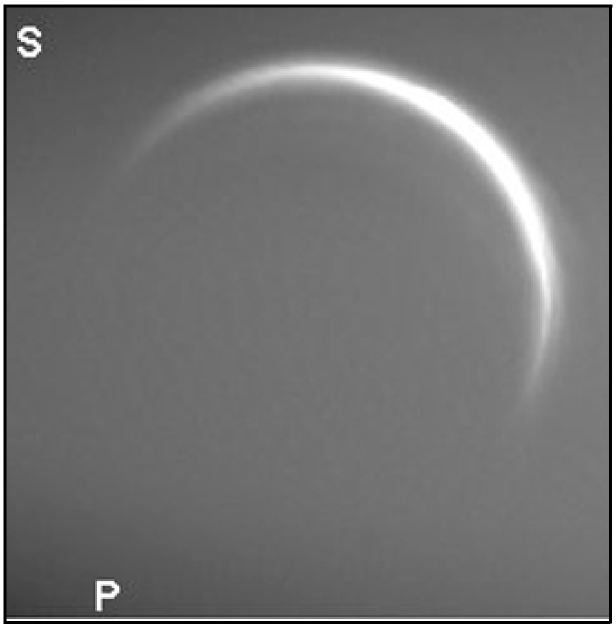


Figure 6. 1999 Aug 24, 18h17m UT. Donald C. Parker. 40.6-cm (16.0-in.) NEW, f/6; used with eyepiece projection at f/9.8;not flat/dark-corrected. Corion NR400 IR Filter, Lynxx PC CCD Camera. Seeing 2-3, Transparency 4.0. Phase (k) = 0.018, Diameter = 57".4. ("P" indicates "preceeding", or celestial west.)

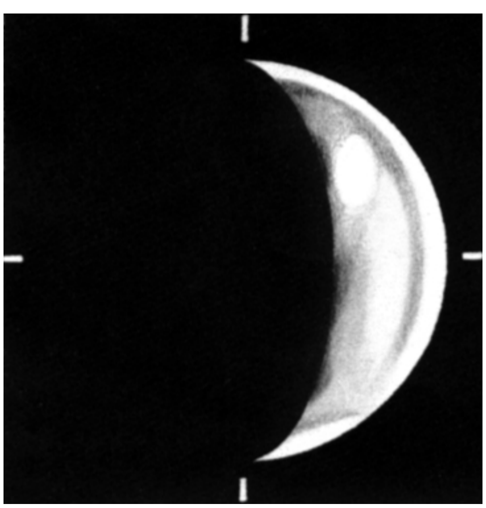


Figure 7. 1999 Sep 29, 05h15m UT. Mario Frassati. 20.3-cm (8.0-in.) SCT, 250X, W80A (blue) Filter. Seeing 5.0 (interpolated). Phase (k) = 0.297, Diameter = 36".5. Phase estimated as 0.28.

and equal in brightness in 58.5% of the observations. The northern cusp-cap was considered larger 26.4% of the time and brighter in 20.8% of the observations, while the southern cusp-cap was larger in 15.1% of the observations and brighter 20.8% of the time. Neither cusp-cap was visible in 43.8% of the reports. The mean relative intensity of the cusp-caps was about 9.9 during the 1999-2000 apparition. Dusky cusp-bands bordering the bright cusp-caps were not reported in 58.8% of the observations when cusp-caps were visible, and the cusp-bands displayed a mean relative intensity of about 7.0 (see *Figure 5*).

Cusp Extensions

As can be noticed by referring to *Figure 5*, there were no cusp extensions reported beyond the 180° expected from simple geometry in 80.0% of the observations (in integrated light and with color filters). Early in the apparition, as Venus progressed through its crescentic phases following inferior conjunction in 1999-2000, several observers recorded cusp extensions that ranged from 2° to 40°. In 1999 August (just after inferior conjunction), a few observers were convinced that the cusps joined along the planet's unilluminated limb, forming a beautiful halo encircling the dark hemisphere of Venus. Reported cusp extensions were shown on drawings, with their appearance enhanced by color filters and polarizers, but none were photographed or imaged successfully. Experience has shown that cusp extensions are very difficult to document on film due to the fact that the sunlit regions of Venus are so much brighter than the faint extensions. Observers are encouraged to try their hand at recording extremely faint cusp extensions using CCD's and/or video cameras in future apparitions.

Estimates of Dichotomy

A discrepancy between the predicted and the observed dates of dichotomy (half-phase), known as the "Schröter Effect" on Venus, was not reported by observers during the 1999-2000 Western (Morning) Apparition (i.e., no observers submitted estimates during the apparition). The predicted half-phase occurs when $\boldsymbol{k}$ = 0.500, and the phase angle, $\boldsymbol{i}$, between the Sun and the Earth as seen from Venus equals 90°.

Dark Hemisphere Phenomena and Ashen Light Observations

The Ashen Light, first reported by G. Riccioli in 1643, refers to an extremely elusive, faint illumination of Venus' dark hemisphere. Although it does not have the same origin, the Ashen Light resembles Earthshine on the dark portion of the Moon. Most observers agree that Venus must be viewed against a com-

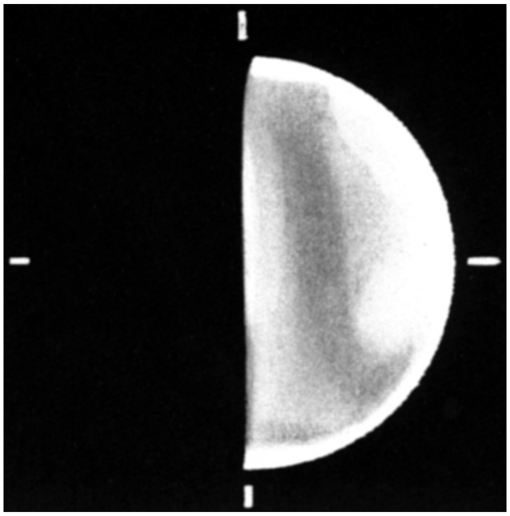


Figure 8. 1999 Nov 09, 06h00m UT. Mario Frassati. 20.3-cm (8.0-in.) SCT, 160X, W80A (blue) Filter. Seeing 5.0 (interpolated). Phase (k) = 0.552, Diameter = 21".9. Phase estimated as 0.51-0.52.

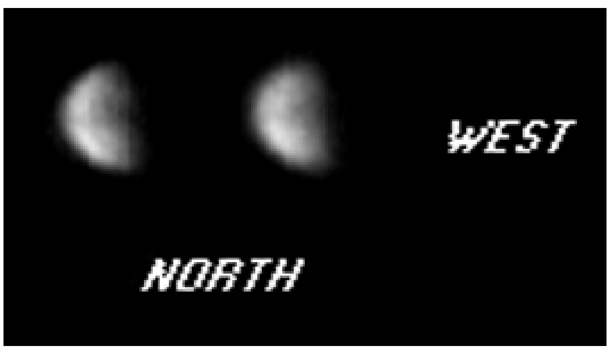


Figure 9. 1999 Nov 28, 14h10m-14h20m UT. Frank J. Melillo. 20.3-cm (8.0-in.) SCT, Schott UG-1 UV Filter w/ IR blocker, Starlight Xpress MX-5 CCD Camera. Seeing 7.0. Phase (k) = 0.638, Diameter = 18".5. Note orientation; image is reversed.

