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Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 61, Number 3, Summer 2019
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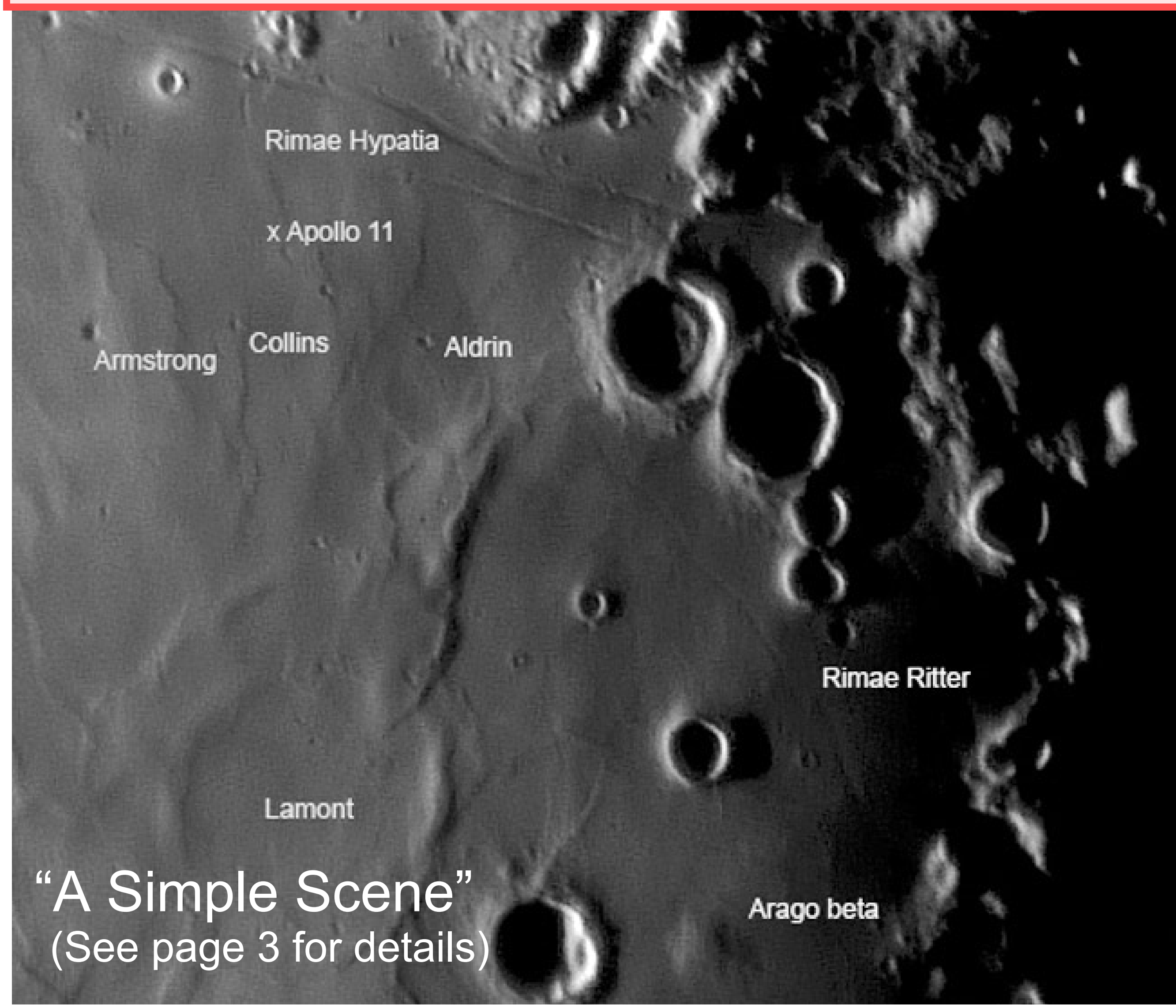
Founded in 1947



"A Simple Scene"
(See page 3 for details)

Journal of the Association of Lunar & Planetary Observers

The Strolling Astronomer

Volume 61, No.3, Summer 2019
This issue published in June 2019 for distribution in both portable document format (pdf) and hardcopy format.

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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Visit the ALPO online at:
http://www.alpo-astronomy.org

Founded in 1947

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Association of Lunar & Planetary Observers (ALPO)

Founded by Walter H. Haas, 1947

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Youth Section: Timothy J. Robertson

Point of View

It's Time for a Change

By Ken Poshedly, editor & publisher, *The Strolling Astronomer*

The English poet and author wrote in 1374, "All things must come to an end." And so it is with my tenure as editor & publisher of your ALPO Journal. JALPO61-4, due for release in September, will be my final one.

My decision was not an easy one and has been on my mind for perhaps the past 10 years. But a recent serious health diagnosis by my doctor has pushed that decision way up to the front of the line.

Age has a way of oh-so-slowly taking its toll on all of us, and I'm no exception. So with considerably more open time available to me, I plan to perhaps finally get around to doing those things that I've had on my checklist since well before taking on this job in 2001. (Yikes! It's been THAT long?)

I am proud to have done my best to use my skills as a technical publications writer/editor since 1984 to make our Journal what it is today, now an award-winning publication (see page 3) available both in hard-copy format as well as online that serves to announce to all interested parties the goings-on within our organization as well as publish top-notch scientific papers about solar system phenomena observed with Earth-based instruments. And let's not forget the apparently often overlooked directory of who's-who and what's-what at the back of every issue; I still see questions posted on the ALPO-member-discussion e-mail list asking who to contact for whatever or how to get a back issue of this publication, yet all of that is included in every issue.

Who will fill this position and how will the Journal be handled after I leave it? I don't know, but I hope and wish it will be someone from within our ranks. It really is time for someone with maybe fresh ideas and a new approach. And whoever it is will not be simply cut loose with no help. I'll still be available for guidance, plus all of the usual contributors will certainly be continuing their share to submit reports and papers.

I do plan to remain on the board of directors and might even be able to actually do some observing and submit reports once in awhile. We'll see. Like they say, "Thanks for having me."

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News of General Interest

Our Cover: Where IT All Happened

With this issue of *The Strolling Astronomer* dedicated to our own ALPO Lunar Section in recognition of the Apollo 11 Moon landing, we present on our cover a beautiful image of Mare Tranquillitatis by Tamas Ladanyi of Veszprem, Hungary, which first appeared on the November 10, 2010 “Lunar Photo of the Day” web site hosted by Charles Wood. Mr. Woods’ comments hereby follow:

“When I used to study volcanoes, a colleague who worked at the Hawaii Volcano Observatory said that a recent series of an eruptions produced such a complex landform that it could never be understood if it hadn't been witnessed. Sometimes I feel that way when looking at the Moon, except I wasn't there to witness any of it. Ladanyi's image of the Apollo 11 region in southwestern Mare Tranquillitatis doesn't look very complex, but I can't figure it all out. The mare is younger than the highlands to the south (at top), and the rilles and impact craters came later. In fact, the ejecta from Sabine covers part of the Hypatia Rilles so that crater must be younger than the rilles. The Arago Beta dome has always been something of a mystery - why is it so much steeper and rougher surfaced than most domes? And is Lamont really a buried two-ring impact basin? If so, why does it have massive mare ridges radiating away? With this lighting, the unnamed ridge extending from Lamont towards Sabine is seen to cut off the outer ring of Lamont, implying that the ridge is more recent. Hmm. There is also a speculative suggestion from the arc of the ridge that it is the ghost rim of a large crater or small basin that extended all the way to the western shore where topography is on the terminator. In fact, a parallel curved ridge passing near the small crater Arago B could be an inner ring for the putative basin. Notice also that the mare surface inside this arc-bounded area is smoother and less ridged than any comparable area of Tranquillitatis. I wish I had seen this form, because it’s probably impossible to figure it all out, looking 3.6 billion years after the fact.”

Equipment and exposure details: Image taken12.02.2008, 17:39 UT. using a 25cm Cassegrain reflector at f/14,2, an ATK 1 HS CCD camera, stacked 28 frames from1,900, at average seeing.


STC Regional TechComm Competition
Atlanta | Houston | New England | New York | Philadelphia | Rochester

The STC Regional TechComm Competition Committee presents this

Award of Merit

to

Ken Poshedly

in recognition of contributions to the winning entry

Journal of the Assn of Lunar & Planetary Observers

during the 2018-2019 STC Regional TechComm Competition

STC Award for The Strolling Astronomer

By Ken Poshedly, JALPO editor

This editor is proud to announce that *The Strolling Astronomer* (the quarterly Journal of the Assn of Lunar & Planetary Observers) has earned an Award of Merit from the Society for Technical Communication (STC) as part of one of the organization's 2018 regional publications competitions.

The STC is a professional association dedicated to the advancement of technical communication, where technical writers, editors, illustrators and others research and create information about technical processes or products directed to a targeted audience through various forms of media, whether it be hard copy, pdf files, videos or online. Some companies whose technical documentation staffs are members include Adobe, Boeing, Madcap, Hewlitt-Packard, Wells Fargo, GE, Eaton, Oracle and VISA, to name only a few.

This particular regional contest included entries from the Atlanta chapter (including mine), the Houston chapter, the New England chapter, New York City chapter, the Philadelphia chapter and the Rochester, NY, chapter of the STC. I've been a member of the Atlanta chapter

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since October 1987, but this is the first time I submitted our Journal for judging.

This year, there were 26 entries being judged by 40 volunteers from 10 states as well as India and Saudi Arabia. Categories included informational materials, instructional materials and user support materials representing some very high-tech industries. Entries were submitted last fall with judging announced on April 3, 2019.

I wish to point out that many, if not most, of the entries in the STC competition were produced by staffs of multiple individuals, while I produce and coordinate publication of our Journal single-handedly after gathering all the fine contributions from our subject matter experts. Here is the complete list of those who received Awards of Merit:

- Welch Allyn for *Vital Welch Allyn Connex® Vital Signs Monitor 6000 Series™ - Service Manual* (user support)
- Medidata for *Medidata Medical Imaging Knowledge* (user support)
- Sciemetric Instruments for *Sciemetric Enterprise Services User Guide v1.60* (user support)
- Inficon for *D-TEK Stratus Quick Start Guide* (user support)
- Assn of Lunar & Planetary Observers for the *Journal of the Assn of Lunar & Planetary Observers* (informational)
- Information Builders for *Accelerator for IoT: Predictive Maintenance and Connected Asset Management* (Video) (instructional)

Finally, I want to publicly thank all of you who have contributed to our Journal. It was your data that I was able to package in a professional manner for our readership, whether it be the professional community, those just getting started in observational solar system astronomy or everybody in between.

For more on all of the entries and winners in this regional competition — including hyperlinks for the various entries — go to these two items:

http://stcnymetro.net/roadshow/2019/

and

https://mail.yahoo.com/d/folders/1/messages/AOGL6Lpmp9e2XKUYMQj44EZtvWw?reason=invalid_cred

ALPO Board & Staff Member Updates

With the extremely helpful Shawn Dilles having produced searchable pdf files of the pre-2001 issues of *The Strolling Astronomer* and also assisting Mike Mattei with getting the JALPO indexes up-to-date (or really "back-to-date"), both Mike and Shawn are now listed in the "ALPO Resources" section of the JALPO as "Journal Indexer" and "Assistant Journal Indexer"respectively.

ALPO board member and coordinator of the ALPO Eclipse Section Dr. Mike Reynolds has announced his retirement as Dean of Liberal Arts & Sciences at Florida State College at Jacksonville.

Effective with this issue of your Journal, his new contact information is as follows:

12740 Shellcracker Road, Jacksonville, FL 32226 USA;
e-mail to dr.mike@ootwastro.com

Wayne Bailey, who heads several ALPO lunar studies programs, is gradually relocating to Arizona. Effective with this issue of your Journal, his new contact information is as follows;

14120 S. Mica Place, Tucson, AZ 85736 USA
e-mail to wayne.bailey@alpo-astronomy.org

Our Advertisers

It is with great relief that all of us in the amateur astronomical community are relieved to know that *Sky & Telescope* magazine has a new owner, that is, the American Astronomical Society.

Sky & Tel has been a loyal and consistent advertiser in this Journal since about 1960. We thank the AAS for stepping up to rescue *Sky & Tel* and with that organization now at the helm, we look forward to many more years of support with perhaps the most appropriate owner this publication could ask for.

F+W, the previous owner of S&T, filed for bankruptcy several months ago after what was described in official paperwork as longtime major management problems at the very top.

Also, it is with great pleasure that the Assn of Lunar & Planetary Observers announces the addition of two new advertisers to the pages of this Journal.

- *Celestron*,an optics industry leader for decades. See their ad on the inside front cover of this Journal.
- *Sirius Astro Products*, maker of Red Eyes "Film" Computer Light Shield, and its cousin, Red Eyes "Acrylic" Computer Light Shield. See their ad on the inside back cover of this Journal.

To all, PLEASE support all of our advertisers.

ALPO 2019 Conference News

Interested parties are hereby invited to submit papers and research posters on the astronomy-related topics of their

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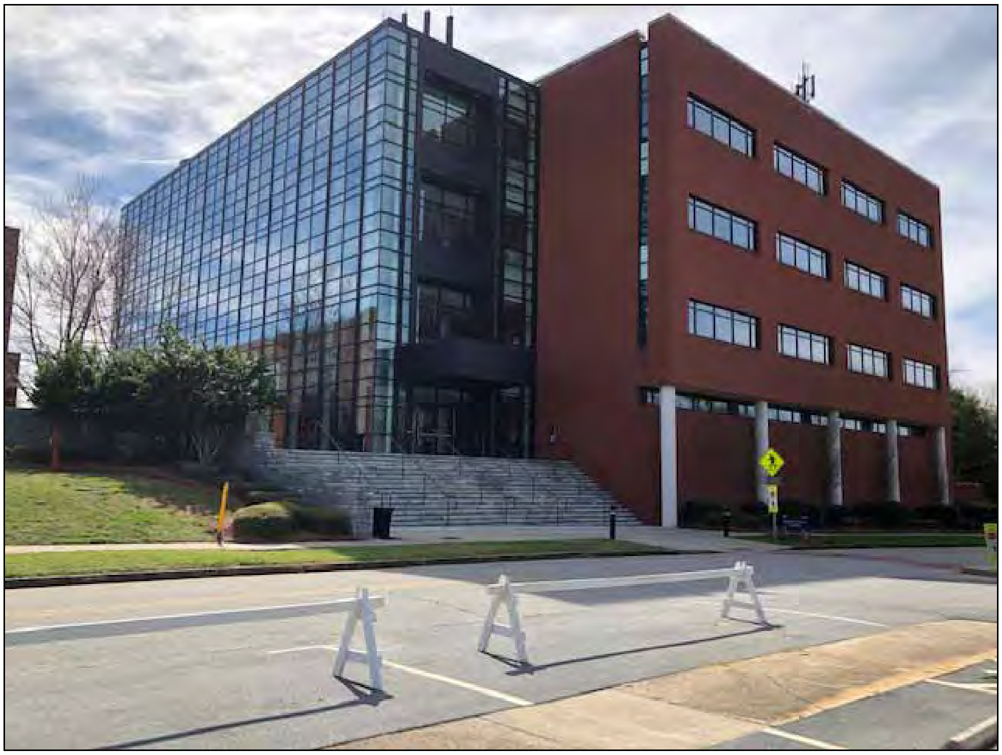

Gordon State College Instructional Complex in Barnesville, Georgia, site of the 2019 ALPO Conference presentations.

choice for presentation at the next ALPO conference to be held jointly with the Southeastern Region of the Astronomical League at Gordon College, in Barnesville, Georgia, Friday and Saturday, July 15 and 16, 2019.

Barnesville is located just southwest of Atlanta and is accessible by air via Atlanta's Hartsfield Airport and by freeway via _I-75.

Paper presentations will take place at the school's Instructional Complex building from 9 a.m. to 5 p.m., on both Friday and Saturday. The annual ALPO board meeting will be held on Saturday evening. The traditional awards dinner with featured speaker will be on Saturday evening at Brian's Buffet restaurant, 1323 North Expressway, in Griffin, Georgia

ALPO Interest Section Reports

ALPO Online Section

Larry Owens, section coordinator
Larry.Owens@alpo-astronomy.org

See the Publications Section report on page 7 for an update on the progress made with making the ALPO Journals and indexes available online.

Follow us on Twitter, "friend" us on FaceBook or join us on MySpace.

To all section coordinators: If you need an ID for your section's blog, contact Larry Owens at *larry.owens@alpo-astronomy.org*

For details on all of the above, visit the ALPO home page online at *www.alpo-astronomy.org*

Computing Section

Larry Owens, section coordinator
Larry.Owens@alpo-astronomy.org

Important links:

- To subscribe to the ALPOCS yahoo e-mail list, *http://groups.yahoo.com/group/alpocs/*
- To post messages (either on the site or via your e-mail program), *alpocs@yahoogroups.com*
- To unsubscribe to the ALPOCS yahoo e-mail list, *alpocs-unsubscribe@yahoogroups.com*
- Visit the ALPO Computing Section online at *www.alpo-astronomy.org/computing*

Lunar & Planetary Training Program & 'Observers Notebook' Podcasts

Tim Robertson, program coordinator
cometman@cometman.net

ALPO Lunar & Planetary Training Program

The ALPO Training Program currently has 3 active students at various stages of the program.

The ALPO training program is a two-step program, and there is no time requirement for completing the steps. But I have seen that those students who are motivated usually complete the program in a short amount of time. That motivation comes from the desire to improve their observing skills and

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contribute to the pages of the Journal of the ALPO.

The ALPO Lunar & Planetary Training Program is open to all members of the ALPO, beginner as well as the expert observer. The goal is to help make members proficient observers. The ALPO revolves around the submission of astronomical observations of members for the purposes of scientific research. Therefore, it is the responsibility of our organization to guide prospective contributors toward a productive and meaningful scientific observation.

The course of instruction for our program is two-tiered.

- The first tier is the "Basic Level" and includes reading the ALPO's *Novice Observers Handbook* and mastering the fundamentals of observing. These fundamentals include performing simple calculations and understanding observing techniques.
- When the student has successfully demonstrated these skills, he or she can then advance to the "Novice Level" for further training where one can specialize in one or more areas of study. This includes obtaining and reading handbooks for specific lunar and planetary subjects. The novice then continues to learn and refine upon observing techniques specific to his or her area of study and is assigned to a tutor to monitor the novice's progress in the Novice Level of the program.

When the novice has mastered this final phase of the program, that person can then be certified to "Observer Status" for that particular field.

'Observers Notebook' Podcasts

The Observers Notebook podcast is going strong with over 70 podcasts recorded with various members of the ALPO, mostly section coordinators to highlight the programs within each section. While the length of the podcast averages around 30 minutes, the longest podcast thus far is over 1 hour and 30 minutes. But we can record longer and there is no time limit — the hosting service that I am using has unlimited space available for podcasts.

It takes a great amount of time and money to make and produce the podcast. Thus far it has been done with the help of service called Patreon, and we currently have five supporters – two of whon are NOT even members of the ALPO!

You can support the podcast by giving as little as $1 a month; for a $5 monthly donation, you receive early access to the podcast before it goes public; for a monthly donation $10, you receive a copy of the *Novice Observers Handbook*, and for $35 a month, you receive producer credits on the podcast and a one-year membership in the ALPO. You can help us out by going to the link below:

https://www.patreon.com/ObserversNotebook

The most recent podcasts now online include:

A member profile of Mike Reynolds, Bob Lunsford discussing the May Aquariids Meteor Shower

, and from outside the ALPO I interviewed Gary Tomlinson of the Astronomical League about National Astronomy Day and also from Kosovo Pranvera Hyseni!

- A fun conversation with Carl Hergenrother on the upcoming comets for 2019.
- Lunar expert and founder of the *Lunar Photo of The Day* website, Chuck Wood who came on to chat about everything lunar.
- Astronomical League Master Observer couple of David and Valorie Whalen who chatted with me about the process they went through to get that prestigious award.
- Gary Tomlinson, who came on to discuss National Astronomy Day.
- Mike Reynolds, who talked about his life and career in astronomy.

If you have an idea for a podcast, please drop me a note. I would like to have a discussion on the use of color filters for planetary observing and how you plan your own evening observing sessions. If any of you would be interested in discussing those subjects, please let me know.