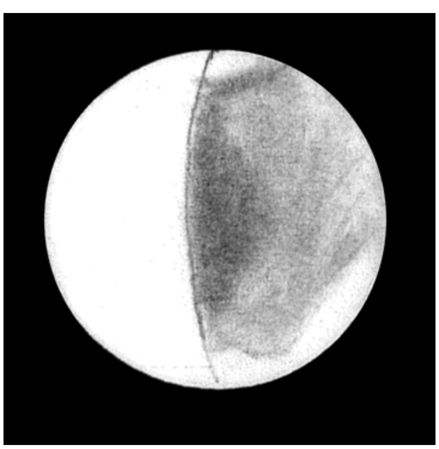


Figure 10. 1999 Dec 01, 12h42m-13h12m UT. Ed Crandall. 25.4-cm (10.0-in.) NEW, 110–177X, W47 (dark blue) and W23A (light red) Filters. Seeing 6.0. Phase (k) = 0.650, Diameter = 18".0. (Dark hemisphere left blank.)

pletely dark sky for the Ashen Light to be seen, but such circumstances occur only when the planet is very low in the sky where adverse terrestrial atmospheric conditions contribute to poor seeing. Also, substantial glare in contrast with the surrounding dark sky influences such observations. Even so, the ALPO Venus Section continues to hear from observers who say they have seen the Ashen Light when Venus was seen against a twilight sky.

During 1999-2000, there were no instances (100% of the observations) when the Ashen Light was seen or suspected in Integrated Light, color filters, or variable-density polarizers. There were a few instances during the 1999-2000 Western (Morning) Apparition (8.9%) when observers described the dark hemisphere of Venus looking *darker* than the background sky, this phenomenon is almost surely an effect of contrast.

Conclusions

The results of our analysis of visual and photographic observations contributed to the ALPO Venus Section during the 1999-2000 Western (Morning) Apparition of Venus indicated limited activity in the atmosphere of the Venus. It has already been mentioned earlier in this report that it very troublesome to differentiate between what constitutes real atmospheric phenomena and what is merely illusory on Venus at visual wavelengths. A greater level of confidence in our results will improve as the number of observers and incidence of simultaneous observations increase. The Venus Section is making a special effort to organize and implement a simultaneous observation schedule so that observers in relative proximity to one another can set aside times to follow Venus when others (using similar methods and equipment) are looking at the planet. The simultaneous observing schedule is expected to appear on the ALPO Website in the very near future http://www.lpl.arizona.edu/alpo. In addition to routine observations, the Venus Section desperately needs more ultraviolet photographs of Venus, as well as digital camera and CCD images of the planet at different wavelengths. We are attempting to standardize and improve observational techniques and methodology so that comparison of our results with those of previous morning observing seasons, as well as with evening apparitions of Venus, is more reliable.

ALPO studies of the Ashen Light, which peaked during the Pioneer Venus Orbiter Project, are continuing every apparition. Constant monitoring of the planet for the presence of this phenomenon by a large number of observers (ideally participating in a simultaneous observing program) remains important as a means of improving our chances of capturing confirmed dark hemisphere events.

Figure 11. 1999 Dec 05, 14h00m-14h30m UT. Frank J. Melillo. 20.3-cm (8.0-in.) SCT, Schott UG-1 UV Filter w/ IR blocker, Starlight Xpress MX-5 CCD Camera. Seeing 7.0. Phase (k) = 0.666, Diameter = 17".5. Note orientation; image is reversed.

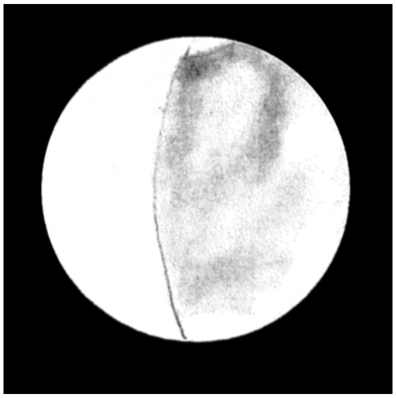
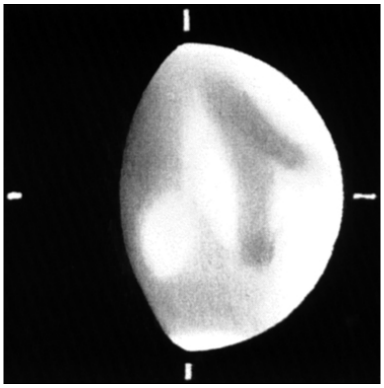


Figure 12. 1999 Dec 15, 11h33m-11h55m UT. Ed Crandall. 25.4-cm (10.0-in.) NEW, 150X, W47 (dark blue) Filter. Seeing 6-7, Transparency 4. Phase (k) = 0.702, Diameter = 16".3. (Dark hemisphere left blank.)

Figure 13. 1999 Dec 31, 07h30m UT. Mario Frassati. 20.3-cm (8.0-in.) SCT, 250X, W8 (yellow) Filter. Seeing 5.0 (interpolated). Phase (k) = 0.755, Diameter = 14".8. Phase estimated as 0.73.



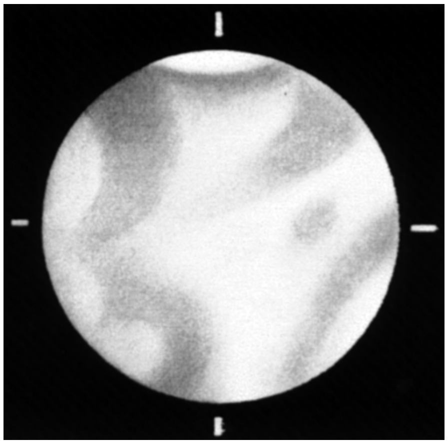


Figure 14. 2000 May 14, 09h58m UT. Mario Frassati. 20.3-cm (8.0-in.) SCT, 250X, W56 (light green) Filter. Seeing 8.0 (interpolated). Phase (k) = 0.991, Diameter = 9".7. Phase estimated as 0.99.

Active international cooperation by individuals making regular systematic, simultaneous observations of Venus remains our main objective, and the ALPO Venus Section invites interested readers to join us in our projects and challenges ahead.

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ALPO Feature — Unfinished Business: The Rebirth of the ALPO Lunar Dome Survey

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Abstract

The ALPO board of directors approved the revival of the Lunar Dome Survey during their annual board meeting in the summer of 2003. The initial LDS program was conceived by Harry Jamieson in the early 1960's and headed by him when the British Astronomical Assn. (BAA) was invited to join the program, which they did. The joint effort between the ALPO and BAA lunar sections lasted for approximately 14 years, ending officially around 1976 due to a decline in interest. The program was again revived in 1987 under the direction of Jim Phillips and lasted until the mid-1990's. All told, this program has been one of the longest running programs in the history of the Lunar Section of ALPO

The revived program will concentrate on cleaning up the existing catalog, classification and confirmation of the objects contained therein, and analysis of the database created in the process. It is hoped that, as in the past, much of the newly revived Lunar Dome Survey will be an international effort.

Introduction

Lunar domes are gentle swellings on the lunar surface that resemble terrestrial shield volcanoes (similar shield volcanoes are also found on Mars). Domes are not difficult objects to observe despite the fact that they are practically invisible at solar altitudes exceeding 8-10 degrees. Under higher illumination, they tend to blend in to the surrounding lunar terrain. Thus, the window of opportunity for their observation is quite narrow. However, most lunar domes are well within the reach of practically any amateur telescope and valuable contributions may be made by just about anyone willing to learn some simple techniques.

There have been a number of theories as to the morphology of lunar domes. These include the possibility that they are surface expressions of laccolithic intrusions. Another possibility, as already mentioned above, is that they are small lava shields (i.e., lava domes). If this is the case, they are the result of repeated extrusions of low viscosity flows(1). The small scale shield hypothesis appears the most tenable of the current theories, and if this proves to be the case, then they may be lunar examples of Hawaiian-style lava domes. Their terrestrial equivalent differs from their lunar counterpart in that they have much steeper slope angles than the normal lunar dome and probably have a quite different genesis.

Earth-based volcanic domes of the cinder cone variety form via explosive eruptions which pile up lava around a central vent. Such explosive eruptions on the Moon, due to gravity differences (lunar volcanism occurred in 1/6th the gravity as that of the Earth),

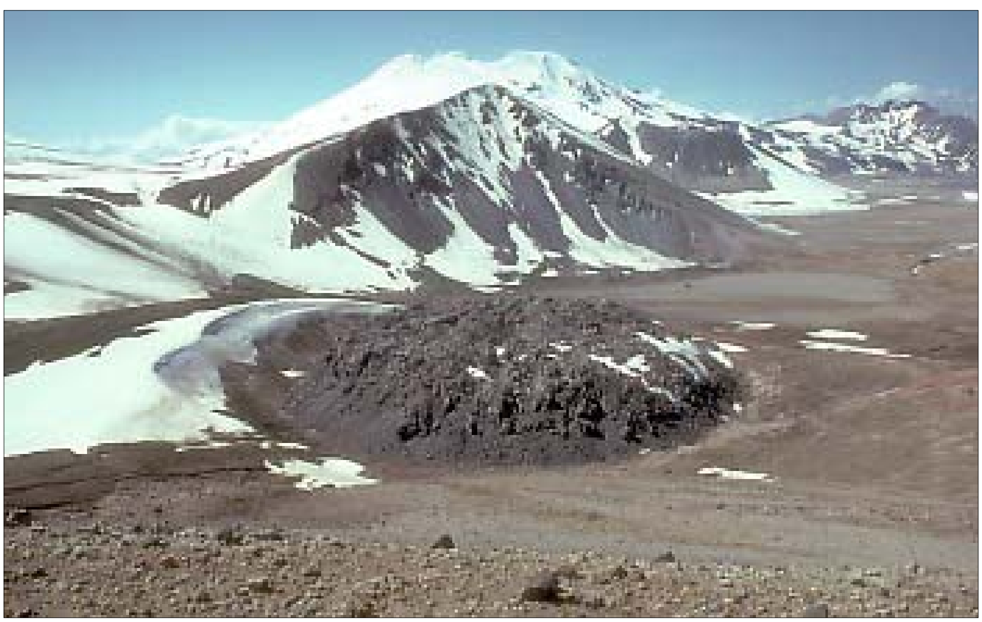

Figure 1. Volcanic dome atop Novarupta vent, Valley of Ten Thousand Smokes, Katmai National Park and Preserve, Alaska. The dome was erupted from the same vent that expelled about 15 km^3 of magma in an enormous explosive eruption in 1912. Note the much steeper slope angle as compared to lunar domes. (3) Photograph by T.P. Miller in June 1979.

would have thrown such material much further, leaving little material in order to form the dome around a central vent. Terrestrial domes also form from much thicker lava, whereas lunar domes likely form from basaltic lavas which are more liquid in nature. Furthermore, lunar dome genesis is more likely a function of much cooler lava than those found on Earth. Large scale shields such as Olympus Mons and Mauna Loa do not occur on the Moon.(2) See Figure 1.

John Westfall gave us the following definition of lunar domes which the newly revived program will continue to adopt as our working model:

> Dome: A discrete regular swelling whose major axis:minor axis ratio, when corrected for foreshortening, does not exceed 2:1, and whose maximum slope, not including secondary features, does not exceed 5 degrees. Under high illumination, domes are indistinguishable from their surroundings. Domes may exhibit secondary features, such as pits, clefts, ridges, and hills as long as any single such feature does not occupy more than a quarter of the area of the dome.
>
> Dome Complex: Any object similar to a dome which has two or more contiguous swellings or an irregularly vertical profile.(4)

The study of lunar domes can be traced back to the early 20th century. One of the earliest contributions to this line of scientific research was the observations of the Milichius/Tobias Mayer region by S.R.B. Cook in 1935. At this same time, a drawing of the Hortensius domes by Schlumberger was published in *The Moon*, by W. Goodacre.

The formal study of lunar domes dates to around 1963, when the Lunar Sections of the Association of Lunar & Planetary Observers (ALPO) and the British Astronomical Association (BAA) agreed to undertake a joint effort in selenology (lunar astronomy) with the launching of the joint ALPO/BAA Lunar Dome Project. The ALPO Lunar Dome Project was the product of the dedicated work and leadership of Mr. Harry D. Jamieson beginning around 1960.

An initial catalog was published listing 113 objects. A revised catalog which listed 713 objects was published in 1992 by the ALPO Lunar Section. In addition to these catalogs, this writer published a revised catalog which listed a total of 607 confirmed and unconfirmed lunar domes on the World Wide Web (the first such listing widely available via the net).(5) The best current official catalog appears to be the one available as a part of the "Lunar Observers Toolkit" mentioned elsewhere in this paper. It will be this work which will constitute the "official" catalog for ALPO purposes. It is comprised of the labors of many people, and is considered by the Lunar Dome Section as the standard reference for research. Another good work (currently unpublished) has been produced by Bob Garfinkle, F.R.A.S., which lists 702 objects. Mr. Garfinkle has attempted to fix errors and omissions as well as duplications in the 1992 and web-based catalogs. Of special value to dome researchers and observers is the extensive remarks column offered in this work.

Lunar dome research is one avenue available for the amateur astronomer who wishes to make truly valuable contributions to the science of selenology. The ALPO has been involved in the scientific study of these elusive objects for over four decades now, beginning with the inception of the joint ALPO/BAA Lunar Dome Project in the mid 1960's.

The renewed program of lunar dome study is deemed a valuable effort. This renewed study will concentrate on cleaning up the catalog as well as in fully classifying the objects in the catalog using the Westfall Classification System. The revived program will also stress obtaining accurate measurements of the slope angles and diameters of the domes in the catalog. Another primary goal of the revised program will be to undertake the establishment of a digital catalog of lunar dome images.

Much as in the program's original inception in the early 1960's, it is desired that the present effort be an international one. Members of the ALPO, the BAA, Geological Lunar Researches Group (GLR), and the American Lunar Society (ALS), as well as all other students of selenology, are invited to partner with us in the effort to complete the work which began four decades ago.

The Situation Today

In February of 1961, Joseph Asbrook wrote concerning lunar domes: "There is a serious lack of quantitative information about the properties of lunar domes — diameters, slope angles, and heights. Such data are helpful in defining what a dome is and essential for subclassification [sic] and meaningful interpretation."(6) This writer wishes that the situation after 42 subsequent years of research and study of lunar domes has now been resolved and that we have an accurate and fully classified catalog of the domes under study. However, to do so would be an exaggeration of the greatest albedo!

The original catalog of lunar domes published as a joint effort between the ALPO and the BAA Lunar Sections included 113 objects. To this initial catalog, the studies over the past four decades have added approximately 589 objects. So in respect to the numbers of known and suspected objects, much progress

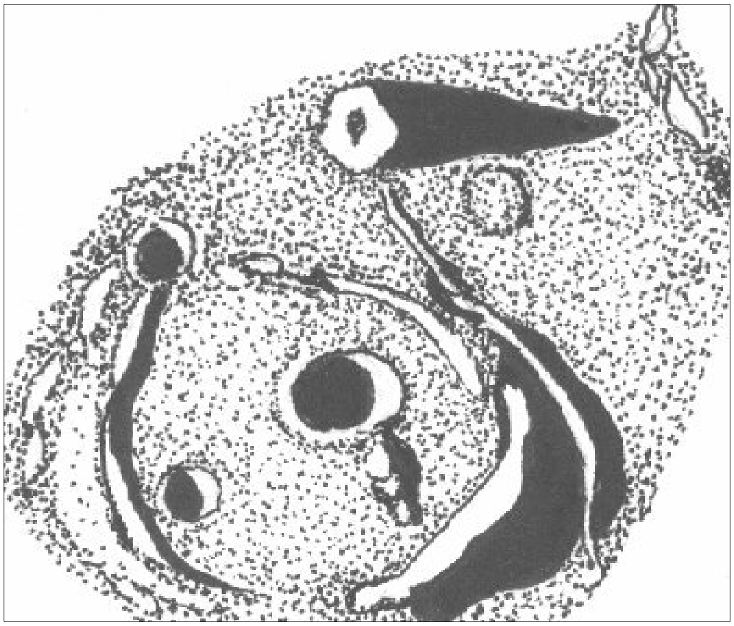

Figure 2. Drawing of the Cassini region showing suspected dome by Raffaello Lena, September 28, 2002 at 4:08 UT; 100mm refractor at f/15, 250X. Seeing good. For more information please visit: http://utenti.lycos.it/gibbidomine/cassinidome.htm

has been made. In respect to routine science, however, it appears that little progress has been made, because today, little more is known about the approximately 702 objects in the current catalog than was known about the original 113 objects as published in 1965.(7)

This is a curious situation. During the four-decade-old formal study of lunar domes, much was done toward the discovery and confirmation of new objects, but little has been done during this same time period to determine the properties and characteristics of the domes currently known. Many of us appear to have been committed to the glory and satisfaction of discovery, but few of us appear to be interested in the mundane *science* behind the original project.(The author must stress that in pointing fingers in this he points three at himself for every one pointed at other readers.) See Figure 2.