I am also looking for member profile pieces where we get to know the members of the ALPO. Please contact me if any of you would be interested in discussing those subjects.

Our podcasts are also used to announce any breaking astronomy news or events happening in the night sky. So let me know if you have any breaking news that you want announced.

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Here are a few interesting statistics you might be interested in as well:

- Number of downloads as of January 14, 2019: 15,000+
- Number of subscribers (all formats): 200+
- Average of number daily downloads (last 3 months): 53
- iTunes rating: 5 Stars!
- Locations of most downloads: USA, UK, Canada, Australia, Sweden, France, and Germany.
- The number one most downloaded podcast so far is with Mars Geologist Caitlin Ahrens, a graduate of West Virginia University with Bachelor of Science degrees in Geology and Physics with an emphasis in Astrophysics. Episode 53.

You can hear the podcast on iTunes, Stitcher, iHeart Radio, Amazon Echo, and Google Play just search for *Observers Notebook*. You can also listen to it at the link below:

https://soundcloud.com/observersnotebook

The *Observers Notebook* is also on Facebook – just search for "Observers Notebook" in the search field on top.

Thanks for listening!

For more information about the ALPO Lunar & Planetary Training Program or the *Observers Notebook*" podcasts, contact Tim Robertson at:

• (e-mail) cometman@cometman.net
•(regular mail) Tim Robertson
195 Tierra Rejada Rd #148
Simi Valley CA, 93065

Publications Section

Ken Poshedly, section coordinator
ken.poshedly@alpo-astronomy.org

We are pleased (and somewhat relieved) to announce that the entire library of ALPO Journals (subtitled *The Strolling Astronomer*) through DJALPO-60-4-Autumn-2018 is now available as searchable pdf (portable document format) files online at the ALPO website.

Issues for 2019 are available only to dues-paying ALPO members; those issues will be posted to the ALPO website gallery for access to all later this year.

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Our next project is to complete posting of the indexes to our Journals to the ALPO website.

To access the Journals, go to alpo-astronomy.org, then click on ALPO Section Galleries near the top of the right sidebar.

Next, click on the Publications Section icon, then click on ALPO Journals to open the two-screen library.

The Journals are arranged from latest to oldest. To access the second screen, click on the number "2" near the top left of the first screen. To return to the first screen, click on the number "1" near the top left of the second screen.

To access a particular Journal, click on the folder icon for that volume (or year), for instance DJALPO Volume 54 for calendar year 2012.

Once inside that folder, simply click on the desired issue then either click on either the left or right blue text prompt as desired.

HINT: It is best to download the desired issue to your computer for access at a later time if you do not have a stable Internet connection.

All of the Journals are searchable using Adobe Reader or equivalent, that is, you can use your program's "Find" tool to locate key words or phrases within that issue.

Plus, beginning with the Winter 2001 issue (Volume 43, No. 1), there are two methods to "jump" directly to a desired article or other item. With the Journal on your screen:

- Click on the electronic bookmark at the left side of the screen for the item you wish to read, or
- Go to page 1 of that issue and left-click your mouse-pointer on the desired item in the table of contents.

Another feature in the later issues allows you to "jump" to outside resources or your own email program by clicking on the blue text hyperlinks.

All of the Journals may be printed out if so desired.

Also, all of our Journals and their contents have been provided to the SAO/NASA Astrophysics Data System (ADS), a Digital Library portal for researchers in Astronomy and Physics and which is operated by the Smithsonian Astrophysical Observatory (SAO) under a NASA grant.

Finally, note that references in some ALPO Journals may point to an out-of-date location where ALPO Journals had been located. If you are taken to a "locked" Journal, simply follow the instructions above to reach the free and open version of that Journal on the ALPO website.

I will be most happy to answer any questions regarding these matters.

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Available indexes in the ALPO Publications Section Gallery are as follows:

- Volumes 1 through 8.
- Volumes 16 through 29.
- Volumes 34 thru 56.

We will post the remaining indexes as soon as they are made available.

All Journals and indexes are freely available with no password required.

Besides the ALPO journals and indexes, the Publications Section Gallery also includes various observing forms and monographs, all of which will be upgraded as new versions are made available.

To begin your own exploration of the Publications Gallery:

1. Go to the ALPO home page at http://www.alpo-astronomy.org/, then click on the “ALPO Section Galleries” link at the top-right of the screen.
2. Click on the icon for the “Publications Section”.
3. Click on the icon for the “ALPO Journals”.
4. Click on the icon for any of the various years.
5. Click on the icon for any of the Journals in the chosen year.
6. Click on the link near the top of the screen to access that publication.

Accessing the monographs and observing forms is similar.

Then either save the document to your own computer or just read it online without saving it. Saving the document to your own terminal allows you to access it at any time, even if online access is not available.

Call for JALPO Papers

The ALPO appreciates articles for publication and encourages its membership to submit written works (with images, if possible).

As with other peer-reviewed publications, all papers will be forwarded to the appropriate observing section or interest section coordinator.

Thus, the best method is to send them directly to the coordinator of the ALPO section which handles your topic.

A complete list of ALPO section coordinators and their contact information can be found in the *ALPO Resources* section of this Journal.

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ALPO Observing Section Reports

Eclipse Section

Mike Reynolds, section coordinator
dr.mike@ootwastro.com

Total Solar Eclipse
The next total solar eclipse is 2 July 2019. Those experiencing totality will have a maximum duration of 4 minutes and 33 seconds. Partial phase will be visible in the South Pacific and South America, whereas totality visible in the South Pacific, Chile, and Argentina. The altitude of totality over land will be low, presenting observers with challenges. However if clear weather prevails, a stunning sunset eclipse will be visible.

Please submit eclipse reports, including inclement weather, to the ALPO Eclipse Section. We are planning a preliminary results talk for this summer's ALPO-SERAL Conference on July 12-13.

January 2019 Total Lunar Eclipse
We are still accepting reports on the 20-21 January 2019 total lunar eclipse.

Please continue to send your reports via either email or regular mail to the contact information in the *ALPO Resources* section of this Journal.

Visit the ALPO Eclipse Section online at *www.alpo-astronomy.org/eclipseblog*

Mercury / Venus Transit Section

Mike Reynolds, acting section coordinator
m.d.reynolds@fscj.edu

It is with great humility that Keith Spring and I are now tasked with running the ALPO Mercury/Venus Transit Section.

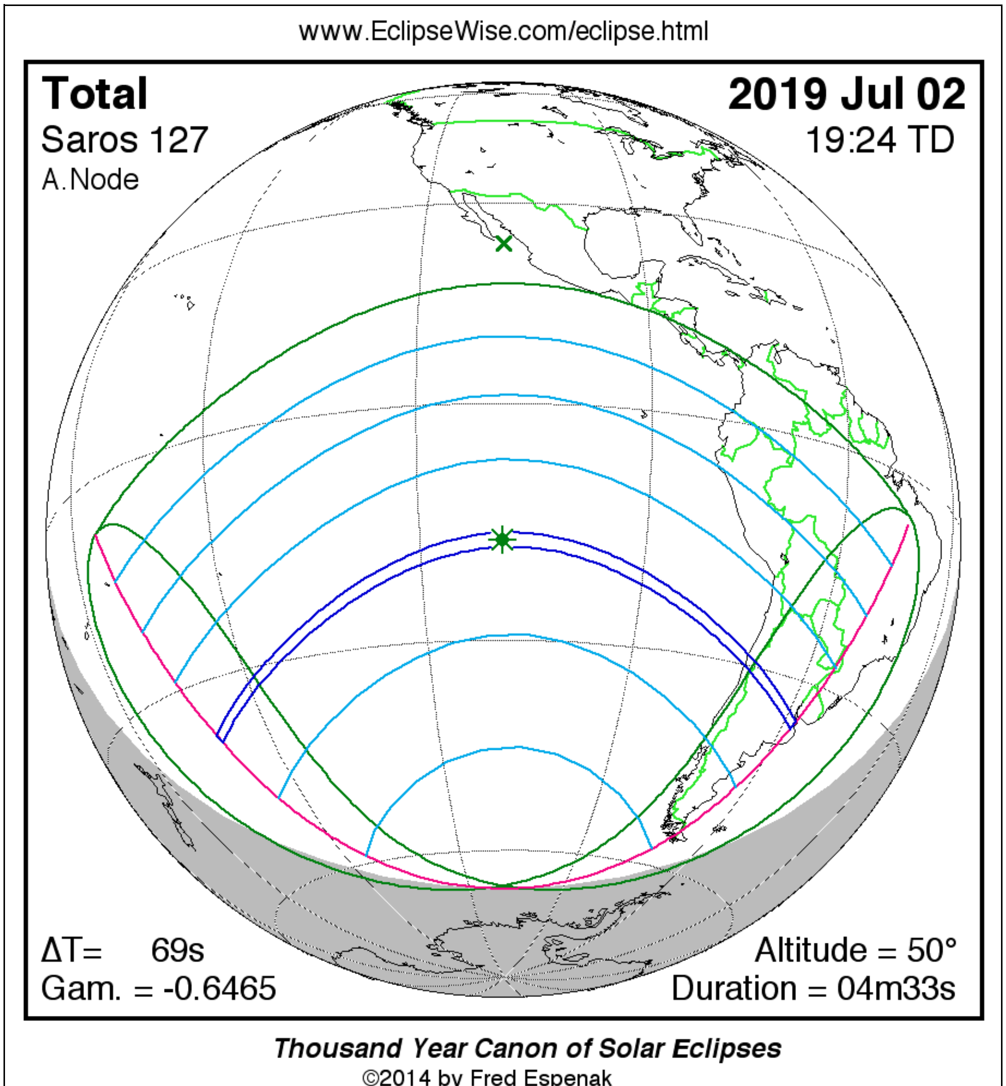
This section was aptly chaired by the late John Westfall whose shoes we can never fill.

Transit of Mercury 11 November 2019
This November we will have the opportunity to observe a transit of Mercury. This is fairly-well placed for most North and South American Observers. The path of Mercury across the face of the sun is nearly dead-center.

A full report and planning guide will appear in the next JALPO, and Mercury Coordinator Frank Mellilo will give a talk about the November transit at the summer's ALPO-SERAL Conference.

Transit of Mercury 13 November 2032

The next transit of Mercury will occur 13 years after this November's event. And if you are calendaring future transits,



Graphic courtesy of Fred Espenak, *http://www.mreclipse.com/main/preview.html*

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please include the next transit of Venus on 10-11 December 2117.

Visit the ALPO Mercury/Venus Transit Section online at www.alpo-astronomy.org/transit

Meteors Section

Robert Lunsford, section coordinator
lunro.imo.usa@cox.net

A reminder here that your section recorder has taken advantage of podcasts to verbally spread the news of upcoming major meteoric events. Tim Robertson does a great job asking interesting questions while I try my best not to bore the listener! Give these podcasts a try at:

https://soundcloud.com/observersnotebook

Be sure to also check out the other interesting podcasts offered by the many sections of ALPO!

Visit the ALPO Meteors Section online at www.alpo-astronomy.org/meteorblog/ Be sure to click on the link to viewing meteors, meteor shower calendar and references.

Meteorites Section

Report by Dolores H. Hill, section coordinator
dhill@lpl.arizona.edu

Section News

This report includes meteorite highlights and new meteorite approvals from February 1, 2019 to April 15, 2019 from the Meteoritical Society's Nomenclature Committee.

We received several inquiries about suspected meteorites, most of which are terrestrial and do not require further analysis. As always, ALPO members who collect meteorites are encouraged to report unusual features in their meteorite samples that might be of interest to researchers for specialized analysis.

Meteorite News

Noteworthy meteorites approved or updated during this period include 5 witnessed chondrite falls that were accompanied by sounds: Natun Balijan L4 (India); Jalangi L5/6 (India); Benenitra L6 (Madagascar); Komaki L6 (Japan); Viñales L6 (Cuba) and one probable fall in India: Bhanupratappur L4. (Note these did not necessarily fall in the same year).

The *Meteoritical Bulletin Database* (https://www.lpi.usra.edu/meteor/) records officially recognized, classified meteorites of the world's inventory. As of April 15, 2019, it contains a total of 60,788 meteorites. There were 632 new meteorites approved, most from desert regions. Newly approved meteorites include 507 ordinary chondrites (267 H, 189 L, 50 LL, 3 chondrite-ung); 41 carbonaceous chondrites (1 C1-ung, 1 CBa, 1 CH3, 5 CK, 2 CM2, 7 CO, 1 CR3, 20 CV), 8 R chondrites, 1 EH3; 4 irons; 1 acapulcoite; 4 mesosiderites, 2 winonaites; 13 ureilites; 37 HEDs; 6 lunars; 7 Martian Shergottites; 1 discredited chondrite.

For more information and official details on particular meteorites, go to https://www.lpi.usra.edu/meteor/metbull.php

Antarctic meteorite Miller Range 15539 (MIL 15539) was the smallest meteorite reported this period with a mass of only 0.74 grams. The largest meteorite reported was the 102 kg Bojiyare L5 chondrite from Kenya.

Visit the ALPO Meteorites Section online at www.alpo-astronomy.org/meteorite/

Comets Section

Report by Carl Hergenrother, section coordinator
carl.hergenrother @ alpo-astronomy.org

Over the past quarter, most visual comet watchers were either catching up on their sleep or observing other types of objects. As of this writing (early April), 2019 remains a slow year for comets bright enough to be seen in small backyard telescopes. And it seems that, unfortunately, the upcoming quarter will see more of the same with only one long-period comet, C/2018 W2 (Africano), possibly providing some excitement towards the end of the quarter.

C/2018 W2 (Africano) was discovered nearly simultaneously by Hannes Groeller with the Catalina Sky Survey 0.68-m schmidt and Brian Africano with the Mount Lemmon 1.5-m reflector. Groeller actually observed the comet first, but Africano was the first to submit his discovery report to the Minor Planet Center. C/2018 W2 is a dynamically old long-period comet that will reach perihelion on 2019 September 5 at 1.45 AU. Comet Africano has been near solar conjunction since late March when it was last seen between magnitudes 15.8 and 16.6. As a result, the predicted magnitudes for the July-through-September quarter may be not reflect reality.

By July 1st, Comet Africano will be located in the northeastern sky just before dawn at between 13th and 14th magnitude. The comet will steadily brighten and may even break magnitude 10.0 by mid-September. Peak brightness occurs around the time of its closest approach to Earth on Sep 27 at 0.49 AU.

While the comet will initially be well-placed for northern observers, observers in the southern hemisphere will need to

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Ephemerides for Comet C/2018 W2 (Africano) NEW 4-8

Date	R.A.	Decl.	r (au)	d (au)	Elon (deg)	m1	Const	Max El 40°N	Max El 40°S
2019 Jul 01	04 27.14	+60 00.0	1.73	2.311	43	13.7	Cam	26	0
2019 Jul 11	04 30.18	+60 14.0	1.66	2.158	48	13.4	Cam	30	0
2019 Jul 21	04 30.46	+59 35.7	1.598	1.977	53	13.0	Cam	36	0
2019 Jul 31	04 26.86	+59 2.0	1.545	1.769	60	12.6	Cam	43	0
2019 Aug 10	04 17.42	+58 26.6	1.503	1.537	68	12.2	Cam	51	0
2019 Aug 20	03 58.80	+57 34.6	1.474	1.287	78	11.7	Cam	60	0
2019 Aug 30	03 25.27	+55 45.4	1.458	1.026	91	11.2	Cam	71	0
2019 Sep 09	02 28.71	+50 53.6	1.455	0.772	108	10.6	And	79	0
2019 Sep 19	01 07.64	+37 17.5	1.467	0.566	136	9.9	And	87	13
2019 Sep 29	23 43.42	+09 31.1	1.492	0.497	168	9.7	Peg	57	43

Long-period comet C/2018 Y1 (Iwamoto) peaked at around 6th magnitude in February. This CCD image was taken by Martin Mobberley on 2019 February 8, one day after perihelion.

wait until mid-September for their chance to visually observe this comet.

Image caption: Long-period comet C/ 2018 Y1 (Iwamoto) peaked at around 6th magnitude in February. This CCD image was taken by Martin Mobberley on 2019 February 8, one day after perihelion.

As always, the Comet Section is happy to receive all comet observations, whether images, drawings, magnitude estimates, and even spectra. Please send your observations via email to *carl.hergenrother @ alpo-astronomy.org*

Drawings and images of current and past comets are being archived in the ALPO Comets Section image gallery at *http://www.alpo-astronomy.org/gallery/main.php?g2_itemId=4491*

Visit the ALPO Comets Section online at *www.alpo-astronomy.org/comet*

Solar Section

Report by Rik Hill, section coordinator & scientific advisor
rhill@lpl.arizona.edu

Solar activity continues at a very low level, still heading for a minimum predicted for some time in 2022-23 according to the Space Weather Prediction Center at NOAA.

The ALPO Solar Section staffing and operations are very stable and while growth in members is poor during solar minimum, we still have a good core of active observers. In the first 4 rotations of the current year (CR2213-16), 1,176 images and observing reports were entered into the archive from about half our observers. We have 6 potential observers from other countries that have expressed interest in joining but as yet have not.

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Assistant Coordinator Theo Ramakers has taken particular interest in monitoring the Sun for reverse polarized areas indicating the new cycle, Cycle 25 starting up. One of his observations here shows just such a region so take heart, things may be starting back up!

In closing, I again want to mention that a group of Europeans under the coordination of Christian Viladrich (whose excellent images can be seen in our reports) have published a new book about solar observing in French. This book, *Astronomie Solaire* (*Solar Astronomy*) is now available from Springer Verlag. It was co-written with a group of his fellow solar observers much like *Observe and Understanding the Sun* was authored by a group of our own solar observers in the second half of 2015.

So if you are all fluent in French, you might want to check this out!

For more information go to:

http://www.astronomiesolaire.com/index.php

To join the Yahoo Solar ALPO e-mail list, please go to *https://groups.yahoo.com/neo/groups/Solar-Alpo/info*

For information on solar observing – including the various observing forms and information on completing them – go to *www.alpo-astronomy.org/solar*

Mercury Section

Report by Frank J. Melillo, section coordinator
frankj12@aol.com

By the time you read this, Mercury will be on its way towards inferior conjunction with the Sun on July 21, where it will pass roughly 5 degrees south of the Sun, about the furthest away from the Sun during conjunction.

Unlike Venus, there is no way that Mercury can be visible as a 5th magnitude object at a 0.01% illuminated disk in full daylight!

But the good news is that Mercury is heading for a favorable morning apparition. By the first week of August, it should be faintly visible as a rosy star, but a pair of binoculars may be needed to see it clearly in the morning twilight. The second week of August should be a lot better, as Mercury approaches its greatest elongation on August 10. On that day, Mercury will appear as a 0-magnitude star at 19 degrees (west) of the Sun. Telescopically, it is slightly less than a half-phase with 7.4-arc seconds disk diameter.

By the third week of August, Mercury improves its visibility to nearly -1.0 magnitude! But it will move slightly closer to the Sun, about 15 degrees away. Its appearance through the eyepiece is gibbous and just under 6 arc-seconds in diameter. And by month's end, it will be very difficult to see Mercury as it approaches superior conjunction on September 4.

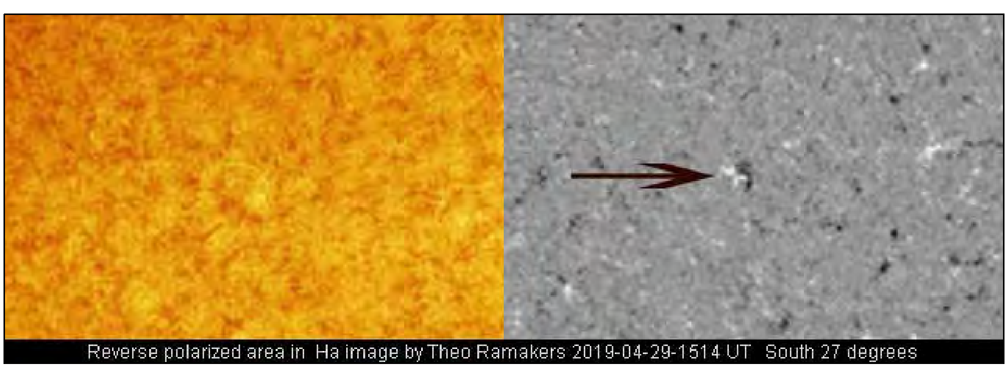
Unfortunately, throughout the whole morning apparition, there is no planetary conjunction or even a crescent moon

Mercury Needs You!!