The study of lunar domes has been viewed by many of us as one of the foremost contributions amateur astronomers can make to the science of astronomy. This program remains as one of the areas in amateur astronomy in general and selenology in particular, wherein the amateur astronomer may make a truly valuable and lasting contribution to science. Our generation of selenologists has the opportunity to leave a lasting legacy in the work we do in our current and future studies of lunar domes. In the words of one of the characters from the 1984 film *Ghostbusters*, "We have the tools, and we have the talent!"

Earlier generations of dedicated selenologists, particularly in the amateur ranks, were dedicated to observation of the Moon and its many features with quite modest astronomical equipment. This writer himself began his own LDS studies with a 2.4-inch refractor, when the mean aperture for amateur astronomers was in the neighborhood of 8 inches. We now live in an age when the mean aperture of the amateur astronomer's equipment is growing (it is now likely to be a mean of 14 inches aperture) almost daily to staggering statistics (one word of caution: this writer has discovered a suspected correlation in the aperture gain of the telescope primary mirror with the aperture gain in his waist over the past 30 years; more scientific study may be necessary before this correlation may be considered a scientific fact). It is common today for an amateur astronomer to attend an event such as the Texas Star Party in the Texas Davis Mountains and have the opportunity to observe with instruments in the 36-inch and larger range. These days, this writer observes with a modest aperture Dobsonian of 18 inches, complete with electronic *GOTO* and tracking ability! See Figure 3.

In addition, the lunar observer of yesteryear had to laboriously plot domes on a chart for observation and study when today this effort is a needless exercise thanks to the *Lunar Observers Toolkit* written by Mr. Harry D. Jamieson.(8) This software is simply phenomenal in its capabilities, listing domes for observation on any given date and plotting them on

Figure 3. The author, Marvin W. Huddleston, F.R.A.S., the ALPO Lunar Coordinator for the Lunar Dome Survey, with his 18-inch Starmaster Newtonian telescope at the Texas Star Party held at the Prude Ranch near McDonald Observatory in May of 2002. This telescope features a superb f/4.3 Zambuto primary mirror and the Skytracker electronic "GOTO" and tracking package developed by Rick Singmaster of Starmaster Telescopes.

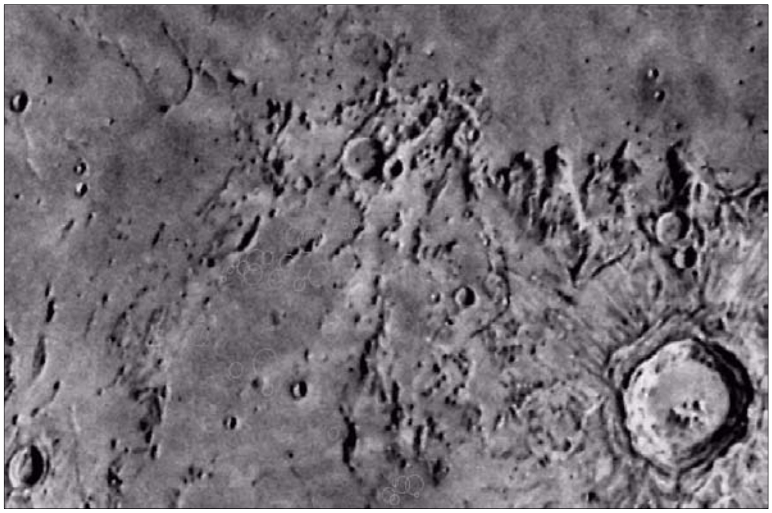

Figure 4. *Lunar Map Pro* chart of the Copernicus region also showing the crater Hortensius and Tobias Mayer, both regions well known to Lunar Dome Observers. Compare this image with the Figure 5 taken by Ed Crandall.

a Moon graphic showing the night's Moon phase as well. Other useful features offered in the *Toolkit* are such abilities as the computation of accurate heights and depths. Overall, this software is deemed indispensable and unequaled in value to any student of selenology.

Additional software that has become available to the Lunar Observer interested in lunar domes in particular and selenology in general include the commercial product *Lunar Map Pro* produced by RITI.(9) An example of this software's charting capability may be seen in Figure 4, showing the Copernicus region which includes the craters Hortensius and Tobias Mayer, both familiar sights to lunar dome observers.

One of the interesting tools in the *Lunar Map Pro* software is the "Surveyor" tool. This tool allows the user to mark two locations with their computers cursor and with a simple click, measure the distance from point A to point B. The resulting computation is given both in kilometers as well as in miles; it also gives the azimuth between the two points. It should be noted that the accuracy of this method has not been confirmed. However, there is a useful feature in the software allowing the user to specify specific image scaling, which it is assumed would increase accuracy.

Another nice program for plotting lunar phases is *Lunar Phase Pro* produced by Gary Nugent.(10) This writer especially likes the real-time display format of this software. This software is useful for the observer wishing to keep tabs on real-time technical data such as libration, colongitude, position angles, etc.

Another advantage we have over previous generations has been recent advances in imaging technologies. Today the amateur selenologist can, with a very modest monetary investment, perform lunar imaging rivaling the professional astronomer of yesteryear with such instruments as CCD cameras, CCD video cameras, digital cameras and/or inexpensive web-cams. See Figure 6.

One advantage that our predecessors had over us was the availability of some of the finest lunar atlases of all times. This writer has contacted the University of Arizona Press numerous times in hopes that the *Orthographic Lunar Atlas* might eventually be reprinted, but to no avail. There were hopes at one time that a digital version might be made available, but this writer has been unable to confirm this rumor. Likewise, Antonin Rukl's *Atlas of the Moon* is out of print, leaving our generation with the best equipment in selenological history, but in the worst situation in decades as far as availability of accurate hardcopy lunar atlases for positional work. However, light is visible at the end of the tunnel, as this writer has it on

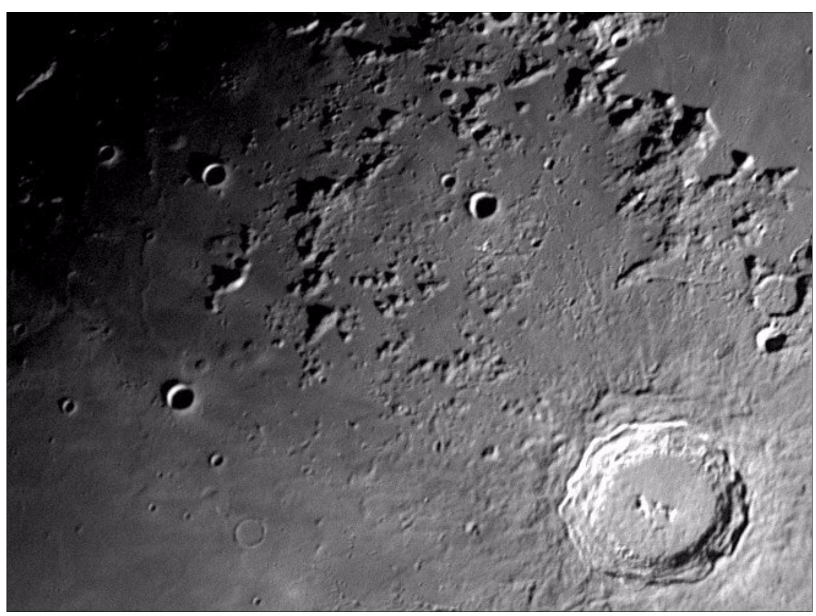

Figure 5. Image of lunar domes near Hortensuis by Ed Crandall. Copernicus is at lower right. 10-inch f/7 Newt SLX HX 516 CCD camera; 10 June 2003 @ 2:24 UT (S=5/10).

good authority that the Rukl's atlas will be available soon in a reprint edition.(12).