More correctly, the ALPO Mercury Observing Section needs you.

Your reports — no matter how sparse they may be — are indeed valuable for scientific research.

Our professional-amateur collaboration activities are getting stronger and we need you to keep the movement going!



See Solar Section report text for details.

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near Mercury. So, again, it is just a rosy star twinkling lonely in the morning twilight. Please send in your observations to the Mercury section!

Please be sure to send in your observations to the Mercury section so we can have nice coverage of its favorable morning apparition of the year.

Visit the ALPO Mercury Section online at *www.alpo-astronomy.org/mercury*

Venus Section

Report by Julius Benton, section coordinator
jlbaina@msn.com

Venus continues to rise a few hours ahead of the Sun as summer approaches, but becomes more difficult to view as conjunction with the Sun approaches on August 14, 2019. During the current 2018-19 Western (Morning) Apparition, Venus continues to progress through its waxing phases as it shrinks in angular diameter slowly changing from a thin crescent to a gibbous and ultimately a fully illuminated disk as it reaches Superior Conjunction.

The accompanying table of Geocentric Phenomena in Universal Time (UT) are presented for the convenience of observers for the 2018-19 Western (Morning) Apparition.

As of the date of this report (early January), a considerable number of excellent visual drawings in integrated light and with color filters, as well as digital images at UV and near IR wavelengths have been received from several ALPO Venus Section observers for the ongoing 2018-19 western (morning) apparition.

Readers of this Journal should be familiar with our on-going collaboration with professional astronomers as exemplified by our sharing of visual observations and digital images at various wavelengths during ESA's previous *Venus Express* (VEX) mission that ran for about nine years from 2006 until the mission ended in 2015. It remains as one of the most successful Pro-Am efforts to date involving ALPO Venus observers around the globe. Such observations will remain important for further study and will continue to be analyzed for several years to come as a result of this endeavor.

For reference, the VEX website is *http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38833&fbodylongid=1856.*

A follow-on collaborative Pro-Am effort continues in in 2019 in support of Japan's (JAXA) *Akatsuki* mission that began full-scale observations starting back in April of 2016. The website for the *Akatsuki* mission has is currently active so interested and adequately equipped ALPO observers can still register and start submitting images if they have not already done so. More information will continue to be provided on the progress of the mission in forthcoming reports in this Journal.

It is extremely important that all observers participating in the programs of the ALPO Venus Section always first contribute their observations to the ALPO Venus Section at the same time submittals are sent to the Akatsuki mission.

This will enable full coordination and teamwork between the ALPO Venus Section and the Akatsuki team in collection and analysis of all observations whether they are submitted to the Akatsuki team or not. If there are any questions, please do not hesitate to contact the ALPO Venus Section for guidance and assistance.

Those still wishing to register to participate in the coordinated observing

NEW 3-31 -- Paul Maxson of Surprise, AZ, submitted an excellent UV and IR image of Venus taken at 14:10 UT on January 8, 2019 employing his 25.4cm (10.0 in.) Mewlon (Dall Kirkham) telescope under fair seeing conditions. The UV image shows a shaded and slightly irregular terminator and banded dusky markings across the disk as well as the bright limb band running partially along the limb of Venus between the northern and southern cusps. The apparent diameter of Venus is 24.3", phase k=0.515 (5`1.5% illuminated), and visual magnitude -4.5. This image occurs roughly three days following the time of predicted dichotomy (half phase or 50% illuminated) that occurred on January 05, 2019. South is at upper left top of image.

Geocentric Phenomena of the 2018-19 Western (Morning) Apparition of Venus in Universal Time (UT)

Inferior Conjunction	2018 Oct 26 14^h (angular diameter = 61.8°)
Predicted Dichotomy	2019 Jan 05.81^d (Venus is predicted to be exactly half-phase)
Greatest Elongation West	2019 Jan 06 05^h (46°)
Superior Conjunction	2019 Aug 14 06^h (angular diameter = 61.8")

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effort between the ALPO and Japan's (JAXA) *Akatsuki* mission should utilize the following link:

https://akatsuki.matsue-ct.jp/

The observation programs of the ALPO Venus Section are listed on the Venus page of the ALPO website at *http://www.alpo-astronomy.org/venus* as well as in considerable detail in the author's *ALPO Venus Handbook* available from the ALPO Venus Section as a pdf file.

Observers are urged to attempt to make simultaneous observations by performing digital imaging of Venus at the same time and date that others are imaging or making visual drawings of the planet. Regular imaging of Venus in both UV, IR and other wavelengths is important, as are visual numerical relative intensity estimates and reports of features seen or suspected in the atmosphere of the planet (for example, dusky atmospheric markings, visibility of cusp caps and cusp bands, measurement of cusp extensions, monitoring the Schröter phase effect near the date of predicted dichotomy, and looking for terminator irregularities).

Routine use of the standard ALPO Venus observing form will help observers know what should be reported in addition to supporting information such as telescope aperture and type, UT date and time, magnifications and filters used, seeing and transparency conditions, etc. The ALPO Venus observing form is located online at:

http://www.alpo-astronomy.org/gallery/main.php?g2_view=core.DownloadItem&g2_itemId=85642

Venus observers should monitor the dark side of Venus visually for the Ashen Light and use digital imagers to capture any illumination that may be present on the plane as a cooperative simultaneous observing endeavor with visual observers. Also, observers should undertake imaging of the planet at near-IR wavelengths (for example, 1,000 nm), whereby the hot surface of the planet becomes apparent and occasionally mottling shows up in such images attributable to cooler dark higher-elevation terrain and warmer bright lower surface areas in the near-IR.

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

Individuals interested in participating in the programs of the ALPO Venus Section are encouraged to visit the ALPO Venus Section online *http://www.alpo-astronomy.org/venusblog/*

Lunar Section

Lunar Topographical Studies / Selected Areas Program

Report by Wayne Bailey, program coordinator
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The ALPO Lunar Topographical Studies Section (ALPO LTSS) received a total of 163 observations from 18 observers during the January-March quarter.

Eighteen contributed articles were published in addition to numerous commentaries on images submitted.

The *Focus-On* series continued under Jerry Hubbell, with an article on the Apollo 14 Region.

The next *Focus-On* subjects will continue the series on each of the Apollo landing sites.

Alberto Anunziato also recently sent the following announcement of the formation of a new lunar observing society. The photo was taken at the inaugural meeting.

"On March 1 at 7:00 pm in the city of Paraná, Argentine Republic, la Sociedad Lunar Argentia-Argentine Lunar Society (SLA) was formally inaugurated. The first Latin American association specifically dedicated to lunar studies was born under the auspices of the Liga Iberoamericana de Astronomía-Ibero-American League of Astronomy (LIADA), the entity that have gathered amateur and professional astronomers from 19 Latin American countries, Spain and Portugal for 60 years, and with the support from the Centro de Observadores del Espacio-Center for Space Observers (CODE), the

Inauguration photo of the newly formed la Sociedad Lunar Argentia-Argentine Lunar Society (SLA), the first Latin American association specifically dedicated to lunar studies.

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Faculty of Chemical Engineering of the National University of the Litoral and the Nova Persei II Observatory of Formosa. The objective of the SLA is to promote and disseminate amateur lunar observation and space exploration. The new astronomical association will have its headquarters shared between the cities of Santa Fe and Paraná, very close geographically to each other. The inaugural event included three lectures:

Copernicus as imaged by Maurice Collins, of Palmerston North, New Zealand, on April 17, 2019, 09:02-10:02 UT. FLT-110 f/14. ASI120MC North is at bottom. (Source: June 2019 *The Lunar Observer*.)

'Lunar Observation and Exploration: Past, Present and Future' (Alberto Anunziato), 'Luna Movements' (Prof. Dr. Raúl Roberto Podestá) and 'A Clock on the Moon' (Dr. Roberto Aquilano). The Argentine Lunar Society already has members in the provinces of Entre Ríos, Santa Fe, Córdoba, Formosa and San Juan."

The members of the SLA have been regular contributors to the ALPO lunar section. We wish them success with their new organization and look forward to continued cooperation.

Electronic submissions can now be submitted through the ALPO website, (lunar@alpo-astronomy.org). (This is the preferred method, while the former method of sending them to both myself and Jerry Hubbell will still work. In any case, please do NOT submit through the website AND directly to myself and Jerry Hubbell). See the most recent issue of *The Lunar Observer* (moon.scopesandscapes.com/tlo) for instructions on its use. Hard copy submissions should continue to be mailed to me at the address listed in the ALPO resources section of the Journal.

The lunar image gallery/archive is also now active. By the end of the year all images submitted in 2018 should be available. Images will continue to be inserted, working back through the years

Thanks to Theo Ramakers and Larry Owens for setting up the gallery.

Visit the following online web site for more info moon.scopesandscapes.com (including current and archived issues of *The Lunar Observer*).

Lunar Meteoritic Impacts

Brian Cudnik, program coordinator
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Since the lunar meteor impact observed during the Total Lunar Eclipse last January, we have not received any further observation reports about lunar meteor activity. This could change as we move into the time of year (late Spring-Summer) where meteor streams become more active.

Please visit the ALPO Lunar Meteoritic Impact Search site online at http://alpo-astronomy.org/lunarupload/lunimpacts.htm

Lunar Transient Phenomena

Report by Dr. Anthony Cook, program coordinator
tony.cook@alpo-astronomy.org

Three LTP reports have been received since the last JALPO section report that summarized observation:

- 2019 Mar 24 UT 21:30 (±30 min) Julien Quirin (Société Astronomique de France) imaged Alphonsus and captured a faint blue fuzzy glow in the shadowed area and also on the needly-like shadow to the west of the central peaks, with a bit of blue also on the eastern illuminated rim. Although no adjacent craters in the image exhibited this effect, another image of the Montes Alpes area showed something similar. This has been tentatively given an ALPO/BAA weight of 1, in order to encourage repeat illumination imaging, but it sounds like an internal reflection issue in the optics, as a Barlow was being used.
- 2018 Jun 19 UT 20:18 Gene Cross (ALPO), using a 60-inch reflector at Mt Wilson Observatory, found that the ghost crater near Ross D was not visible. This has been given a weight of 1 until we obtain some repeat illumination images.
- 2018 Jul 21 UT 21:04 Julien Quirin (Société Astronomique de France) videoed a moving white spot off the WSW limb of the Moon followed by a brief red flash. This was captured

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whilst the observer was on holiday in the south of France. We are not sure exactly what this might have been, but possibly it was a drone with flashing lights that just happened to be seen along the line of sight to the Moon? Due to the large movement involved this clearly was not lunar in origin and so does not make it into our LTP catalog.

Lunar observers are encouraged to image, or visually observe, the Moon at specific narrow selenographic colongitude and sub-solar latitude observing windows that match those of many past LTP observations on: *http://users.aber.ac.uk/atc/lunar_schedule.htm* . This has proved very successful in eliminating some past LTP reports as normal appearances of the lunar surface.

We welcome new participants in our program, whether they are experienced visual observers, or high-resolution lunar imagers. This helps us to solve some past historical lunar observational puzzles.

LTP observational alerts are given on this Twitter page: *https://twitter.com/lunarnaut*

Finally, please visit the ALPO Lunar Transient Phenomena site online at *http://users.aber.ac.uk/atc/alpo/ltp.htm*

Lunar Domes

Report by Raffaello Lena, acting program coordinator
raffaello.lena@alpo-astronomy.org

A report on the Marius Shield (Part 2) appears later in this issue of your ALPO Journal.

We have received many images, including some by Tom Astron, Javier Fuertes, Richard Hill, K.C. Pau, Guy Leinen, Frank Schenck, Martin Stenke, Ryan Cornell, John Ho, Howard Eskildsen, Hartmut Schubert and Raffaello Lena for a total of 102 images. Some images display the well-known domes in Arago, Milichius, Birt domes and Kies dome.

Frank Schenck has imaged the domes near Lansberg D, the Wollanston domes, Marius hills and the Kepler dome.

Martin Stenke has imaged the Grimaldi dome, a large intrusive dome already described in our previous studies.

Tom Astron has imaged the Hortensius-Milichius domes.

Guy Leinen has imaged the dome Herodotus omega, the wide domes field in Milichius-T. Mayer, the Valentine dome and its northern dome termed V2, the domes near Hortensius and two domes near Reinhold, two domes near Laplace, Rümker domes, Grimaldi dome, Petavius dome, Yerkes dome, Gruithuisen domes and the domes near Archytas, Aristillus, Autolycus, Palus Putredinis and Huxley.

Pau has imaged the domes near Gambart D, Marius hills, dome Herodotus omega and the domes near Vitruvius-Cauchy region.

Richard Hill has imaged the domes in Laplace.

Schubert has imaged Archimedes and the Apennine Bench formation.

Eskildsen has submitted images of Hortensius-Milichius-T. Mayer domes field, Kies and Capuanus domes, Gambart domes, Birt bisected domes, Archytas dome, Marius hills, Gruithuisen highland domes, Rümker domes and Gardner megadome with Cauchy domes.

Lena has imaged the Petavius dome and some domes in mare Fecunditatis.

Interested observers can publish their future images using the email *lunar-domes@alpo-astronomy.org* .

Wierzchos on January 18, 2019, at 23:35 UT, noticed a dome-shaped structure near Grimaldi C when observing with a 4-inch f/9 refractor at 225x. Images under oblique illumination are requested to identify the shape of the suspect feature. Leinen has imaged the dome located near Cavalerius A and Hevelius A in a complex region known as Hevelius Formation, showing evidence of ancient (pre-Orientale) mare volcanism and cryptomare deposits. The image displays part of the dome which has been characterized and described in a previous paper by Lena and Pau. Its height amounts to 188 m and the average slope angle corresponds to 0.83°. Cav 1 lies at coordinates 70.28° W and 3.59° N.

Many images are shared in our Facebook group Lunar Dome Atlas Project, *https://www.facebook.com/groups/814815478531774/*

In March 2019, some Lunar Planetary Science Conference abstracts were published regarding domes in Cauchy shield, near T. Mayer domes field, near Encke crater and near Manilius. The abstracts are online at the following webpage:

https://www.hou.usra.edu/meetings/lpsc2019/pdf/1007.pdf

https://www.hou.usra.edu/meetings/lpsc2019/pdf/1008.pdf

https://www.hou.usra.edu/meetings/lpsc2019/pdf/1012.pdf

https://www.hou.usra.edu/meetings/lpsc2019/pdf/1011.pdf

Two of the LPSC abstracts describe the dome to the east of T. Mayer, termed M21 and the dome termed Encke1 published in this Journal because the ALPO really does favor professional-amateur collaborations.

Wierzchos has noticed the presence of an elevated feature imaged in Apollo imagery AS16-M-1410 located at 8.32° W and 3.88° N in the wide Sinus Aestuum province, which spectrally is characterized by Dark Mantling Deposit

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(DMDs) and pyroclastic glasses described in literature.

The Sinus Aestuum area displays high Titanium content and exhibits extensive evidence of volcanic activity in the form of extensive pyroclastic deposits, often of a Fe-rich spinel/chromite composition. The possible vent structure shows a structure typical of an impact crater chain with a series of craters each separated by a low septum. This crater chain shares a similar orientation to a number of others in the general area, with a general NW-SE trend what seem to be Copernicus secondary clusters. The bright ray originates with the cluster and extends for several kms to the SE, orientated radial to Copernicus. The cluster has impacted the western side of an elevated area, so the ray initially travels up-slope, over the summit and then down the other side. I did not find any certain indications of lava flows. Thus the volcanic activity developed as explosive eruption like other regions in Sinus Aestuum, with emplacement of pyroclastic material, which has a spectral spinel signature. In this scenario, and based on available data, the examined feature cannot be defined as an effusive dome; likely, it is only an elevated area. The volcanism originated only with explosive activity. Based on M3 spectral data, I have identified in several areas of the feature a spinel spectral signature.

The identification of further domes in the wide T. Mayer-Milichius domes field is ongoing and future updates will be done, including morphometric and spectral properties of another dome which is termed M23. Based on recent images, Lena has identified further volcanic constructs near crater Messier. Fecunditatis is a pre-Nectarian impact basin which was filled by ejecta material from neighboring younger basins, Nectaris (the oldest), Crisium, and Imbrium (youngest), ranging in age from 3.7 to 3.5 billion years to 3.4 billion years in the late Imbrium Period. Most of Mare Fecunditatis is filled with lavas that reach thicknesses of a few hundred meters. In previous studies, two domes in Mare Fecunditatis have been examined, named Messier 1 and 2 (Me1 and Me2), respectively. During the observing session made on March 24, 2019, three additional domes near Messier crater, termed Me3 through Me5, were imaged and are under study using the LRO WAC imagery and spectral data.

Interested observers can participate in the lunar domes program by contacting and sending their observations to both Raffaello Lena (*raffaello.lena@alpo-astronomy.org*) and Jim Phillips (*thefamily90@gmail.com*).

Mars Section

Report by Roger Venable, section coordinator
rjvmd@hughes.net

Mars is still visible in the evening sky. On May 15th, it subtended only 4 arc seconds diameter, so it was not an easy object to study, though it remained in the northern sky with a declination of +24.5 degrees. The North Polar Cap remained bright, and was the easiest feature to espy, as the relatively dull white North Polar Hood has cleared. One may be able to glimpse the South Polar Hood, which will appear as a bright area when observed with a blue filter. (Our late, great friend Don Parker used to say “Real men use filters.”)

By June 15th, its angular diameter will diminish to 3.75 arc seconds and its solar elongation will diminish to 25 degrees. The end of this apparition is approaching.

This coordinator expresses his gratitude to the many observers who have faithfully studied Mars during the two years of the present apparition.

The Mars image gallery online has been updated with a great many images. To find it, go the ALPO website at www.alpo-astronomy.org and look in the sidebar on the far right, for "Section Galleries." There you will find lots of images from the ALPO sections, including the Mars Section.

Share your drawings, images, and descriptions with us in the Yahoo Mars observers message list, at *https://groups.yahoo.com/neo/groups/marsobservers/info* .

Minor Planets Section

Frederick Pilcher, section coordinator
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The *Minor Planet Bulletin* is a refereed publication and that it is available online at:

http://www.MinorPlanet.info/MPB/mpb.php

Annual voluntary contributions of $5 or more in support of the publication are welcome.

Please visit the ALPO Minor Planets Section online at *http://www.alpo-astronomy.org/minor*

Jupiter Section

Report by section staff members Schmude, MacDougal and McAnally

Jupiter will be more conveniently visible the evening sky during July. Observers in the southern hemisphere will get the best view. The planet lies near the constellation Scorpius.

This coordinator has collected some near-infrared brightness measurements of Jupiter and hopes to get a few more this summer. Also in thew works is at

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least one Jupiter apparition report this summer. Plans are to make the reports more readable, with images replacing large tables. I believe this will work best and will allow this coordinator to catch up on apparition reports.

Assistant Coordinator Craig MacDougal reports the ALPO_Jupiter Yahoo Group has 510 members as of April 8, 2019. The main activity of the group has been the sharing of images. Observers have already submitted over 100 Jupiter images.

Unfortunately, no activity has been reported to John McAnally (Jupiter Transit Timings Program).

Visit the ALPO Jupiter Section online at http://www.alpo-astronomy.org/jupiter

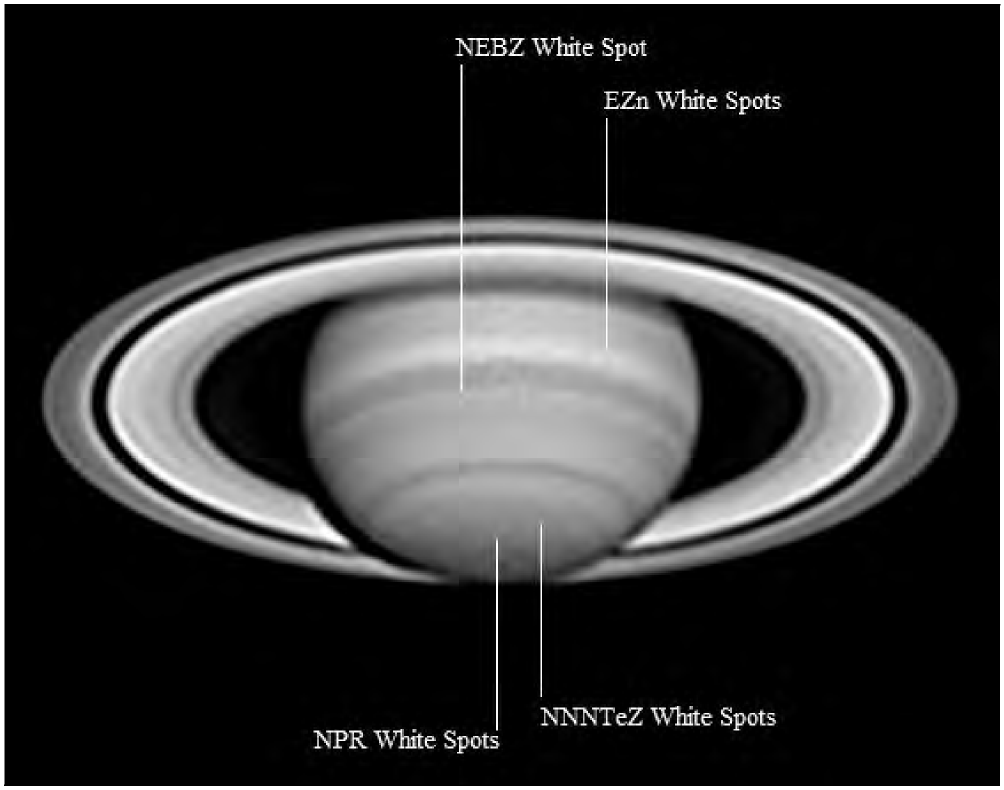
Saturn Section

Report by Julius Benton, section coordinator
jlbaina@msn.com

Saturn's westward elongation increases steadily so that the planet will be well placed for viewing most of the night during the summer months, reaching opposition to the Sun on July 9, 2019, affording favorable opportunities for observers to view, draw, and image the planet most of the night.

The accompanying Table of Geocentric Phenomena for the 2019-20 Apparition in Universal Time (UT) is included here for the convenience of observers.

As of early April, the ALPO Saturn Section had already received a substantial number of excellent digital images of the planet at visual and infrared wavelengths. Observers are reporting discrete atmospheric phenomena in Saturn's northern hemisphere, including an interesting recurring white spot or spots in the EZn (northern half of the Equatorial Zone) interacting with the adjacent EB (equatorial band), plus a



NEW 3-31 -- Excellent image of Saturn taken by Clyde Foster of Centurion, South Africa March 22, 2019 at 02:59 UT. His 685nmIR image was captured in fair seeing using a 35.6cm (14.0 in.) SCT. His image shows the recurring diffuse white spot within the EZn adjacent to the EB, plus a vague appearance of the long-lived white spots in Saturn's NNNTeZ (North North North Temperate Zone) and what appear to be small white spots at the S edge of the NPR (North Polar Region). Cassini's division (A0 or B10) is quite obvious running all the way around the circumference of the rings except where the globe blocks our view of the rings. The north polar hexagon is also barely visible. The apparent diameter of Saturn's globe was 16.0" with a ring tilt of +23.7º. CMI = 183.6º, CMII = 129.2º, CMIII = 237.0º. Apparent visual magnitude = +0.6. South is at the top of the image.

Table of Geocentric Phenomena for the 2019-20 Apparition of Saturn in Universal Time (UT)

Conjunction	2019 Jan 02^d UT
Opposition	2019 July 09^d
Conjunction	2020 Jan 13^d
Opposition Data for July 09, 2019	
Equatorial Diameter Globe	18.08″
Polar Diameter Globe	16.68″
Major Axis of Rings	41.05″
Minor Axis of Rings	18.24″
Visual Magnitude (m_v)	+0.2
B =	+26.18°
Declination	-22.80°
Constellation	Sagittarius

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possible small white spot in the EZs (southern half of the Equatorial Zone, as well as a persistent group of white spots in the NNNTeZ (North North North Tmperate Zone) with what appeared to be a closely associated white spot near the southern edge of the NPR. There are also several possible white spots noted within the NEBZ (North Equatorial Belt Zone) that lies midway between the NEBn (North Equatorial Belt, northern component) and NEBs (North Equatorial Belt, southern component). These observations seem to suggest that the aforementioned white spot activity at these saturnigraphic latitudes may have persisted since the 2018-19 apparition that ended on January 2, 2019.

Somewhat elongated white streaks were reported in the EB (Equatorial Belt). The aforementioned white spots have persisted and have shown up well in. It will be extremely worthwhile to continue to monitor Saturn and capture images with alternating RGB, 685nmIR, and red filters to determine if the longevity and changing morphology of these or similar features during the 2019-20 apparition. Observers should be watchful for any new atmospheric phenomena that might suddenly appear. With the rings tilted by about +24° toward our line of sight from Earth in 2019-20, observers still have fairly good view of the northern hemisphere of the globe and north face of the rings during this apparition.

Pro-Am cooperation with the Cassini mission continued during the past 2016-17 apparition as NASA's remarkable close-range surveillance of the planet for nearly thirteen years that started back on April 1, 2004, and concluded its amazing odyssey on September 15, 2017 when it plunged into Saturn's atmosphere.

For quite a few years to come, planetary scientists will be carefully studying the vast database of images and data gleaned from the Cassini mission, including images provided during the mission. It should be emphasized, that ALPO Pro-Am efforts did not cease when the Cassini mission ended during the fall of2017. Indeed, as in the immediately preceding 2018-19 apparition, and still ongoing during the 2019-20 observing season, our team of observers will regularly monitor atmospheric phenomena occurring on Saturn and actively share our results and images with the professional community. Thus, anyone worldwide who wants to join us in our observational endeavors is highly encouraged to submit systematic observations and digital images of the planet at various wavelengths throughout the current 2019-20 apparition. Observers are also reminded that visual numerical relative intensity estimates (also known as visual photometry) remain an extremely important part of our visual observing program and are badly needed to ascertain recurring brightness variations in the belts and zones on Saturn as well as the major ring components.

ALPO Saturn observing programs are listed on the Saturn page of the ALPO website at http://www.alpo-astronomy.org/saturn as well as in more detail in the author's book, *Saturn and How to Observe It*, available from Springer, Amazon.com, etc., or by writing to the ALPO Saturn Section for further information.

Observers are urged to pursue digital imaging of Saturn at the same time that others are imaging or visually monitoring the planet (i.e., simultaneous observations).

The ALPO Saturn Section thanks all observers for their dedication and perseverance in regularly submitting so many excellent reports and images in recent years. Cassini mission scientists, as well as other professional specialists, continue to request drawings, digital images, and supporting data from amateur observers around the globe in an active Pro-Am cooperative effort.

Information on ALPO Saturn programs, including observing forms and instructions, can be found on the Saturn pages on the official ALPO Website at www.alpo-astronomy.org/saturn

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

Remote Planets Section

Report by Richard W. Schmude, Jr., section coordinator
schmude@gordonstate.edu

Both Uranus and Neptune will be visible in the early morning sky in July. Look for Uranus near Cetus and Neptune near Aquarius. Pluto will also reach opposition in July near Sagittarius.

To find any of the remote planets for telescopic observations, I suggest that you first use a star chart which shows the position of the target, then use binoculars to find the target. [Note: skyandtelescope.com is a great source to find specific locations of sky objects.]

Next, locate the target in the finder scope of your telescope. Finally, use a low-power eyepiece and center it in the field-of-view. Note that you may need a dark site to locate Neptune in binoculars and in the finder scope.

Observers continued to send images of Uranus and Neptune in late 2018 and early 2019. Over a dozen individuals submitted images showing distinct albedo features on Uranus and Neptune. Highlights include the image made by Blake Estes on October 22, 2018 from Mt. Wilson, California. Blake imaged a small storm just south of the bright North Polar Region. Damian Peach and the “Chiliscope Project” team obtained high resolution images showing fine detail on Uranus in late November.

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Both Jim Fox and this writer obtained brightness measurements of Uranus and Neptune. Christophe Pellier also obtained spectra and has attempted to extract brightness data from his spectra.

Finally, my usual reminder that my book *Uranus, Neptune and Pluto and How to Observe Them* is available from Springer at *www.springer.com/astronomy/popular+astronomy/book/978-0-387-76601-0* or elsewhere (such as *www.amazon.ca/Uranus-Neptune-Pluto-Observe-Them/dp/0387766014*).

Visit the ALPO Remote Planets Section online at *www.alpoastronomy.org/remote*

A Follow-Up

In JALPO61-2, we included a series of e-mails between ALPO member Bob Danford of Tulsa, OK, and this editor regarding Dan's search for a sketch of Jupiter that he contributed and was published in an issue of this Journal way-back-when, but exactly when was unknown.

This editor located Bob's sketch in *The Strolling Astronomer*, Volume 15, Nos. 3-4, which was the March-April 1961 issue; a pdf file of that issue was then provided to him.

Bob also mentioned that his observations were made using the Astronomy Club of Tulsa's 12-inch Newtonian telescope, but he completely lost track of that scope.

On March 8 of this year, Bob e-mailed this editor the following:

****

Here are photos of newspaper clippings, showing the 12-inch telescope that I used to make the drawing the ALPO published (plus one of the club's 8-inch scope, which I don't recall at all). I had contacted the Astronomy Club of Tulsa, and these photos were sent to me by Jack C. Wells <cafjcw@msn.com>.

FRIDAY, MAY 4, 1956

Interest in Astronomy Grows

Fan Club for Real Stars

By GEORGE KANE

Are there any star-gazers present? If so, you'll be interested in the rapidly-growing hobby of astronomy in Tulsa.

Jack C. Wells, an electrical engineer at Public Service Co. and president of the Tulsa Astronomy Club which dates back to the early 1930's, said there are now 30 active members in the club.

In 1957, the members plan to observe the first flight of a space satellite around the earth with telescopes they have constructed.

"The satellite will travel on a course within 150 miles of Tulsa," Wells said, "and it will give us a good chance to follow it in its flight."

"In 1948 we acquired a 12½-inch telescope," George H. Rose, a past president of the club, said, "and with different size eyepieces, we have been able to obtain up to 480 times magnification of heavenly bodies."

Arthur Sweeney Jr., another club member, is working on a project to construct a radio-telescope which will not only be used to observe a planet or other body in its orbit, but will be able to pick up sound waves which the planet or comet emits.

The Tulsa club is affiliated with the National Astronomical League.

"The club was not active during World War II," Wells said, "but began again in 1948 with more members and much more interest."

Dr. Leon Stuart, a club member and Tulsa physician, uses his hobby of photography in connection with the club.

"I had the pleasure of taking a 'first' picture in the field of astronomy some time ago," Dr. Stuart said.

"Through luck, mostly, I got a picture of a meteor striking the surface of the moon."

Dr. Stuart said that to his knowledge there has never been another such picture taken in the 30 or more years he has been studying astronomy and photography.

Wells announced that there would be a public demonstration, a "star party," at the University of Tulsa's Student Union building at 7:30 p.m. Saturday.

"We will have a display of astronomical equipment," he said. "We'll also show how mirrors for telescopes are ground, how telescopes can be made by the astronomy fan, and photographs of the sky and moon."

STAR GAZING—Jack C. Wells, president of the Astronomy Club of Tulsa, observes through a 12½-inch telescope at the home of George H. Rose, a club member. Left, H. A. Monteith, club secretary, and Dr. Leon Stuart, a member, watch as Wells sights an object in the sky.

Wells said if the weather permits, there will be a telescope available for viewing at the home of H. A. Monteith, secretary of the club.

"The purpose of the show is to acquaint the public with the club and invite new members," Wells said.

Officers of the club include Wells, Monteith, and John A. Stewart, observing chairman.

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The ALPO Lunar Section

Who and What is the Lunar Topographical Studies Program?

Wayne Bailey
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Figure 1. Wayne Bailey in March 2019 at his Tucson, AZ, observatory with his C-11 equipped with an SBIG STF-8300M CCD camera & filter wheel.

I was born and raised in southern New Jersey, where my interest in astronomy really developed as the result of my eighth grade science teacher giving me a copy of a magazine article on making a reflecting telescope, and the appearance of Comet Arend-Roland. The resulting 6-inch Newtonian telescope wasn't finished in time to view the comet, and in any case was of less than superb optical quality, but served until it was replaced by a somewhat better 8-inch.

Over the years, I've accumulated more equipment, including an 8-inch Meade Starfinder, two Celestron 11-inch SCTs, a 4-inch achromatic refractor, a Coronado CaK PST (personal solar telescope), spectrographs, planetary imagers, CCD cameras, and numerous filters and gadgets. In NJ we live in an age-restricted development, where my usual observing site is the driveway and almost directly under a street light. The South Jersey Astronomy Club does have a dark observing site in the Pine Barrens, but it's over an hour drive each way, so I seldom use it.

In 2016, we bought a house in southern Arizona, where I was able to build a roll-off roof observatory, and the nearest street light is more than five miles away. We now spend most of our time in Arizona.

After receiving a BA in physics/math from Rutgers University in 1965 and a PhD in astronomy from the University of Arizona in 1971, I once again moved back to NJ to teach astronomy at Jersey City State College and continue research in infrared stellar spectra with the NASA Ames Research Center. In 1977, I accepted a job in Huntsville, Alabama, with Teledyne Brown Engineering's Space Programs Division to work on NASA support contracts, mostly at NASA Marshall Space Flight Center for the Spacelab program. In 1998, when the Spacelab science program ended, I retired and with several others from TBE formed Frederick Energy Products to develop gamma ray detectors for oil well and coal mine use.

Four years later, the company emphasis changed from development to manufacturing. I preferred the variety involved in development, not the routine activities of manufacturing so I again retired and moved back to NJ. There I taught astronomy, and occasionally physics or math, at Gloucester County College before finally (so far) retiring in 2012.

Family and career took priority between 1977 and 1995 although I was a member and sometimes officer and planetarium lecturer of the von Braun Astronomical Society. Then I joined the AAVSO and started visually observing variable stars. I had always been interested in photography, so in early 1996, the appearance of Comet Hyakutake convinced me to try astrophotography. My attempts at wide-field 35mm photography were fairly successful. Occasionally I would attempt film photography of the moon or planets without much success. Webcams changed all that, however. Suddenly I could determine proper focus and exposure on the spot. By this time, I had moved back to NJ, where the skies are bright and discovered *The Lunar Observer* newsletter, where the "Feature of the Month" and "Focus On" articles provided a focus for my own interests. That convinced me to join the ALPO and start contributing images. In an email exchange with Bill Dembowski in 2008, he mentioned that he was planning to retire as coordinator of the LTSS section and asked if I'd be interested in taking over. After some additional explanation of what is involved, including assuring me that he would continue as assistant to help with any problems, I agreed and was appointed in December 2008.

My astronomical interests have changed considerably over the years. Initially I was only interested in stellar astrophysics, primarily spectroscopy. I (often unsuccessfully) argued that the Moon and planets were more interesting than faint fuzzy objects to view during public star parties at whichever astronomy club I belonged to at the time, but wasn't especially interested in them myself (other than the Sun).

So when I returned to observing, I settled on variable star observing as something that was feasible with limited equipment. Where we returned to in southern NJ (which isn't far from where I grew up), the naked-eye limit is now typically second magnitude, so lunar and planetary viewing became the most feasible activity, and through the ALPO, I found that there really were interesting things to study.

I still observe variable stars, now with a CCD camera instead of visually. Since commercial spectrographs became available for amateurs several years ago, I've also resumed my interest in spectroscopy of chemically peculiar and spectrum variable stars. And my lunar interests have broadened from just imaging to include photometry, spectroscopy and, recently, polarimetry. I still try to participate in the public star parties of the local astronomy club. One thing I do miss about observing from the driveway in NJ is the impromptu star parties that would sometimes occur as people walked by in the early evening.

William Dembowski
Assistant Coordinator
Windber, Pennsylvania, United States
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My interest in astronomy began when I was in grade school and got a real boost when my mother went to bat for me to get a card for the adult section of our local public library. The librarian was quite adamant at first in denying the request. She insisted that I was too young (nine years old), and could not borrow adult level books until I was at least 16. My mother was equally adamant that I should be given an adult card but was told "Mrs. Dembowski, I don't think that you understand." One of the fondest memories of my childhood was

Figure 2. Bill Dembowski with his "Moonshine Observatory" near his home in Elton, PA. Photo credit: *The Johnstown Tribune Democrat* newspaper; *https://www.tribdem.com/news/local-man-honored-for-his-moon-observations/article_445b09ca-700f-55ae-9129-04f5457bf2c0.html*.

when my mother replied "Oh, no! I don't think that YOU understand." She then proceeded to explain to the librarian that I had been reading the daily newspaper since before I was three years old. I got my adult card.

My participation in astronomy consisted solely of reading until I was about 12 years old. It was then that I made a major purchase ($2.50) for a telescope kit which consisted of a single objective lens (35mm in diameter with a focal length of 48 inches), two single lenses for eyepieces (1 inch and ½ inch focal lengths) and a brass tube with a diameter equal to that of a standard spool of thread. I glued an eyepiece lens to an empty spool and loaded everything into a piece of downspout. With a diameter of 3 or 4 inches, the downspout refractor looked much more impressive than it needed to. With a mount and tripod made from scrap lumber from the same friendly hardware dealer that donated the piece of downspout, I was ready to observe the universe first-hand. Hey; it was 1952!

This modest refractor stood me in good stead for years, especially since it did an adequate job on the Moon. I learned early on that its magnifying powers of 48X and 96X showed me a great deal of detail on the lunar surface. And, if there was one thing that I found very satisfying, it was a lot of detail; faint fuzzies had no appeal for me. Besides, my views of the Moon looked an awful lot like the pictures in books and magazines; something that I could not say about distant galaxies.

Eventually, marriage and greater responsibilities at work took their toll. Observing sessions grew shorter and less frequent, but I never lost interest in my old friend, the Moon. When I was in my mid-40's, some work related events freed up some time and money. I was finally able to buy a "real" telescope (10-inch SCT) and my interest in astronomy, especially the Moon, went from an interest to a passion,

I read about the American Lunar Society and it sounded right up my alley. I joined but soon found out that it was not quite what I had expected, so long story short, I ended up as the president and editor of their journal. Until this time I hadn't paid much attention to organizations, but that all changed and I learned about the ALPO; many of the Lunar Society members were also ALPO members, so I joined ALPO as well.

The ALPO had several lunar coordinators; each specialized in a separate area of lunar study; lunar transient phenomenon, lunar domes, etc. I noticed, however, that nowhere was there mention of topographical studies, the type of non-specialized lunar observing that I did. I wrote to Harry Jamieson, lunar coordinator at the time, and suggested that he create a new lunar section for topographical studies. He phoned me to say that he liked the idea and said that all we needed was a section coordinator; then followed that up with "….. and oh, yes - by the way - it's you."

The first thing that I did was create a monthly newsletter, *The Lunar Observer*, and we were off and running.

Being a staff member of the ALPO opened many doors in the world of amateur astronomy. I was asked to contribute to Peter Wlasuk's book "Observing the Moon," published by Springer in 2000. In 2003, sponsored by Robert Garfinkle and Ewen Whitaker, I was elected a Fellow of the Royal Astronomical Society. And then in 2006 I received the ALPO Walter Haas Observers Award for outstanding observations of the Moon.

Some personal misfortunes necessitated my stepping down from the position of Coordinator to that of Assistant Coordinator, where I still contribute in some small ways to the ALPO Lunar Section and will continue to do so for the foreseeable future.

Jerry Hubbell
Assistant Coordinator
Locust Grove, Virginia, United States
jerry.hubbell@alpo-astronomy.org

Jerry Hubbell has served as the Assistant Coordinator for ther ALPO Lunar Topographical Studies program since 2014. He is currently the VP of Engineering for Explore Scientific, LLC, and is the Assistant Director of the Mark Slade Remote Observatory (MSRO). He recently became a member of the Transiting Exoplanet Survey Satellite (TESS) Follow up Working Group (TFOP SG1.)