The renewed Lunar Dome Survey will concentrate its efforts on the mundane science of LDS research. Science depends upon accurate data. It will be our mission to take as our foremost responsibility the existing extensive catalog of Lunar Domes and make this catalog an example of some of the finest work ever accomplished by students of selenology. Our emphasis will not be on the discovery of new objects, though occasional discoveries may be made in the process; rather, our emphasis will be on the classification, measurement, and analysis of the domes in the existing catalog. See Figure 8.

Figure 6. The Philips To-U-Cam, one of the many inexpensive web-cams available which is allowing the amateur astronomer to secure high resolution photographs of the lunar surface (as well as planetary subjects such as Mars and Jupiter). The addition of an inexpensive adapter by Steven Mogg (center) turns this simple web-camera into an effective Astronomical Imaging instrument. Meade's new LPI (Lunar Planetary Imager, right) is a new and exciting product for Lunar and Planetary Imaging. The LPI is shown here attached to a LX200GPS Telescope.

Many questions remain as to the nature of lunar domes, which the renewed program will attempt to answer. For example, what is the correlation between central craters and a dome's shape, size and other characteristics? Is there a ratio to central crater size and dome diameter? What are the statistics between circular domes with central craters and those without these craters? Are there correlations between elliptical domes and associated secondary features? What is the relationship between lunar domes and specialized secondary features, such as white patches?(14)

The renewed program will concentrate on the following observational data much as it did during the late 1980's revival of the project. The following is based on a paper by Harry Jamieson and is reproduced here for the benefit of those new to lunar dome work:(15)

- **Position** – Observers should carefully check dome positions and report any errors or inaccuracy in catalog positions.

- **Diameter** – Measure dome diameters using size comparisons to nearby craters of known diameter. Joseph Ashbrook detailed this method thusly: The observation consists in estimating the ratio between the dome's apparent diameter and the parallel diameter of the comparison crater. For example, if the crater has a diameter of 10.0 kilometers, and you estimate the dome's diameter as 0.55 of this, the dome diameter is 0.55 x 10 = 5.5 kilometers.(16) Additional methods may include the use of micrometers or reticle eyepieces.

- **Average Slope angle and Height** – The moment at which a dome is covered by ¼ black (not grey, which represents grazing illumination by sunlight) shadow should be accurately noted. Average slope angles and heights can be computed at this time because the Sun's altitude over the dome at that moment may be taken as the dome's average slope angle. Given the dome's average slope and diameter, the height can be found easily using the *Lunar Observer's Toolkit* negating the complicated calculations necessary in past years. Consult the help file in *Toolkit* concerning "Lunar heights and depths" for detailed instructions.

- **Maximum Slope Angle** – This value is equal to the Sun's altitude when the last trace of shadow is observed at the foot of the dome in the lunar morning. Note that this determination should also be done in the lunar afternoon and that the two values thus found may be different.

- **Dome classification (Westfall Classification)**:
  a. A dome is a discrete feature, and not a part of something else.

  b. A dome's ratio of major/minor axis (corrected for foreshortening) may not exceed 2:1. This is designed to eliminate ridges.

  c. A dome may not exceed a maximum slope angle of 5 degrees. This definition is designed to eliminate hills and peaks.

  d. No single secondary feature (cleft, crater, etc.) may occupy more than ¼ of the surface area of a dome (with perhaps the single exception of "White Patches" which have been noted atop some domes). White patches are largely poorly understood and have been ignored for the most part.

  The renewed effort will be quite interested in the study of the various types of secondary features. Data are needed concerning the characteristics and correlations of such features.

More on the Westfall Classification System

The Westfall Classification system is designed to describe the physical characteristics of a dome using a combination of letters and numbers. Readers should note the addition of a Type 10 secondary feature listed under the heading "Surface Feature *type*." The following is a brief outline of the classification system:(17)

Broad Category:

D: Dome

DC: Dome complex (several domes in physical contact (e.g., the Rumker complex).

Surroundings:

U: Uplands

W. Maria

UW: Uncertain if Uplands or Maria

Plan:

The dome's major axis is:

1. Less than 5 kilometers

2. 5-20 kilometers

3. 20-35 kilometers

4. More than 35 kilometers

Written notes submitted to the ALPO Lunar Dome Survey Section Recorder should include size estimations with as much accuracy as possible.

Border:

a. Circular (major/minor axis 1.00-1.25)

b. Elliptical (major/minor axis 1.26-2.00).

c. Polygonal

d. Irregular

e. Too ill-defined to classify

Profile (average slope):

5. Gentle (under 2 degrees)

6. Moderate (2-5 degrees)

Profile (cross section):

f. hemispherical

g. flat summit (platykurtic)

h. sharp summit (leptokurtic)

i. Multiple summit (more than one summit; of different types).

f'. Hemispherical (Asymmetric)

g'. Flat summit (Asymmetric)

h'. Sharp summit (Asymmetric)

i'. Complex summit (more than one summit and of different type).

Surface Detail-type:

7. Depression (pit, craterlet, or saucer)

8. Elevation (hill, ridge, or pit)

9. Cleft or Valley

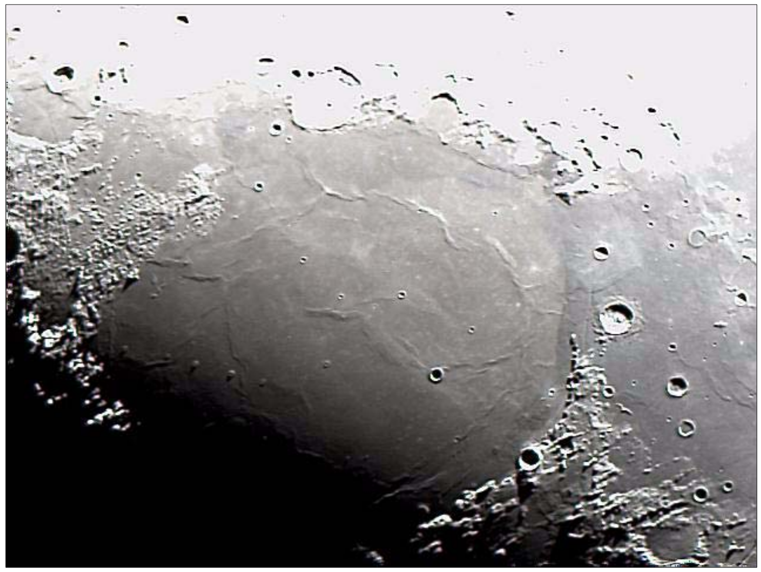

Figure 7. Image of Mare Serenitatis showing the Bessell region, site of a number of elusive objects (possibly domes) associated with "White Patches." Also note: taken by the author; Starmaster 18-inch f/4.3 and Meade LPI imaging camera. 12/30/2003 UD 00:21:17UT, Colongitude 348.57° Composite of 20 images stacked automatically by the LPI software.

10. White Patch (area of higher albedo than surrounding lunar surface usually located atop the domes location).

0. No observable detail.

Surface Detail Position:

j. central

k. Off-central

m. margin

n. Transversal (cross dome)

p. more than one such feature

An example of the classification system in actual use might be recorded as **DW/2b/6f//7j/9m/8p** which translated means: (**DW**) dome within a mare, (**2b**) 5-20 kilometers and elliptical, (**6f**) moderate slope and hemispherical, (**7j**) depression central on the dome, (**9m**) cleft or valley on the margin of the dome, (**8p**) elevation – more than one such feature.

It is hoped that many will take on the challenge of helping us finalize the catalog and answer this call to arms! What the reader must understand is that until the catalog is completed and an accurate database established, analysis of the objects cannot produce usable date. Taking accurate data such as the Westfall Classifications and analyzing these will allow researchers to produce an accurate definition based on the data. We need observers dedicated to the study of these elusive lunar domes.

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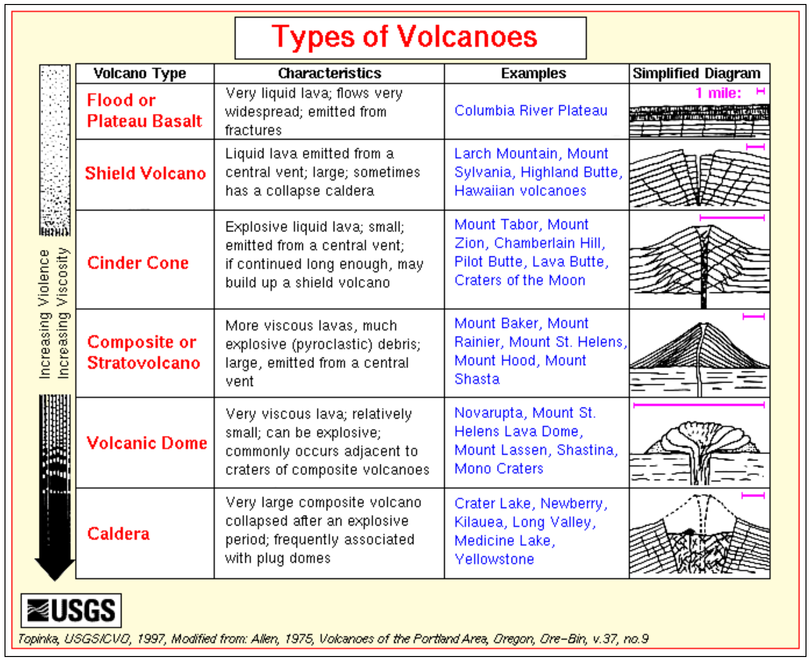

Figure 8. USGS illustration of Volcano Types. Lunar domes are thought to be the Lunar counterparts of Shield and/or Volcanic Domes. Though their genesis may differ, much is to be learned from studying the terrestrial counterparts.(13)

Westfall, John E., "A Generic Classification of Lunar Domes", *Journal of the Assn. of Lunar & Planetary Observers (JALPO),*Vol. 18, No. 1-2. (University Park, N.M.: Association of Lunar & Planetary Observers, 1964).

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1. Peter H. Schultz, *Moon Morphology.* (Austin, Texas: University of Texas Press, 1972), p. 286.

2. Stuart Ross Taylor, *Domes and Cones* in *Planetary Science: A Lunar Perspective*. (Houston, Texas: Lunar and Planetary Institute, 1982), p. 274.

3. http://volcanoes.usgs.gov/Products/Pglossary/LavaDome.html

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5. This listing can be found on the author's web page which is devoted to lunar domes at http://www.lunar-dome.com

6. Joseph Ashbrook, "Dimensions of The Lunar Dome Kies I", *Journal of the Assn. of Lunar & Planetary Observers (JALPO)*, Vol. 15, No. 1-2. (Edinburg, Texas: Pan American College, 1961), pp. 1-3.

7. Harry D. Jamieson and W.L. Rae, "The Joint ALPO-BAA Lunar Dome Project", *Journal of the Assn. of Lunar & Planetary Observers (JALPO)*, Vol. 18, No. 9-10 (University Park, N.M.: The Association of Lunar & Planetary Observers, 1965), pp. 179-182.

8. Mr. Jamieson may be contacted concerning his *Lunar Observer's Toolkit* at h.jamieson@bresnan.net His toolkit will be an essential accessory for participants in the newly revived Lunar Dome Survey and is available at very modest cost. This software runs independently of installation CD. One of the numerous great features in the *Toolkit* is its link feature to the *Consolidated Lunar Atlas*. The lunar phase display screen also plots all domes in the catalog on a graphic display of the current lunar phase, though the phase is a stagnant display and not a continuous phase updating screen.

9. http://www.riti.com

10. http://www.nightskyobserver.com Loads into the user's computer running independently from the installation CD, a huge advantage.

11. http://webcaddy.com.au/astro/adapter.htm

12. Ing Antonin Rukl, personal correspondence dated July 1, 2003. Mr. Rukl reported that his atlas will be reprinted by Sky Publishing Corporation in the near future.

13. http://vulcan.wr.usgs.gov/Glossary/VolcanoTypes/volcano_types.html

14. Marvin W. Huddleston, "Lunar Domes and White Patches: A Correlation Report", Proceedings of the joint WAA-ALPO 1972 Convention, pp. 120-121.

15. Harry D. Jamieson, "Observing Lunar Domes", *Journal of the Assn. of Lunar & Planetary Observers (JALPO)*, Vol. 33, No. 1-3 (Heber Springs, Ark.: The Association of Lunar & Planetary Observers, 1989), pp. 23-24.

16. Ashbrook, 1.

17. Jamieson, 24.

ALPO Feature — A Generic Classification Of a Lunar Dome Near Copernicus

By Eric Douglass, Raffaello Lena, KC Pau and Francesco Badalotti (Geologic Lunar Research Group)

Abstract

This study describes a dome which is reported in the ALPO list. Positioned at longitude –27°23' and latitude 11°57' (– 0.450 +0.207), this dome shows summit craters and protrusions.

Introduction to Lunar Domes

Volcanic domes on the Moon are formed by two possible mechanisms. First, they may be formed by the direct outpouring of magma from a central vent. In this scenario, successive effusive lava flows pile up, forming a structure of positive relief. Because lava on the Moon has low silica content (Mursky, p. 170), it has a very low viscosity, and just this results in a volcano with low sloping sides and little positive incline. On Earth, this would be similar to a shield volcano.

Figure 1. Francesco Badalotti, on May 11, 2003 at 19:30 UT using a 25-cm Schmidt-Cassegrain (colongitude 36.15°, solar altitude 8.52°).

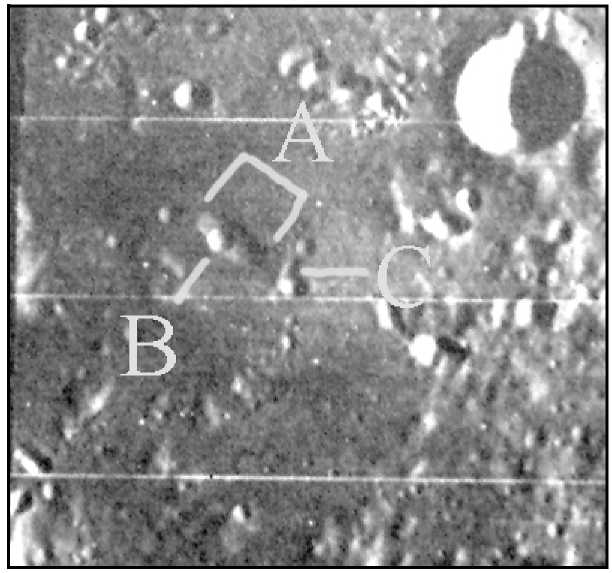

Figure 2. "Lunar Orbiter Photographic Atlas of the Moon"; D. Bowker and J. Hughes; NASA SP-206; GPO, 1971; plate 189.

Note that this kind of dome often has a central pit crater where the lava originally flowed out to form the volcano (in some extrusive volcanoes, the pit crater is not apparent due to infilling). The second possible mechanism is that lunar domes are not the result of surface outpourings of magma, but instead the expression of subsurface accumulation of magma. In this scenario, magma accumulates beneath the surface of the Moon in pockets.

These pockets slowly increase in pressure, stressing the bedrock layers above them. This causes an updoming of the bedrock layers, creating a smooth, gently sloping structure of positive relief. On Earth, this would be similar to a laccolith (Heiken, p. 101). Note, however, that in a laccolith, there is generally no central pit or crater, as the magma is usually contained beneath the surface. After examining this dome under "Observations," we will comment on which mechanism appears more likely for this dome's formation.