Jerry has written two books, *Scientific Astrophotography* (Springer 2012) and *Remote Observatories for Amateur Astronomers* (Springer 2015). Jerry earned his pilot's license in 1991. He has a degree in Electrical Engineering and is retired from the nuclear utility industry after 35 years. His principal interests are high-resolution lunar imaging, minor planet observing and observation of exoplanet transits.

In his own words, Jerry says: The biggest influence in my life, and what drove me to several aspects of my education, career, and hobbies, was NASA and the space program in the 1960's. Like a large portion of the astronomical community, my formative years were greatly influenced by the race to the Moon. I really didn't become fully aware until I was eight years old when Apollo 7 was launched. For me, the four years from 1969 to 1972 were filled with excitement and sheer awe at the idea of flying to the Moon. I think that it so impressed me, that I came to believe that anything was possible. At the time, my dad was in the Army and was in Viet Nam; he served several tours there and in Korea. I missed my dad something awful, so it was good to be distracted from that. Those years were the catalyst for my deep interest in science, technology, and astronomy. I remember borrowing a small 4-inch Newtonian reflector from school when I was 9 or 10, and it was the first time I was able to spend some time with a telescope. I pretty much spent all my telescope time during my teenage years observing the Moon, Jupiter and Saturn. The Moon was the primary object, though, and I considered the telescope my personal spaceship to view the Moon from orbit.

Figure 3. Jerry Hubbell at the Mark Slade Remote Observatory. Main instrument: 6.5-inch Explore Scientific 165 FPL-53 ED APO Carbon Fiber mounted on an Explore Scientific/Losmandy G11 PMC-Eight GEM. (Photo courtesy of Bill Paolini).

After graduating college and starting my career in the nuclear industry, I managed to save enough money to buy a 10-inch Meade 2120 LX-5 SCT. I used that scope from the time I purchased it in 1986 until the early 90's. I did some rudimentary lunar video with my video cameras, but in 1991 obtained my pilot’s license and concentrated on my flying.

In 2009 after a nearly 20-year break from astronomy and seeing all the new technology since the late 80's, I jumped back into it. I knew of the ALPO long before that, but it hadn't crossed my mind to join. I joined the ALPO in 2010. My main interests at that time were high-resolution lunar imaging, and minor planet astrometry.

In October 2013, ALPO journal editor Ken Poshedly sent posted an email seeking some help in the Lunar Section, as Bill Dembowski was asking for a reprieve, so I responded to his request. Before then, I was working full-time and doing astronomy on the side. My first book was published the year before, and I wanted to continue to work my way into the industry. I thought that working for the ALPO would give me more credibility once I had moved full-time into the astronomy business. I had just started working for Explore Scientific, so I was ready to commit. ALPO membership secretary Matt Will responded and forwarded my message to ALPO Lunar Topographical Studies coordinator Wayne Bailey. After some discussion and emails back and forth, in December 2013, and with the approval of the ALPO board, I joined the ALPO lunar staff.

Finally, I find it interesting, and maybe a bit ironic since the Apollo 11 Moon landing is what got me excited about observing and photographing the Moon to begin with, that NASA's lunar exploration (both manned and unmanned) has allowed us to see the Moon's surface down to a resolution of a meter or less.

Some might say that NASA images have made my personal explorations meaningless. I don't agree at all with this thinking. Even though the space probes have provided us images that we could never see from Earth, I would argue that we can also observe and photograph features that have never been photographed from space. Since we can observe any time we want, at any phase of the Moon, we can observe features that have never been photographed at the scale that the satellites have imaged. Having this opportunity from Earth can add real value as a tool to help identify new targets for exploration from space and eventually on the surface.

Apart from this, the personal exploration of the lunar surface from our backyard, and the opportunity it gives us to learn the selenography and the named features, is necessary for us to have a personal connection to these NASA missions. Currently, virtual and augmented reality is all the rave and will someday no doubt eclipse "traditional" reality. Will we choose to live in the virtual world and eschew the opportunity to physically explore and observe the real world? I see this as the same argument for not looking at the Moon with our telescopes and just rely on our space probes. I think there will always be a place for both the real world and the virtual world, for both space probes and personal and professional telescopes to observe and image the moon. Something can be said for seeing a fresh batch of photons for yourself versus those that have been captured by someone else. There's nothing like seeing things for yourself to really appreciate what you are looking at.

Mission Statement: The Study of the Lunar Surface

The Moon is the Earth's only known natural satellite and occupies an elliptical orbit at a mean distance of 384,400 km (238,855 miles) from its parent planet. With a diameter of 3,476 km (2,160 miles), it is larger than the planet Pluto and over 70% the diameter of the planet Mercury.

Because the Moon revolves on it axis exactly once during each orbit about the Earth, the same side of this large satellite always faces the Earth. The inclination of the Moon's orbit and other factors allow us to see approximately 59% of its total surface. It is this surface, larger than that of the United States and Australia combined, that is the object of study by the ALPO Lunar Topographical Studies Section.

To the naked eye, the appearance of the Moon exactly repeats itself every month as the terminator (the dividing line between lit and unlit regions) marches across the surface of the Moon. Because of the orbital mechanics involved, however, a telescopic view reveals that changes in the lighting, and the resultant shadows, are not exactly duplicated each month. This slight change in lighting can provide a surprisingly different view of the same feature each month for many years. This, combined with the almost infinite detail available to even modest backyard telescopes, can make the topographical study of the Moon a lifelong adventure.

It is the mission of the ALPO Lunar Topographical Studies Section to observe, study and record the many surface features of the Moon. These features include such broad categories as mountain chains and isolated peaks, impact rays and bright spots, lava flows and wrinkle ridges, domes, rilles and scarps, and craters of every conceivable size. The instrumentation used by Section participants varies from modest 60mm refractors to massive dobsonian-mounted reflectors. Lunar observers utilize imaging equipment that ranges from traditional film cameras to the latest in digital and video systems. Filar micrometers, photoelectric photometers, and a host of other specialized tools are brought into play in the pursuit of topographic studies, but such sophistication, useful as it is, is not a prerequisite. Many insightful and valuable observations are still being performed by those with telescopes of modest size who sketch what they see.

Because of the broad nature of topographical observations, this Section also stands ready to assist other ALPO Lunar programs in the pursuit of their research programs. Requests for corroborating observations from the Lunar Transient Phenomena Program and Selected Areas Program are always quickly researched through the Section's computerized archives and assistance provided whenever possible.

In order to be of scientific value, all observations submitted to the section coordinator should include the following:

- Name and location of the observer (as specific as possible, including exact Earth coordinates, if known)
- Name of feature
- Date and time (UT) of the observation
- Size and type of telescope used
- Seeing: 1 to 10 (1-Worst to 10-Best)
- Transparency: 1 to 6 (1-Worst to 6-Best)
- Magnification
- Medium (computer and other peripherals) employed (for photographs and electronic images)
- Any other vital technical data as it relates to the observation made.

A.L.P.O. Lunar Section: Selected Areas Program

Albedo and Supporting Data for Lunar Drawings

Lunar Feature Observed : ______________________

(use ***Drawing Outline Chart*** for making drawings and attach to this form)

Observer: ______________________ Observing Station: ______________________

Mailing Address: ______________________

street city state zip

Telescope: ______________________

instrument type aperture (cm.) focal ratio

Magnification(s): ________X ________X ________X Filter(s): F1 ________ F2 ________

Seeing: ______________ [A.L.P.O. Scale = 0.0 (worst) to 10.0 (perfect)]

Transparency: ______________ [Faintest star visible to unaided eye]

Date (UT): ______________ Time (UT): ________ ________

year month day start end

Colongitude: ________° ________°

start end

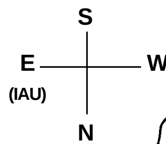
Albedo Data

(refer to ***Albedo Reference Chart*** which shows "Assigned Albedo Indices" for feature and attach to this form)

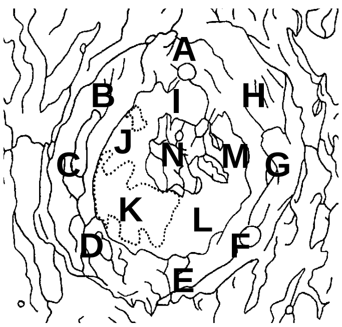
Assigned Albedo Index	Albedo IL	Albedo F1	Albedo F2	Assigned Albedo Index	Albedo IL	Albedo F1	Albedo F2
A				J			
B				K			
C				L			
D				M			
E				N			
F				O			
G				P			
H				Q			
I				R			

NOTES:

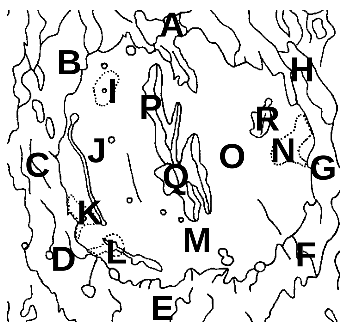
A.L.P.O. Lunar Selected Areas Program



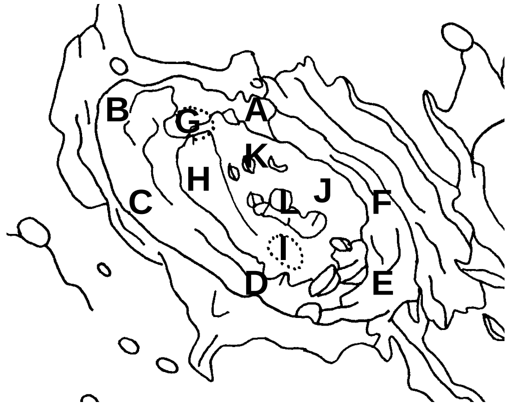
page 1 of 2



Theophilus



Alphonsus



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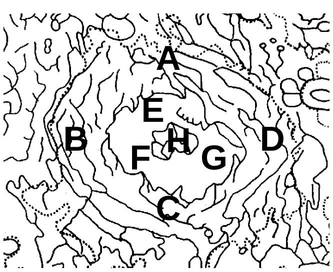

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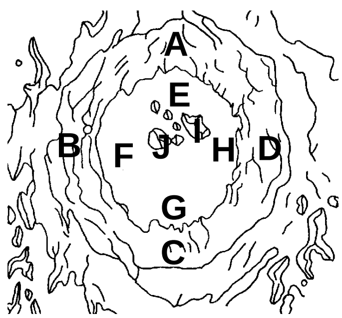
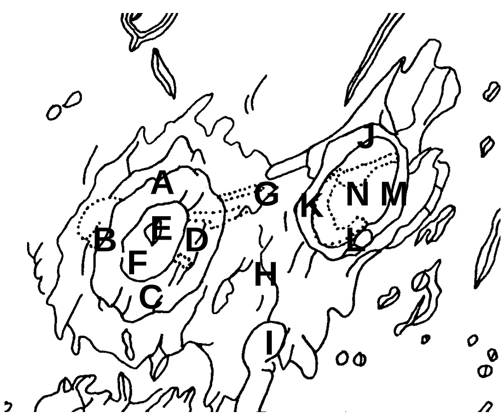
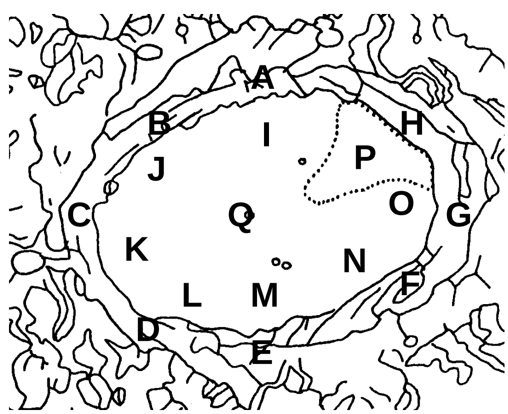


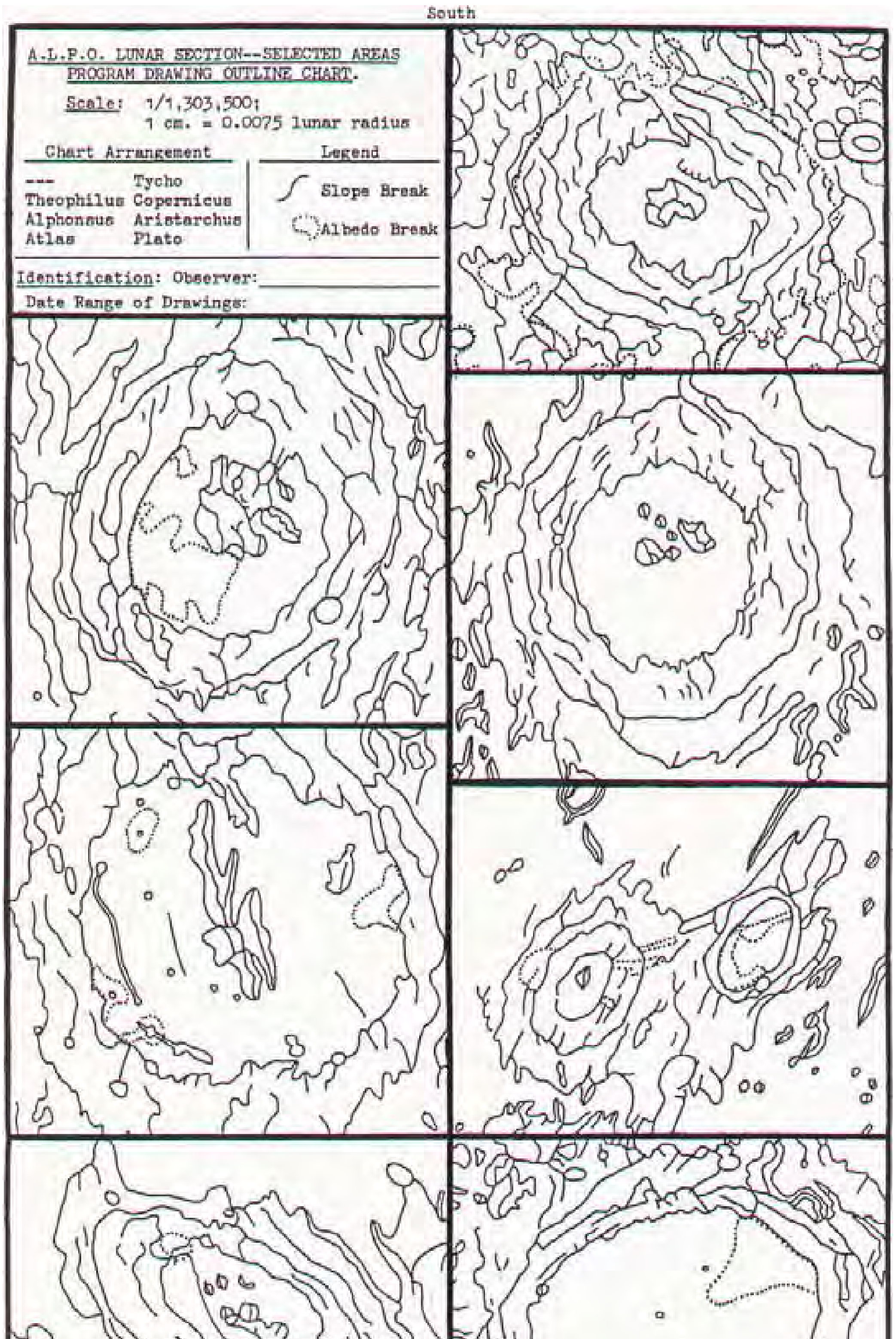
Copernicus



Aristarchus



Plato


South
A.L.P.O. LUNAR SECTION--SELECTED AREAS PROGRAM DRAWING OUTLINE CHART.
Scale: 1/1,303,500; 1 cm. = 0.0075 lunar radius
Chart Arrangement
--- Tycho
Theophilus Copernicus
Alphonsus Aristarchus
Atlas Plato
Legend
Slope Break
Albedo Break
Identification: Observer:
Date Range of Drawings:
J.W. '83

ALPO Lunar Section: Selected Areas Program

Bright and Banded Craters Observing Form

Crater Observed : ____________________________

(identify by name, *xi* and *eta* designation, or *selenographic longitude* and *selenographic latitude*)

Observer: ____________________ Observing Station: ____________________

Mailing Address: ____
street city state zip

Telescope: ____
instrument type aperture (cm.) focal ratio

Magnification(s): ______X ______X ______X Filter(s): F1 ______ F2 ______
Seeing: ________________ [A.L.P.O. Scale = 0.0 (worst) to 10.0 (perfect)]
Transparency: ________________ [Faintest star visible to unaided eye]

Date (UT): ____________________ Time (UT): ____________ ____________
year month day start end

Colongitude: ______________° ______________°
start end

Position of Crater:

xi	*eta*	Selen. Long.	Selen. Lat.	Environs

Lunar Atlas Used as Reference: ______________________________

DRAWING

Show detailed morphology, position, orientation, and other characteristics of the crater, including any bands that are definite or suspected, in the drawing blank below. Use the *Albedo and Supporting Data* form for albedo estimates of assigned indices for the crater and for any bands observed (attach to this form). Indicate correct direction of N (IAU) on the drawing.

DESCRIPTIVE NOTES:

scale

|-------------------------------|

The ALPO Lunar Section

The ALPO Banded Craters Program

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Online Features

Left-click your mouse on the author's e-mail addresses in blue text to contact the author of this article.

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Introduction

Nearly 200 lunar craters have been reported as having dusky radial bands on their inner walls and/or floors. The most prominent of these is Aristarchus, whose bands can easily been seen with a small (7.5cm) telescope. Interestingly, the Aristarchus bands were not recorded by some of the more famous and devoted lunar observers of the past. Neither Schroeter, Beer, Maedler, Lohrmann, nor Schmidt ever included the appearance of these radial bands in their published descriptions of craters. It is not until 1868 that we find their first mention in a work published by John Philips. This is, of course, not to suggest that banding is a recent phenomenon but simply an indication of the relative importance attached to various features by observers in different eras.

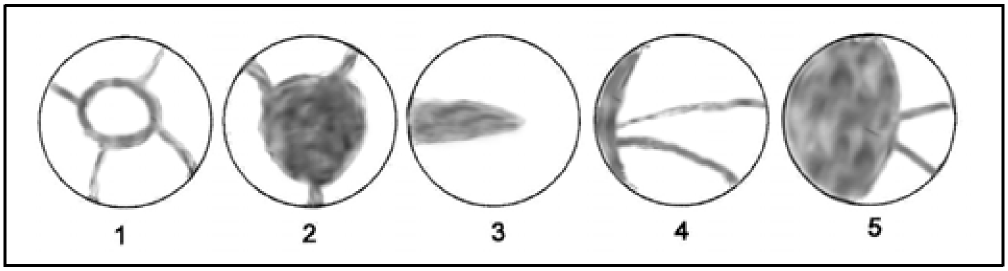

Figure 1. Banded Crater Group Types: These highly stylized drawings (by the author) are intended only to give a general impression of each Group type (see text).

Dusky bands tend to make their appearance shortly after local sunrise and steadily increase in visibility until reaching their peak under a high sun. Changing illumination can affect more than just visibility. Changes in shape, position, and albedo have also been observed. Those having access to Harold Hill's "A Portfolio of Lunar Drawings" will find excellent examples of long term studies of the bands within the craters Birt and Messier.

Some bands appear to be related to topographical features; possibly lava flows into the crater through breaches in the walls or variations in the composition of the lunar surface. Others might simply be dark underlying terrain over which a bright ejecta pattern is displayed. Since not all bands present clues as to their nature, it is more practical to classify them by general appearance alone.

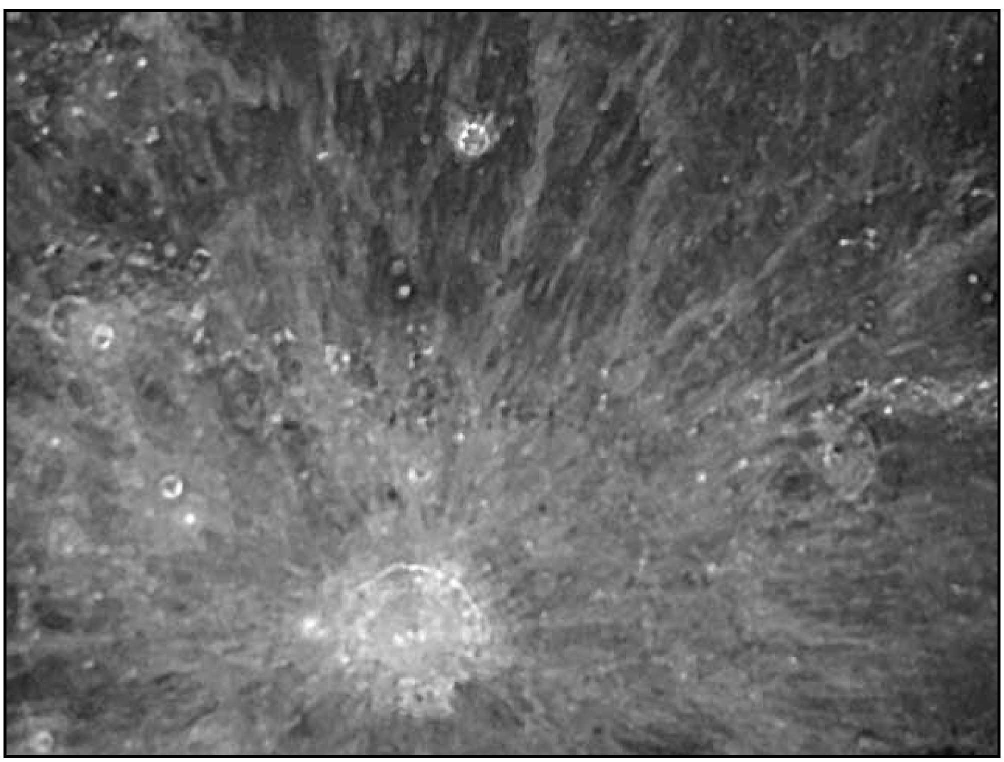

Figure 2. Digital image of Pytheas (at top center, cropped) by William Dembowski of Elton, Pennsylvania, USA taken July 31, 2007, 04:10 UT. Colongitude 108.5°, Seeing 4/10, Transparency 2/6. Celestron 20 cm, f/10 SCT equipped with Orion StarShoot II Camera.

In the March 1955 *Journal of the British Astronomical Association*, K. W. Abineri and A. P. Lenham published a paper in which they suggested that banded craters could be grouped into five categories (See Figure 1):

Figure 3. Digital image of Anaxagoras by Howard Eskildsen of Ocala, Florida, USA, taken June 30, 2007, 02:33 UT. Colongitude 89.0°, Seeing 5/10, Transparency 4/6. Meade 15.2 cm, f/8 refractor equipped with Orion StarShoot II Camera - 2x Barlow

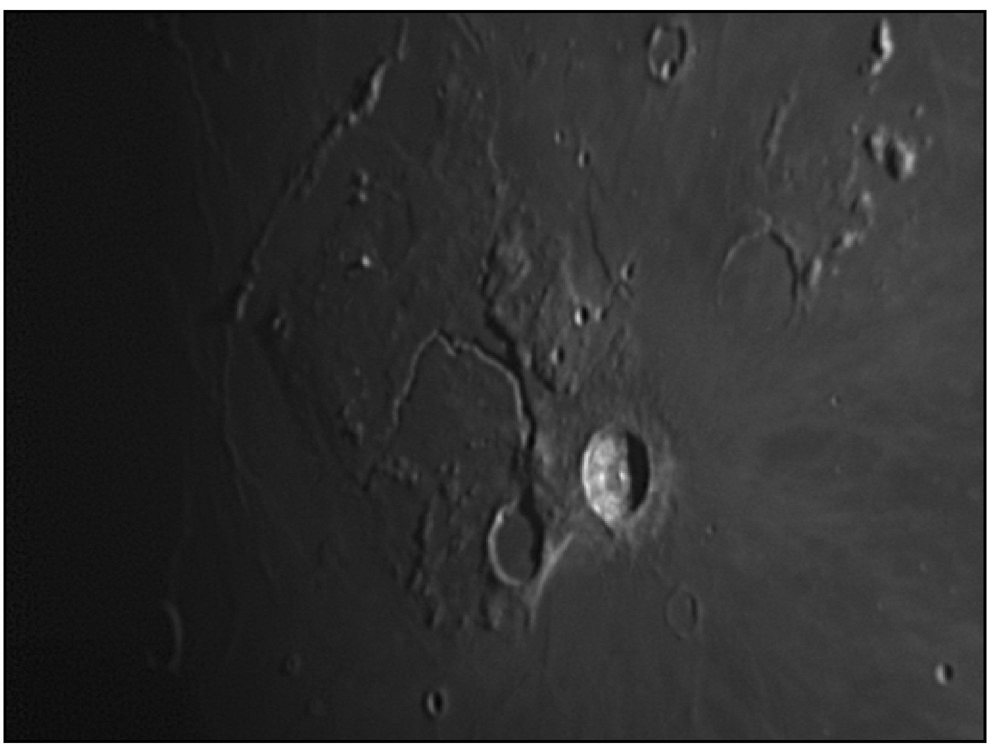

Figure 4. Digital image of Aristarchus by Wayne Bailey of Sewell, New Jersey, USA, taken May 29, 2007, 01:51 UT. Colongitude 57.6°, Seeing 5/10, Transparency 2/6. Celestron 28 cm, f/10 SCT equipped with 2x Barlow, Skynyx 2-1M Camera - Schuler IR72 filter.

Group 1 - (Aristarchus type) Craters are very bright, quite small, and have fairly small dark floors leaving broad bright walls. The bands, on the whole, apparently radiate from near the center of the craters. These craters are often the centers of simple bright ray systems.

Group 2 - (Conon type) Rather dull craters with large dark floors and narrow walls. Very short bands show on the walls but cannot be traced on the floors. The bands, despite their shortness, appear radial to the crater center.

Group 3 - (Messier type) A broad east-west band is the main feature of the floors.

Group 4 - (Birt type) Long, usually curved, bands radiate from a non-central dull area. The brightness and size are similar to the Group 1 craters.

Group 5 - (Agatharchides A type) One half of the floor is dull and the bands radiate from near the wall inside this dull section and are visible on the dull and bright parts of the floor.

Overview of the Banded Craters Program

In 2006 the ALPO Selected Areas Program (SAP), which included the Banded Craters Program (BCP), was transferred to the association's Lunar Topographical Studies Section. Participation in the BCP had been minimal to that point so in the January 2007 issue of the Lunar Section newsletter, a new call for participants in the BCP was issued. As with all lunar topographical programs, drawings, photographs, and digital images were solicited to help support and achieve the following BCP objectives:

1. Detect and catalog craters that exhibit dark and/or bright bands under various lighting conditions throughout a given lunation and from one lunation to another.
2. Determine whether or not there is a relationship between crater brightness at local noon and the visibility of dark or light bands, central peaks, or both.
3. For craters exhibiting banding, determine the relative positions, orientation,

and intensities (albedos) of the bands throughout a lunation and from one lunation to another.

4. Investigate what correlations may or may not exist among crater size, the presence of central peaks, and the occurrence of light and/or dark bands.

5. Observe the radial bands, either visually or photographically, through different colored filters to determine any changes in appearance.

6. Establish whether the banding is related to physical or albedo features, both within and surrounding the crater.

7. Monitor the visibility and morphology of bright and/or banded craters during umbral and penumbral lunar eclipses.

22 Prominent Banded Craters

Crater Name	Diameter (km)	Longitude	Latitude
Agatharchides A	10	28.4 W	23.2 S
Anaxagoras	51	10.1 W	73.4 N
Aristarchus	40	47.4 W	23.7 N
Aristillus	55	01.2 E	33.9 N
Bessarion	10	37.3 W	14.9 N
Birt	17	08.5 W	22.4 S
Bode	19	02.4 W	06.7 N
Brayley	14	36.9 W	20.9 N
Burg	40	28.2 E	45.0 N
Conon	22	02.0E	21.6N
Dawes	18	26.4 E	17.2 N
Kepler	32	38.0 W	08.1 N
Maury	18	39.6 E	37.1 N
Menelaus	27	16.0 E	16.3 N
Messier	10	47.6 E	01.9 S
Milichus	13	30.2 W	10.0 N
Nicollet	15	12.5 W	21.9 S
Proclus	28	46.8 E	16.1 N
Pytheas	20	20.6 W	20.5 N
Rosse	12	35.0 E	17.9 S
Silberschlag	13	12.5 E	06.2 N
Theaetetus	25	06.0 E	37.0 N

It was emphasized that the submission of a few technically superior but unrelated images is not what was required for the program's success. Instead, a series of well documented observations, even of average technical quality, would be far more meaningful. Contributors were also asked to use the SAP Observing Forms and Procedures established by Dr. Julius Benton, the previous coordinator, since only by doing so would it be possible to meaningfully compare observations. These forms and procedures were then uploaded to the Banded Craters webpage at: *http://www.zone-vx.com/alpo-bcp*

Also, rather than spreading initial efforts over the complete list of approximately 200 known banded craters, it was decided to initially concentrate on a shorter list of the more prominent craters exhibiting these features. (See table at left).

The response was minimal, but those contributing to the program have proven to be both skilled and dedicated. With only three observers (Wayne Bailey, Howard Eskildsen, and the author) the number of formally documented observations has at this writing (early August 2007) already exceeded 200.

Observing Banded Craters

Although the bands of Aristarchus are visible in a 7.5cm refractor, larger apertures are often required to study them in detail or to detect the bands in smaller craters. Figure 2 shows the advantage of a larger instrument (28cm f/10 SCT) and the addition of a 2x Barlow.

The monitoring of banded craters throughout a lunation necessitates making observations under a variety of lighting conditions, particularly those of a high Sun. Since many banded craters have very high albedos, care should be taken by lunar imagers not to overexpose the crater interiors thereby obscuring any banding that might be present. Visual observers might find benefit in using a polarizing filter, particularly the type with variable transmission.

Potential participants should not be intimidated by frequently made statements that it is extremely difficult to find one's way about the lunar surface at or near the Full Moon. Most of the craters on the short list are large enough in their own right or adjacent to prominent lunar landmarks to make locating them relatively easy with a little experience. Figure 3 illustrates how the unmistakable crater Copernicus can be used to locate the banded crater Pytheas at Full Moon.

Concentration on the short list of banded craters does not preclude the study of others on the larger list (based largely on that list compiled by Abneri & Lenham), or the search for previously undocumented banded craters. Howard Eskildsen submitted an image of bands within Anaxagoras (Figure 3), a crater not initially included in the full list. Confirming observations by Wayne Bailey resulted in the addition of the 51 km Anaxagoras to the list of prominent banded targets for continued study.

Although this program was not designed for the casual observer, it is well within the capabilities and equipment of the average dedicated amateur. If you are interested in such an endeavor, please visit the Banded Craters Program WebPage at: *http://www.zone-vx.com/alpo-bcp* or contact the program coordinator at: *dembowski@zone-vx.com*

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The ALPO Lunar Section

Apollo 11 — The Sea of Tranquility

By Jerry Hubbell,
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This is the sixth and final article in a series of six articles to appear in the ALPO Lunar Section newsletter *The Lunar Observer* on the Apollo lunar landing missions. A slightly longer version of this paper with additional images is being published in the July issue of the TLO. This series of articles began with Apollo 17 in the September 2018 issue of the TLO. To learn about the background and thinking behind this series of articles to commemorate the Apollo program, go to *http://moon.scopesandscapes.com/tlo_back/tlo201809.pdf* or contact the author directly using the email address in the byline above this box; his regular mail address can be found in the *ALPO Resources* section of this publication under "Lunar Section."

On September 12, 1962, in Houston, Texas, President John F. Kennedy called on the nation to commit itself to placing a man on the Moon and returning him safely to the Earth. His speech, called the "We choose to go to the Moon" speech issued the following challenge:

> "…We choose to go to the Moon! We choose to go to the Moon…We choose to go to the Moon in this decade and do the other things, not because they are easy, but because they are hard; because that goal will serve to organize and measure the best of our energies and skills, because that challenge is one that we are willing to accept, one we are unwilling to postpone, and one we intend to win, and the others, too…" – John F. Kennedy

The Apollo program was the final push in the "Space Race" between the United States and the Soviet Union started with the launch of Sputnik on October 4, 1957. During this period in the "Cold War", the Soviet Union was perceived to be leading the race up until the Apollo 8 mission in December 1968 when three astronauts, Jim Lovell, Frank Borman, and William Anders circumnavigated the Moon. Up until this point the Soviet Union had several space firsts to its name, most notably the first satellite launched into space, the first man in space, and the first spacewalk. What

Figure 1. Apollo 11 Mission Logo/Patch, NASA image.

Figure 2. Apollo 11 Astronauts. (from left to right, Neil Armstrong, Michael Collins, and Edwin "Buzz" Aldrin. NASA image.

Figure 3. Apollo 11 Astronaut Edwin “Buzz” Aldrin on the surface of the Moon on July 20, 1969 during their two and a half-hour EVA. NASA image.

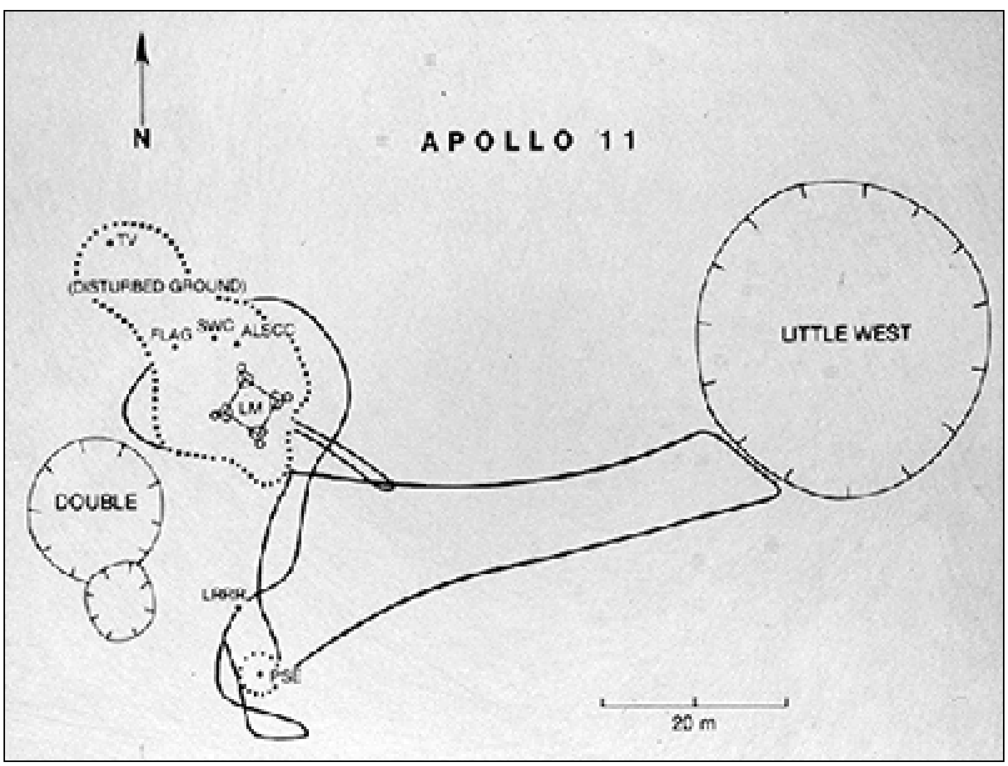

Figure 4. Apollo 11 Landing Site – EVA Traverse Map, Surface Operations Overview. NASA.

made Apollo 8 that more significant is that the United States had just recovered from the Apollo 1 fire which in January 1967 took the lives of astronauts Gus Grissom, Edward White, and Roger Chaffee. This was a significant setback and a blow to the American people. Kennedy’s goal was successfully completed on July 24, 1969 and became a prime source of pride and confidence in the American people going forward and I believe, led to the explosive development in electronic technology in the decades following the Apollo program.

Apollo 11 (*Figure 1*) was launched on July 16, 1969 at 9:32 a.m. EDT from the Kennedy Space Center. The crew consisted of Commander Neil Armstrong, Command Module Pilot Edwin “Buzz” Aldrin, and Lunar Module Pilot Michael Collins. (*Figure 2*.) The astronauts had a trouble-free 76-hour journey to the Moon and arrived in lunar orbit at 01:22 p.m. EDT on July 19, 1969.

Apollo 11 was the first manned lunar landing on the Moon. After an exhilarating landing (my description) in the southwest region of Mare Tranquilitatis (Sea of Tranquility) (*Figure 5*) on July 20, 1969 at 4:18 p.m. EDT the astronauts prepared for a stay of just under 24 hours. Neil Armstrong took manual control of the final approach to landing when the LM computer was leading them to lunar crater West. Armstrong used up most of the last minute of fuel finally setting the LM down with only about 15 seconds of fuel left. During the landing, the famous computer alarms “1201” and “1202” also interrupted the proceedings and were caused by the landing radar being in the wrong mode, thereby causing the computer to become too busy. This caused the computer to reboot itself a few times during the landing approach.

The Apollo 11 Lunar Module (LM) landed approximately 400 meters west of crater West and 20km south-southwest of the crater Sabine D at

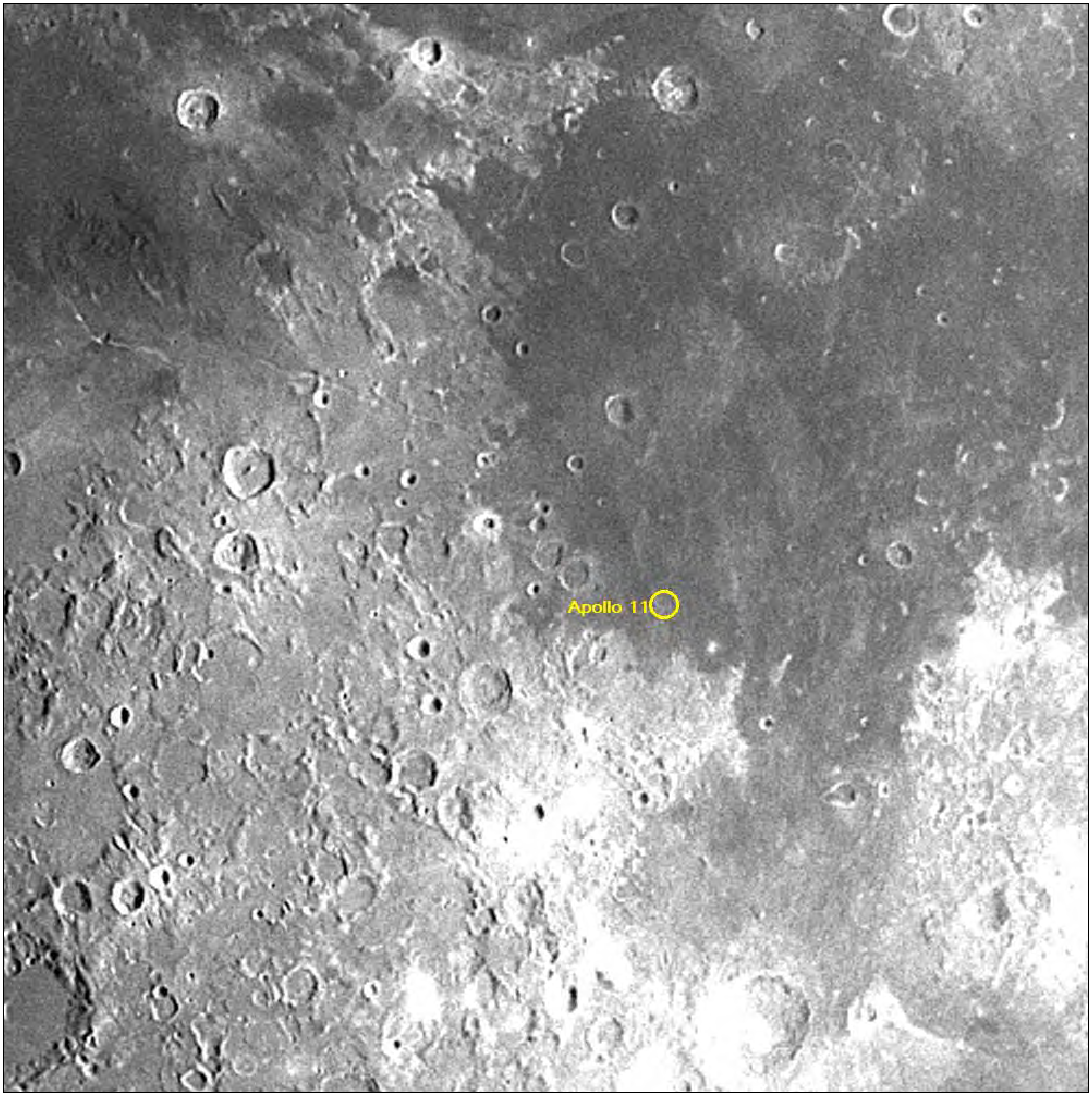

Figure 5. Apollo 11 Landing Site and Surrounding Area, Jerry Hubbell, Locust Grove, Virginia, 03 April 2009, 1926 UT. Colongitude, 17.6°, SkyWatcher 12-cm f/7.5 APO refractor, ATIK 314e CCD Camera. Visibility, 4/5 Transparency, 3/5. (ed. this is a crop of Figure 6.)