Observations

This report is based on an analysis of two visual observations and six images taken under different solar altitudes and sent to the Geologic Lunar Research Group. Table 1 lists the five

Name	Instrument (D & F/L)	Observation Type	Reports
Badalotti F.	Schmidt-Cassegrain 250 mm f/10	Web-cam	2
Crandall E.	Newtonian 250 mm f/6	CCD	1
Lena R.	Refractor 100 mm f/15	Visual	2
Nardella S.	Maksutov 150 mm f/6	Web-cam	1
Pau K.C.	Newtonian-Cassegrain 210 mm f/11	Web-cam	2

Table 1: Contributing Observers and Instruments

observers, their instruments, and the number of observations they submitted. In addition, we utilized lunar orbiter, Ranger VIII, and Apollo 16 imagery.

This dome (longitude –27°23’, latitude 11°57’) is a known structure of about 12 km in diameter by visual estimation (Lena) and as reported in the ALPO Lunar Dome Survey database. The dome appears to have an elongated summit crater, a moderate slope, a relatively flat summit, and an elliptical shape (figures 1 and 6).

Francesco Badalotti examined the dome under high solar altitude (figure 1). The image was taken on May 11, 2003 at 19:30 UT using a 25-cm Schmidt-Cassegrain (colongitude 36.15°, solar altitude 8.52°). Note that for each observation, the local altitude of the Sun and its colongitude were calculated with Jamieson’s *Lunar Observer's Toolkit* software.

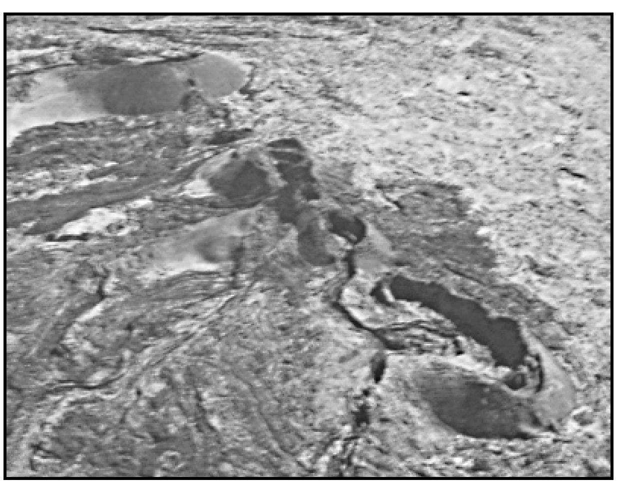

Figure 3. “Volcanic Features of Hawaii”, p. 86; NASA SP 403: GPO, 1980.

A second image by K.C. Pau (Figure 6) was taken on May 11, 2003 at 12:15 UT (colongitude 32.46°, solar altitude 4.91°). The image was obtained using a 21-cm Newtonian-Cassegrain. The image reveals much finer detail in the dome, including small prominences and an elongated central depression.

Geology

Now we consider the question of which mechanism most likely formed the dome under present consideration? An examination of the summit reveals a variety of features, including a central pit crater. Here we see an elongated depression (Figure 2, labeled “A”) and a circular depression (Figure 2, labeled “B”). The elongated depression is much smoother in appearance than the circular depression, suggesting that it has been subject to surface erosion (micrometeorites) for a much longer period, and is thus much older. This would represent the original vent (for if the circular depression was a vent, then it would have filled in the older elongated depression!). The circular depression is much younger, and likely represents an impact crater. Thus, the elongated depression is the place from which lava poured out onto the lunar surface, successively building up a shield-like volcano around it.

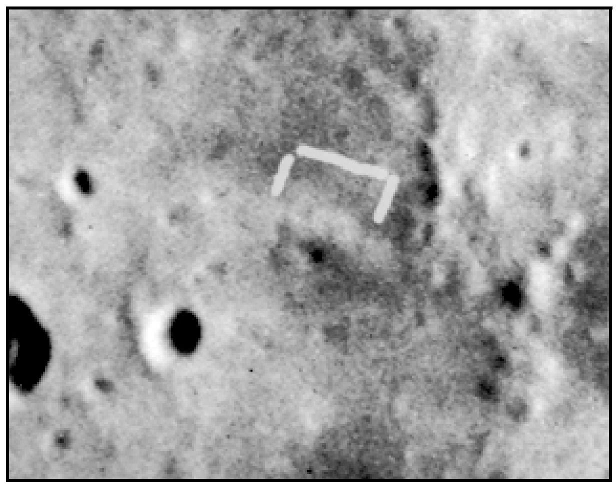

Figure 4. USAF Luna Atlas, E3; Kuiper et. al.

It is of interest that this pit crater is elongated. On Earth, an elongation of this type would most likely represent an eruption along a rift zone

(Figure 3, see McDonald, p. 274), although other mechanisms also exist. While it is tempting to see this elongation as sub-radial to Copernicus, and thus as a fault created by that impact, this is not the case. The ejecta of Copernicus covers this dome, and so the dome is older than Copernicus (Figure 4; note how the white ejecta from Copernicus cover part of the dome). Instead, faulting in this area was most likely caused by the Imbrium impact.

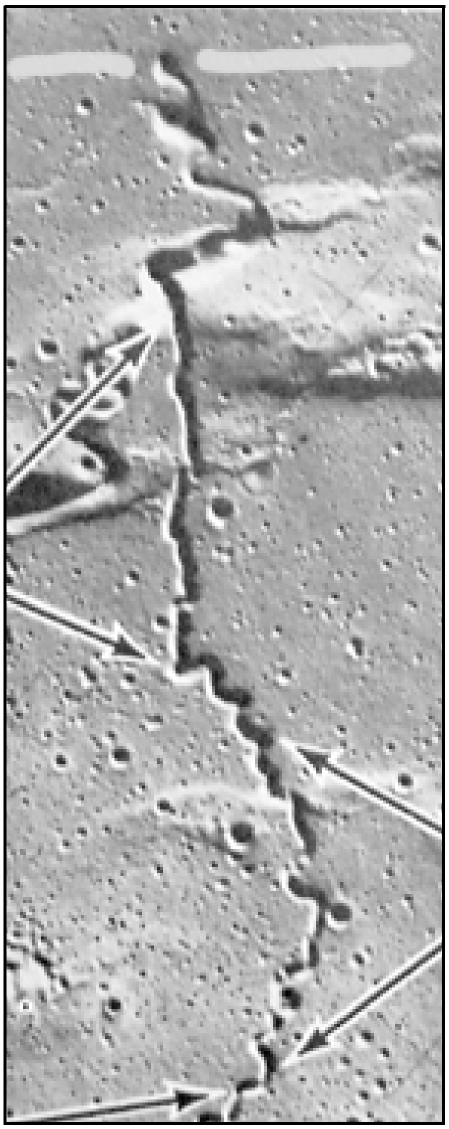

Figure 5a. Apollo 16 Preliminary Science Report, p. 29-82; NASA: GPO, 1972.

Yet another interesting summit feature is the small trough emanating from one of the summit craters (Figure 2, labeled “C”). Rimae that begin in craters have two common means of formation. Some represent sinuous rilles, where lava from a depression poured out onto the surface (Figure 5a; cf. Wilhelms, p. 88-89). These extend out from the depression some distance into a mare surface, twisting along the way. Others appear to represent some kind of collapse, often due to updoming of the surface, generating extension and subsequent collapse (Figure 5b; cf. Masursky, p. 214). These generally contain straight segments, and may be rather short. While this particular segment is short and close to the resolution limit of the image, it nevertheless appears to be one such collapse feature.

In addition, there are a number of protrusions on the dome (Figure 6). These are difficult to clearly define. These most likely represent tumuli, cones, or small shields.

- Tumuli occur when small fractures in the cooling crust permit lava to squeeze up and produce a small dome-like structure. While tumuli on Earth are much smaller than these, the lower gravity permits larger structures to form on the Moon.
- Cones, on the other hand, occur when gas bubbles emanate from a magma, fragmenting and accelerating it above the surface. Where the fragments fall to the surface, a small cone is formed.
- Small shields occur when parasitic vents form laterally (along dikes or sills; McDonald, p. 200), and siphon lava off to the side of a volcano.