selenographic coordinates 0° 40' 27" N latitude and 23° 28' 23" E longitude. The landing site is also 109 miles (175 km) south of crater Arago 16 miles (26 km), and 236 miles (380 km) north of crater Theophilus 61 miles (101 km). The lunar module crew spent only 0.9-day on the surface and performed one 2h32m EVA during their stay (*figures 3 and 4*). At 10:56 p.m. EDT on July 20, 1969, Neil Armstrong became the first man to walk on the Moon. He stepped

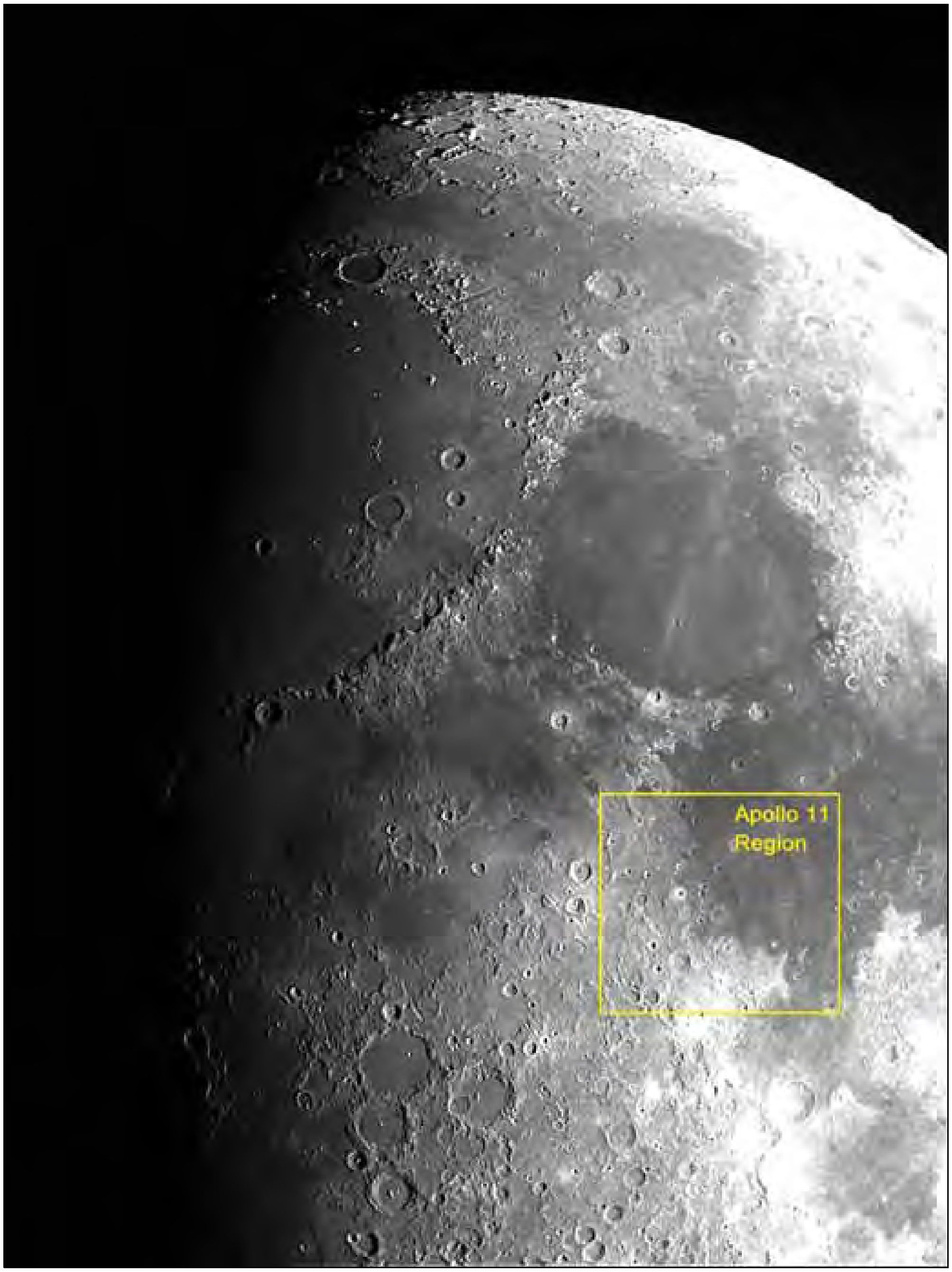

Figure 6. Mare Tranquilitatis (Sea of Tranquility), Jerry Hubbell, Locust Grove, Virginia, 03 April 2009, 1926 UT. Colongitude, 17.6°, SkyWatcher 12-cm f/7.5 APO refractor, ATIK 314e CCD Camera. Visibility, 4/5 Transparency, 3/5.

off the LM and uttered this famous line: "That's one small step for (a) man, one giant leap for mankind."

In his book, *To a Rocky Moon*, geologist Don Wilhelms discusses the process by which Apollo landing sites were chosen.

"…After Apollo 12, scientific considerations were given considerable weight but, for the very first landing (that is, Apollo 11), the site was chosen entirely for operational reasons. During the Lunar Orbiter missions, the high-resolution cameras had been focused on promising sites strung out along a 10-degree-wide band straddling the lunar equator. Equatorial sites were of interest because they could be reached with a minimal expenditure of fuel. Sites were also sought at least 45 degrees west of the east limb of the Moon - the right edge as seen from the northern hemisphere on Earth – because the landers were going to orbit from east to west and Houston was going to need several minutes of tracking data so that the landing computer could be updated prior to the descent. As Jack Schmitt related during a review of this introduction, "The targeted point for Apollo 8 was picked as the easternmost site that the Flight Control Division thought they could handle, the easternmost certified (acceptably smooth) site for which they thought there would be enough time after AOS (Acquisition of Signal) to track the Lunar Module, update its state vector, and get a successful landing. So Apollo 8 was targeted for that site (designated as "Apollo Landing Site 1") and, when it came time for Apollo 10, they targeted it to the same site, because they already had a rough data package (that is, data on orbits and the timing of events during the mission) that they could refine based on the relative positions of the Earth and Moon at the planned time of launch. (Launch times were picked, in part, so that at the time of landing, the Sun would be between 5 and 13 degrees above the landing site horizon, low enough to give good shadow definition of the terrain and not so low that everything would be obscured by overly-long shadows. Lighting conditions at the Cape and at abort recovery sites were also factors) …"

Apollo Mission Information

prepared by G.R. Hubbell - Assistant Coordinator, Lunar Topographical Studies, Lunar Section, ALPO

Mission	Apollo 11	Apollo 12	Apollo 14	Apollo 15	Apollo 16	Apollo 17
Mission Launch	16-Jul-1969 13:32:00 UTC	14-Nov-1969 16:22:00 UTC	31-Jan-1971 21:03:02 UTC	26-Jul-1971 13:34:00 UTC	16-Apr-1972 17:54:00 UTC	07-Dec-1972 05:33:00 UTC
Lunar Landing	20-Jul-1969 20:18:04 UTC	19-Nov-1969 06:54:35 UTC	05-Feb-1971 09:18:11 UTC	30-Jul-1971 22:16:29 UTC	21-Apr-1972 02:23:35 UTC	11-Dec-1972 19:54:57 UTC
Lunar Departure	21-Jul-1969 17:54:00 UTC	20-Nov-1969 14:25:47 UTC	06-Feb-1971 18:48:42 UTC	02-Aug-1971 17:11:23 UTC	24-Apr-1972 01:25:47 UTC	14-Dec-1972 22:54:37 UTC
Splashdown	24-Jul-1969 16:50:35 UTC	24-Nov-1969 20:58:24 UTC	09-Feb-1971 21:05:00 UTC	07-Aug-1971 20:45:53 UTC	27-Apr-1972 19:45:05 UTC	19-Dec-1972 19:24:59 UTC
Mission Duration	8d 03h 18m 35s	10d 04h 36m 24s	9d 00h 01m 58s	12d 07h 11m 53s	11d 01h 51m 05s	12d 13h 51m 59s
Time on Lunar Surface	21h 36m 00s	31h 31m 12s	33h 30m 31s	66h 54m 54s	71h 02m 13s	74h 59m 40s
Number of EVAs	One	Two	Two	Four - One EVA in space	Four - One EVA in space	Four - One EVA in space
EVA Time on Lunar Surface	2h 31m 40s	7h 45m 18s	9h 22m 31s	18h 30m 00s	20h 14m 14s	22h 03m 57s
Mission Commander	Neil Armstrong	Charles Conrad	Alan Shepard	David Scott	John Young	Eugene Cernan
Lunar Module Pilot	Buzz Aldrin	Alan Bean	Edgar Mitchell	James Irwin	Charles Duke	Harrison Schmidt
Command Service Module Pilot	Mike Collins	Richard Gordon	Stuart Roosa	Alfred Worden	Ken Mattingly	Ronald Evans
Mission Goals	First manned landing on the moon, Early Apollo Surface Experiment Package (EASEP)	Precision Landing near Surveyor 3 spacecraft, Apollo Lunar Surface Experiments Package(ALSEP), lunar orbital experiements and photography H mission type	First use of the "Lunar Rickshaw", Examination of Cone Crater, lunar surface experiments (ALSEP) and lunar orbital experiments and photography H mission type	First use of the Lunar Rover, lunar surface experiments (ALSEP) and lunar orbital experiements and photography first J mission type	lunar surface experiments (ALSEP) and lunar orbital experiments and photography J mission type	lunar surface experiments (ALSEP) and lunar orbital experiments and photographyn last mission to the moon
Landing Site Name	Sea of Tranquility	Ocean of Storms	Fra Mauro Highlands	Mare Imbrium-Hadley Rille	Descartes - Cayley Plains	Sea of Serenity
Landing Site Selenographic Coordinates	0.674°N 23.473°E	3.0124°S 23.4216°W	3.654°S 17.471°W	26.132°N 3.634°E	8.973°S 15.500°E	20.191°N 30.772°E
Landing Site Features	Flat plain, near southern edge of Mare Tranquillitatis	Surveyor 3 spacecraft	First mission to lunar highlands, volcanic activity	Mt Hadley, Hadley Delta, Hadley Rille	Lunar Highland material older than previous missions, volcanic activity in area	Lunar Highland material older than Mare Imbrium, volcanic activity in the area
Focus On Observations	Delambre, Sabine, Ritter, Godin, Agrippa, Maskelyne, Lamont, Theophilus, Torricelli	Copernicus, Reinhold, Lansberg, Ptolemaeus, Alphonsus, Arzachel, Bullialdus, Montes Riphaeus	Fra Mauro, Parry, Bonpland, Guericke, Rimae Parry, Gambart, Lansberg, Reinhold, Tolansky	Hadley Rille, Hadley Delta, Archimedes, Aristillus, Autolycus, Conon, Galen, Aratus	Ptolemaeus, Alphonsus, Arzachel, Rupes Recta, Albategnius, Klein, Hipparchus, Herschel, Abulfeda, Delambre	Posidonius, Plinius, Dawes, Cleomedes, Macrobius, Romer, [illegible] Dorsa Smirnov, Dorsa Lister
Observing Equipment - Minimum to observe all objects listed	50 - 100 mm Telescope	50 - 100 mm Telescope	50 - 100 mm Telescope	50 - 100 mm Telescope	50 - 100 mm Telescope	50 - 100 mm Telescope
Submissions - Images	N/A	1 - 8 images + comments	1 - 11 images + comments	5 - 10 images + comments	2 - 5 images + comments	4 - 13 images + comments
NASA Mission Surface Operations Page	NASA Apollo 11 Mission	NASA Apollo 12 Mission	NASA Apollo 14 Mission	NASA Apollo 15 Mission	NASA Apollo 16 Mission	NASA Apollo 17 Mission
TLO - Focus On Article	Apollo 11 Not Yet Written	Apollo 12	Apollo 14	Apollo 15	Apollo 16	Apollo 17

Figure 7. Apollo Manned Lunar Landing Mission Information compiled by Jerry Hubbell.

The main mission and program objective was to successfully complete Kennedy's challenge *to land a man safely on the Moon and return him safely to the Earth*. The secondary objectives included exploring the southwest region of the Sea of Tranquility and set up and activate the first lunar surface scientific experiments, a predecessor to the Apollo Lunar Surface Experiment Package (ALSEP) used in later mission called the Early Apollo Scientific Experiments Package (EASEP). The EASEP consisted of three experiments:

- A Laser Ranging Retroreflector experiment
- A Passive Seismic experiment
- A Lunar Dust Detector experiment

They also deployed a camera system, a solar wind experiment and deployed the first American flag on the Moon's surface.

The early Apollo mission site selection criteria was based on the need to sample sites that were representative of the lunar surface and could provide materials to start to understand the origin of the Moon.

According to the *Criteria for Lunar Site Selection*, Report No. P-30 (reference)

> "…According to the rationale of level 2, the individual mission sites must be chosen to represent homogeneous provinces and/or scientifically significant features. The homogeneous sites must have characteristics, in so far as can be determined from the orbital reconnaissance of level 1 which are typical of the province in which they lie, so that the information obtained from each site is of significance regarding a large portion of the Moan, or hopefully the entire Moon. By this definition it is to be understood, once such a homogeneous province has been defined, that the actual location of the landing site within the province is not critical and that from a scientific stand point extensive traverse capability is not require. Large fractions of the various lunar maria, the majority of exposed ejecta from Imbrium or Oriental, and portions of the cratered upland plains between Maurolycus and Janssen are examples of areas where level 2 landing sites would yield the desired scientific information."

The Sea of Tranquility is in the northeastern quadrant of the Moon and the Apollo 11 landing site is in the southwest region of that quadrant (*Figure 6*.) The northeast quadrant of the Moon has a wealth of features that are suitable for a small telescope to observe and anytime between a 1-day old and a 7-day old Moon will give the best views because of the long shadows near the terminator. The list of craters that are viewable even with a 70 mm refractor, or a 10x60 set of binoculars is large. Some of the most prominent craters and their diameters are Plato (61 miles, 98 km), Aristoteles (53 miles, 85 km), Eudoxus (41 miles, 66 km), Cassini (35 miles, 56 km), Archimedes (50 miles, 80 km), Hercules (42 miles, 68 km), Atlas (53 miles, 85 km), Posidonius (58 miles, 93 km), Aristillus (33 miles, 53 km), Delambre (32 miles, 51 km), Theophilus (61 miles, 98 km), Cyrillus (59 miles, 95 km) and Agrippa (28 miles, 45 km). Details on these and more, can be obtained by using the program *Virtual Moon Atlas* (see *References*). This is an excellent program for those wanting to learn the features of the Moon and identify those features in your own or other's photographs.

All these craters are fascinating in their own way and will provide many hours of enjoyment while studying their special characteristics. *Figure 7* lists all the Apollo Lunar missions and the features that are located near each of the landing sites.

NASA's Apollo Program was probably mankind's greatest adventure up until now, and nothing will rival it until we land on Mars within the next couple of decades. It is ironic that this great space adventure started as a competition between two political ideologies that continue to this day. It is best to remember what was brought to the Moon on a plaque affixed to the landing leg of the Apollo 11 LM:

HERE MEN FROM THE PLANET EARTH

FIRST SET FOOT UPON THE MOON

JULY 1969, AD

WE CAME IN PEACE FOR ALL MANKIND

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The ALPO Lunar Section

Lunar Observing Since Apollo 11

By Wayne Bailey, coordinator,
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Online Features

Left-click your mouse on the author's e-mail addresses in blue text to contact the author of this article.

Figure 1. Clavius region high/low sun comparison. Left: March 23, 2019 09:54 UT. Colongitude 116.1°. Howard Eskildsen, Ocala, Florida USA. 6" f/8 refractor, 2X barlow, W-8 yellow filter. DMK 41AU02.AS. Right: April 13, 2019 22:21 UT. Colongitude 18.6°. Walter Elias,, Oro Verde, Entre Rios, Argentina. 11" f/10 SCT, ZWO ASI 120 MM/S.

Why observe the Moon in an era when it has been studied by orbiting spacecraft, visited by both robotic landers and humans, and samples of its surface returned to Earth and studied? It has no rapidly changing atmospheric phenomena like Jupiter or seasonally changing surface features like Mars. What can amateurs do that hasn't already been done better?

First, two points that have not changed: The Moon is an excellent object to view at public outreach events and to develop observing techniques. Telescopic views of the Moon can be easily related to images people have seen, but the view of "faint fuzzies" is often disappointing when compared to the color images that are widely available. Because the Moon is so close, even the poorest first observation typically will reveal some features, and improvements in observing skill produce obvious results. However, excellent results require just as much skill as for any other object, and continuously changing lighting conditions provide ever changing views to explore (see Figure 1). In this regard, although cartographic and photometric accuracy doesn't approach digital image levels, visual observation and sketching are excellent for developing the ability to recognize subtle details of an image.

But what has changed? Prior to the spacecraft era, the capabilities of amateurs and professionals complemented each other fairly well. Professionals had access to larger telescopes, auxiliary instrumentation, support staff and funding, but also faced observing schedule constraints, and pressure to produce results. The Earth's atmosphere also constrains the improvement achieved by larger telescopes. Amateurs had equipment that could produce results as good as the professionals' equipment in many cases, more flexible observing schedules, and the freedom to pursue studies with uncertain outcomes, but faced constraints of work and family obligations, funding and often lacked timely access to professional results that could influence the choice of subjects to study. Amateurs could map the lunar surface, measure elevations, observe albedo changes with phase and determine surface colors as well as, and with fewer constraints than professionals.

Orbital spacecraft have produced detailed maps of the entire surface of the Moon that would be impossible to duplicate from Earth's surface. Their photometry/spectroscopy has produced maps of the general chemical/mineralogical composition of the surface (see Figure 2). Topography and composition are independent of phase, so these are now beyond the abilities of amateurs.

But albedo features (such as rays or bright/dark spots), polarization and colors depend on the fine scale surface structure, and do change as the lighting changes (see Figure 1). These remain as viable subjects of amateur observation, since orbiting spacecraft, constrained by orbit mechanics, have not produced systematic observations with phase.

Random events, such as meteorite impacts, where large sections of the surface can be continuously monitored, are also best studied from Earth. Orbiting spacecraft observe only a small area that is continuously changing, so they are very inefficient for such observations.

Sample return missions, which brought samples of the lunar surface back for study on Earth, were dominated by the six

Apollo missions that landed humans on the Moon. They returned 842 lbs (382 kg) of lunar rocks and soil. Although many other types of data were obtained, these are the only scientific results of the manned missions that directly relate to amateur observing activities. Analysis of these samples provides "ground truth" calibrations for photometric and spectroscopic observations. An example of this is the article by Evans (2007 a,b) which uses spectroscopic reflectivity data for material from a known site as a standard to remove atmospheric absorption from ground-based lunar spectra.

I've often heard the comment that since humans have visited the Moon and brought back samples, there's nothing useful left for amateurs to do. This may be true for the traditional mapping type observations, where the high resolution achieved by lunar probes exceeds anything that amateurs can do from Earth (see Figure 3).

However, as stated above, observations that involve simultaneous wide-area coverage, studies of changes with lunar phase or that require observations of particular locations under specific lighting conditions are still better performed from Earth.

And finally, if we're willing to broaden the meaning of "observing" the Moon, the data produced by lunar probes, most of which is freely available on-line, provides an additional resource for studying the Moon. The Apollo flights, along with other lunar spacecraft, have significantly changed some areas of lunar observing, but those changes include new opportunities.