Figure 5b. Ranger VIII Photographs of the Moon, B51; NASA. Washington: GPO, 1966.

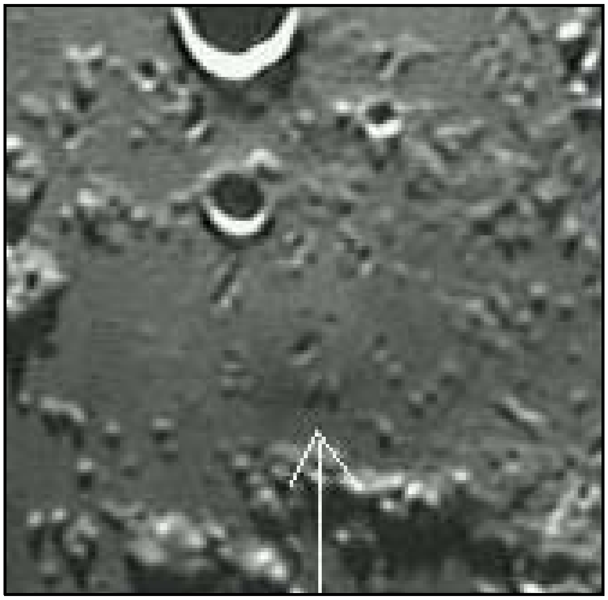

Figure 6. K.C. Pau, image taken on May 11, 2003 at 12:15 UT (colongitude 32.46° solar altitude 4.91°).

It is difficult to decide which mechanism is responsible for these geologic forms, but our suspicion is that they are small shields that formed along lateral dikes.

Finally, it is of interest that there are a number of small protrusions near this dome (Figure 7), each with a small pit crater. These are most likely small volcanic cones that have formed in this volcanic province.

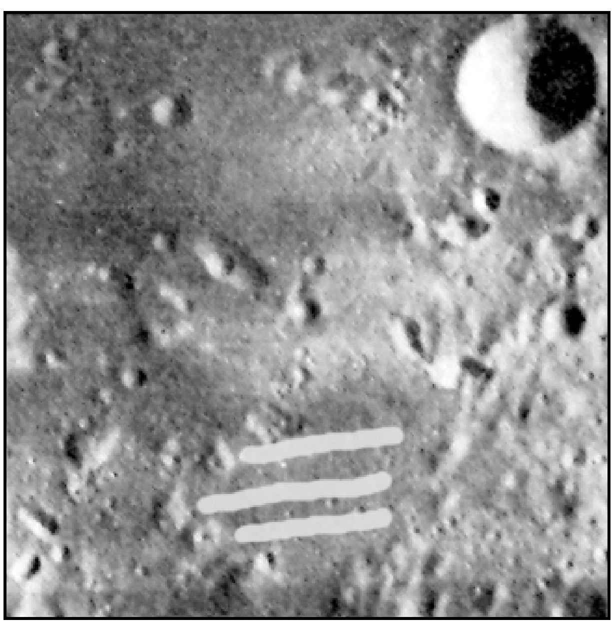

Figure 7. "Lunar Orbiter Photographic Atlas of the Moon"; D. Bowker and J. Hughes; NASA SP-206; GPO, 1971; plate 185.

Conclusion

Using the Westfall Classification Scheme, we categorized the dome as DW/2b/6 g /7p 8p. [The Westfall Classification Scheme is detailed in the article *The Rebirth of the ALPO Lunar Dome Survey* elsewhere in this issue of the *Strolling Astronomer*.] In this paper, we have detailed the geology of this dome, noting that it most likely formed from effusive surface flows. Finally, we have noted a variety of interesting geologic structures both on and surrounding the dome.

This study shows that a combination of careful visual and CCD observations made by different observers provides powerful tools for the study and interpretation of lunar domes. More observations and observers are needed worldwide in order to observe these important geologic lunar formations.

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Eclipse Section

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The Monograph Series

ALPO monographs are publications that we believe will appeal to our members, but which are too lengthy for publication in *The Strolling Astronomer*. They should be ordered from *The Strolling Astronomer* science editor (P.O. Box 2447, Antioch, CA 94531-2447 U.S.A.) for the prices indicated, which include postage. Checks should be in U.S. funds, payable to "ALPO".

- **Monograph Number 1.** *Proceedings of the 43rd Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, August 4-7, 1993.77* pages. Price: $12 for the United States, Canada, and Mexico; $16 elsewhere.
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- **Monograph Number 3**. *H.P Wilkins 300-inch Moon Map.* 3rd Edition (1951), reduced to 50 inches diameter; 25 sections, 4 special charts; also 14 selected areas at 219 inches to the lunar diameter. Price: $28 for the United States, Canada, and Mexico; $40 elsewhere.
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- **Monograph Number 9**. *Does Anything Ever Happen on the Moon?* By Walter H. Haas. Reprint of

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1942 article. 54 pages. Price: $6 for the United States, Canada, and Mexico; $8 elsewhere.

- **Monograph Number 10.** *Observing and Understanding Uranus, Neptune and Pluto*. By Richard W. Schmude, Jr. 31 pages. Price: $4 for the United States, Canada, and Mexico; $5 elsewhere.

ALPO Observing Section Publications

Order the following directly from the appropriate ALPO section coordinators; use the address in the listings pages which appeared earlier in this booklet unless another address is given.

- **Lunar and Planetary Training Program (Robertson):** *The Novice Observers Handbook* $15. An introductory text to the training program. Includes directions for recording lunar and planetary observations, useful exercises for determining observational parameters, and observing forms. To order, send check or money order payable to "Timothy J. Robertson."
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- **Mars (Troiani):** (1) *Martian Chronicle;* published approximately monthly during each apparition; send 8 to 10 SASE's; (2) *Observing Forms;* send SASE to obtain one form for you to copy; otherwise send $3.60 to obtain 25 copies (make checks payable to "Dan Troiani").
- **Mars:** *ALPO Mars Observers Handbook,* send check or money order for $10 per book (postage and handling included) to Astronomical League Book Service, c/o Paul Castle, 2535 45th St., Rock Island, IL 61201.
- **Jupiter:** (1) *Jupiter Observer's Startup Ki*t, $3 from the Jupiter Section Coordinator. (2) *Jupite*r, ALPO section newsletter, available online via the ALPO website or via snail-mail; send SASE to the Jupiter Section Coordinator; (3) To join the ALPO Jupiter Section e-mail network, *J-Ne*t, send an e-mail message to the Jupiter Section Coordinator. (4) *Timing the Eclipses of Jupiter's Galilean Satellites* observing kit and report form; send SASE to John Westfall.
- **Saturn (Benton):** (1) The *ALPO Saturn Observing Ki*t, $20; includes introductory description of Saturn observing programs for beginners, a full set of observing forms, and a copy of *The Saturn Handboo*k. (2) *Saturn Observing Forms Packe*t, $10; includes observing forms to replace those provided in the observing kit described above. Specify *Saturn Forms.* To order, see note for *Venus Forms*.
- **Meteors:** (1) Pamphlet, *The ALPO Guide to Watching Meteors,* send check or money order for $4 per book (postage and handling included) to Astronomical League Book Service, c/o Paul Castle, 2535 45th St., Rock Island, IL 61201. (2) *The ALPO Meteors Section Newslette*r, free (except postage), published quarterly (March, June, September, and December). Send check or money order for first class postage to cover desired number of issues to Robert D. Lunsford, 161 Vance St., Chula Vista, CA 91910.
- **Minor Planets (Derald D. Nye):** *The Minor Planets Bulleti*n, published quarterly $14 per year in the U.S., Mexico and Canada, $19 per year elsewhere (air mail only). Send check or money order payable

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to "Minor Planets Bulletin" to 10385 East Observatory Dr., Corona de Tucson, AZ 8564I-2309.

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- ***An Introductory Bibliography for Solar System Observers.*** **Free** for a stamped, self-addressed envelope. A 4-page list of books and magazines about Solar System bodies and how to observe them. The current edition was updated in October, 1998. Order from: ALPO Membership Secretary.
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