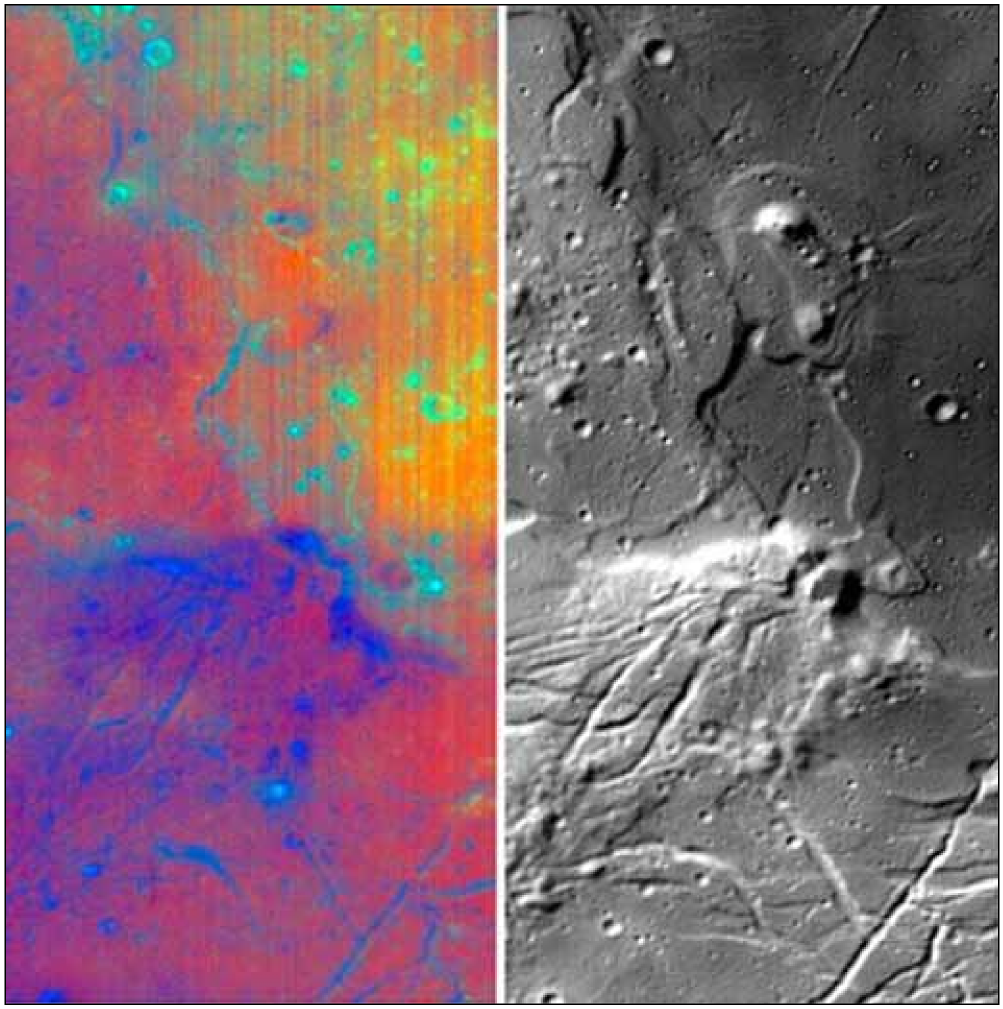

Figure 2. Mare Orientale region. Left: Color composite created from the 28 spectral channels. The blue through red colors distinguish represent different rock/mineral compositions. Green indicates iron-bearing minerals such as pyroxene. Right: The same area viewed in a single channel that includes thermal emission. Spectral data from the NASA Moon Mineralogy Mapper which flew on the Indian Space Research Organization's Chandrayaan-1 spacecraft. (*https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA11727*) Image credit: NASA/JPL/Brown

Figure 3. Menelaus. Lunar Reconnaissance Orbiter Camera (LROC) Quickmap. (*http://target.lroc.asu.edu/q3/*).

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The ALPO Lunar Section

Who and What is the Lunar Domes Survey Program

By Raffaello Lena, acting coordinator, ALPO Lunar Domes Survey Program
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Jim Phillips, acting assistant coordinator, ALPO Lunar Domes Survey Program
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Raffaello Lena

I was born in 1959, and live in Rome Italy, a large metropolis. I have been interested in the Moon since I was 10 years old and have progressed from a small Newtonian telescope to high quality scopes (6-inch Maksutov Cassegrain and a 5" TMB refractor, figures 1 thru 3). Twenty years ago, I used my f/15 Polarex Unitron 100 mm refractor. It is now a vintage object in my house (Figure 4). I have a doctorate in pharmaceutical sciences from the University of Rome and work in food safety for the Italian government at the Ministry of Health. And whenever possible I listen to jazz and explore Italy's volcanoes and mountainous geology, collecting rocks and mineral for my own collection at home.

The Apollo era has stimulated me to improve my knowledge in astronomy: the Moon and Saturn were the first celestial bodies that I observed. I was almost totally a visual observer, making drawings and taking notes at the eyepiece. I began imaging in October 2004 and have continued that practice, although I still observe visually as well.

Because of the close proximity of the Moon to the Earth, an amateur can observe fascinating detail on the surface of the Moon with quite small telescopes. I enjoy spending time looking at the elusive features the lunar surface offers and my first target are the lunar domes.

Digital imaging enhanced amateur capabilities demonstrating the utility of CCD-image analysis in the elucidation of lunar domes and their properties, providing important geologic information and measurements for their classification. Moreover, elusive objects must be imaged under very oblique solar angle, demonstrating how exploring the terminator can still be productive for lunar investigations based on telescopic CCD images.

The results of the work done with Jim Phillips, and many other lunar friends, demonstrate that our Moon is a resource to be still explored. Some years ago, I was lucky to meet Chuck Wood in Rome, talking with him about the projects concerning lunar researches, lunar domes and measurements made using lunar probes data, including the spectral properties of lunar domes. I was described by Chuck Wood as the "dome-master".

Different methods for determining the morphometric properties of lunar domes (diameter, height, flank slope, edifice volume) from CCD image and/or orbital topographic data, and for determining multispectral images data providing insights into the composition of the dome material, have been examined and discussed in the book *Lunar Domes: Properties and Formation Processes*, co-authored by me with Christian Wöhler, Jim Phillips and Maria Teresa Chiocchetta and published by Springer.

Lunar domes represent a clear testimony of the volcanic processes that have occurred on our Moon. In fact, the differences in dome shapes and rheologic parameters raise broad questions concerning the source regions of the various dome types, allowing the knowledge of which differences in the lunar interior are responsible for the different lunar dome properties observed

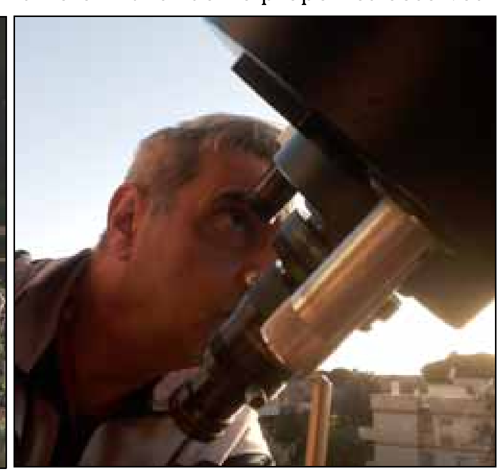

Figure 1 (left). The author with his TMB 13-cm refractor. Figure 2 (center) and Figure 3 (right). With the 18-cm Mak Cassegrain.

on the surface. I authored chapter 11 of the book *Lunar Meteoroid Impacts and How to Observe Them* (Brian Cudnik, published by Springer). I wrote the chapter about the magmatic intrusion structures in the *Encyclopedia of Planetary Landforms* (editors: Ákos Kereszturi and Henrik Hargitai, published by Springer) and the chapter about lunar domes in the *Encyclopedia of Lunar Science* (Cudnick, published by Springer).

Figure 4. The Polarex Unitron 100 mm f/15

Ground-based images obtained with telescopes and CCD cameras used by amateur astronomers are still of great value for the morphometric and morphological analysis of lunar domes in the geologic context (Figure 5), or in the case of unreported domes. As my compatriot, Galileo Galilei wrote, "All truths are easy to understand once they are discovered; the point is to discover them." (See Figure 6 in order to understand the slope of the Pisa tower). I am the acting coordinator of the ALPO Lunar Domes Survey Program and coordinator of the BAA Lunar Domes Program. During last two decades, my prime target has been to elevate amateur lunar studies to a professional level.

Let me conclude by quoting my compatriot Gaetano Filangieri: "Saying that everything has already been done is the language of those who either lack ability or courage," (Gaetano Filangieri 1784). This principle should be the "inspiriting base and the key" for the youngest generation of amateur astronomers.

Finally, Stefano Sposetti of Gnosca Observatory in Switzerland requested that the main belt asteroid, 1999 TG12, be named "Raffaello Lena," in recognition of my lunar contributions and studies. The IAU approved the request so the asteroid is now officially "102224 Raffaellolena".

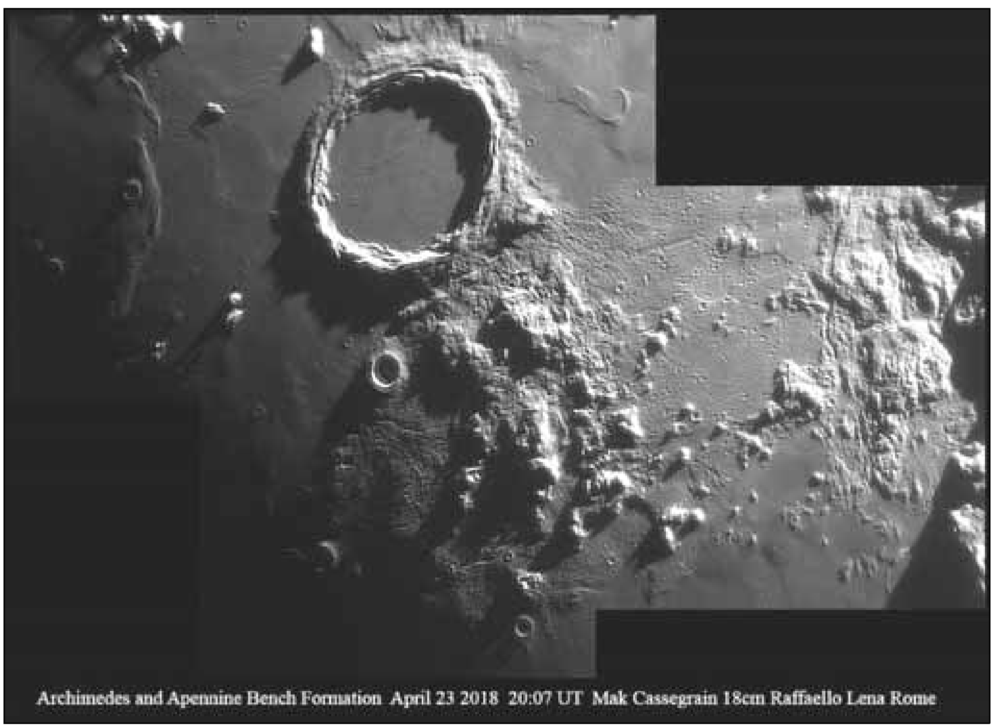

Figure 5. The Apennine Bench Formation (ABF). The origin of ABF has been subject considerable speculation with early interpretations being basin ejecta and impact melt based on comparisons with the Maunder Formation of Mare Orientale. Samples recovered by the Apollo 15 astronauts were interpreted as being representative of the medium-K Fra Mauro basalts which remote sensing data indicates forms the ABF. This reinterpretation placed the ABF in the unique position of being one of the largest non-mare areas of volcanism known, post-dating the Imbrium event by 200 million years. The origin of this putative magadome includes a phase of uplift occurred likely under the influence of a laccolith like intrusion in the shallow crust, effusive and explosive processes originating domes, cones and pyroclastic deposits.

Figure 6. Raffaello Lena with the leaning tower of Pisa (Italy), the home town of Galileo Galilei. The height of the tower is 55.86 meters from the ground on the low side and 56.67 meters on the high side. Prior to restoration work performed between 1990 and 2001, the tower leaned at an angle of 5.5 degrees, but it now leans at about 3.99 degrees.

Jim Phillips

My name is Jim Phillips. I was born in 1950 and am a Dermatopathologist. I am married, have three grown children, and live in South Carolina. I collect old astronomy books and maps and love fly fishing.

I became interested in space and astronomy at an early age. I remember going out to see the Echo 2 satellite pass overhead in 1964. I cannot say exactly when my interest in astronomy began but I do recall waking up on my 15th birthday, September 17, 1965, to my first telescope. It was a "Gilbert 80X", about a 2-inch reflector (Figure 7). I loved observing and sketching. Back then, amateurs were encouraged to do "useful work." But to make a real contribution, I needed more aperture.

I followed the U.S. space program closely. Five of seven Surveyor spacecraft soft landed successfully on the Moon between 1965 and 1968. Then came the real excitement, manned space flight; Mercury, Gemini and finally, Apollo! I followed every flight.

My first really nice telescope was a Criterion RV-6, a 6-inch, f/8 reflector. I was using this telescope when Apollo 11 landed on the Moon July 20, 1969. I have pictures of the telescope pointing to the Moon when our astronauts were there. It was an extraordinary, once-in-a-lifetime event that I will never forget. I have drawn the area of the Apollo 11 landing site many times with different telescopes (Figure 8).

I concentrated on observing the Moon and planets. Patrick Moore was a big influence on me with his book, "Guide to the Moon." The fact that an amateur astronomer could actually discover something new or as is more likely the case, something never before cataloged on the Moon fascinated me. I became

Figure 7. Jim Phillips with Gilbert 80X reflector in 1965.

Figure 8. Sketch by Jim Phillips of Tranquility Base landing site, 12 April 1989.

interested in observing and searching for new lunar domes.

The British Astronomical Assn and the ALPO had programs on lunar domes, so I wrote to John Westfall of the ALPO looking for the most up-to-date catalog. By then, I had an 8-inch f/13 RE Brandt achromat refractor (Figure 9) and I was ready to start searching for new domes. John responded by saying the catalog had never been completed and suggested that I restart the ALPO program. The previous ALPO executive director insisted I not look for any new domes, but just concentrate on cleaning up the observations from the previous survey.

I did the best I could, but not being able to look for new domes was a problem for me. WE ended up publishing what we had at the time, a useful – but inaccurate – catalog.

It was at this time that I met Raffaella Lena, who was in charge of the GLR (Geologic Lunar Research) group and he invited me to participate. This time, I could and did find a large number of uncataloged domes. We were a highly efficient team, consisting of a core of four individuals: Raffaella Lena, Christian Wohler, Jim Phillips and Maria Teresa Chiocchetta.

Figure 9. Jim Phillips (at left) with an 8-inch f/13 RE Brandt achromat refractor and Tom Dobbins, also of the ALPO and builder of the scope and mount.

Our hard work paid off, as we published the first and only book devoted exclusively to lunar domes, "Lunar Domes Properties and Formative Processes." Raf continued his research afterwards and now heads the ALPO Lunar Domes Survey Program with me as his assistant.

The Moon has always been a fascinating object for me. Through the eyepiece of a telescope I can see more detail on the lunar surface with my finder scope than can be seen on Mars with the largest telescopes in the world. That should give anyone an idea of the detail one can see on the Moon with even a small telescope.

While visual observing and drawing what I see at the eyepiece was my preference for 35 years, after the turn of this century I recognized the need to image (Figure 11).

Figure 10 (left). Sketch of Beer and Feuillée crater field with domes, 3 April 1990.
Figure 11 (right). Image of Straight Wall by Jim Phillips, 3 September 2018.

ALPO Lunar Dome Observation Form

Submit electronically (attach images and scanned drawings to e-mail) to:
Raffaello.Lena@alpo-astronomy.org
or via regular mail to:
Raffaello Lena
Cartesio 144 D
00137 Rome, Italy

Observers Name:	**Last:**					**First:**				
Date: (UD)	**Month:**			**Day:**			**Year:**			
Time: (UT)	**(UT) Hours:**					**(UT) Minutes:**				
Colongitude:										
Region Observed:										
Telescope:	**Size (Inches or Cm.):**					**Type:**				
Eyepieces Used:									**Filters:**	
Seeing (Circle)	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Transparency:										
Type of Observation (list details):	**Visual:**					**Photographic:**				

Domes Observed (Positions)

Xi	Eta	OR	Lunar Long.	Lunar Lat.

Notes: (**Include observer location here (City, State, and Country):** Use back if necessary):

The ALPO Lunar Section

Lunar Domes – The Marius Shield (Part II)

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Abstract

In this second report regarding the Marius hills region, an additional 21 volcanic constructs are described and characterized in their morphometric and spectral properties. During our survey we have now characterized a total of 62 features. Finally, using new data, we have updated our maps which illustrate the distribution of some lunar domes and cones in the Marius Shield.

Introduction

The Marius hills region in the Oceanus Procellarum consists of large numbers of lunar domes which formed as a result of multiple volcanic outbreaks. The Marius domes and cones are different from typical mare domes due to their complex structure, indicating a formation in several stages involving different eruption styles (Head and Gifford, 1980). During our survey, we have characterized a total of 41 volcanic features described in our previous works [Lena et al., 2013; Lena and Phillips, 2018]. The following is a continuation of this characterization of domes in the Marius shield region. For the current study, we have analyzed 17 CCD images reported in Table 1. Based on CCD telescopic images and GLD 100 dataset [Scholten et al., 2012], we describe the morphometric properties of further 21 volcanic constructs (Table 2), extending their classification as proposed by Lena et al. [Lena et al., 2013; Lena et al., 2009]. Some data regarding coordinates and diameters of the previous domes termed Ma1-40 have been updated during the current study and reported in Appendix (Table 3), which may be due to the limited spatial accuracy of telescopic based observations.

Data Sources and Approach

The new global topographic map of the Moon obtained by the Lunar Reconnaissance Orbiter (LRO) is the principal source of topographic information used in this study. Associated topographic profiles of each feature examined were extracted from the GLD100 database using the Quickmap LRO global basemap (*http://target.lroc.asu.edu/da/qmap.html*).

The surface elevation plots derived for the examined domes are shown in figures 1 through 3. The 3D reconstructions using WAC mosaic draped on top of the global WAC-derived elevation model (GLD100) are shown in Figure 4. Note that the flank slope derived for these domes is an average value, since the profile of most domes is somewhat asymmetric. The domes described in the current article are reported in Table 2, and are marked in the WAC imagery shown in figures 5 through 7. Some telescopic CCD images of the examined lunar region are shown in figures 8 through 10. Morphometric data and 3D reconstruction have also been obtained

Table 1. Observers and Number of the Analyzed CCD Images

Observers	Images	Telescope
F. Badalotti (Italy)	1	Maksutov 25cm
R. Hill (USA)	2	Mak Cassegrain 25 cm
G. Leinen (Luxembourg)	2	Schmidt Cassegrain 23.5 cm
R. Lena (Italy)	3	Mak Cassegrain 18 cm
J. Phillips (USA)	4	TMB 20 cm refractor
KC Pau (Hong Kong)	2	Newton 25 cm
M. Wirths (USA)	2	Dobsonian 40 cm
I. Zajac (Croatia)	1	Newton 25 cm

Online Readers

Your comments, questions, submitting observing reports of your own, etc., about this report are appreciated. Please send them to the authors by left-clicking your mouse on either of the e-mail addresses under the bylines on this page in blue text.

Also left-click on any hyperlinks in blue text within the text of this paper for additional information.

Observing Scales

Standard ALPO Scale of Intensity:
0.0 = Completely black
10.0 = Very brightest features
Intermediate values are assigned along the scale to account for observed intensity of features

ALPO Scale of Seeing Conditions:
0 = Worst
• 10 = Perfect

IAU directions are used in all instances.

from CCD telescopic images (Figure 11) using photoclinometry and shape-from-shading techniques (SfS) [Lena et al., 2013]. Generating an elevation map of a part of the lunar surface requires its three-dimensional (3D) reconstruction. A well-known image-based method for 3D surface reconstruction is shape-from-shading (SfS). It makes use of the fact that surface parts inclined towards the light source appear brighter than surface parts inclined away from it. This method takes into account the geometric configuration of camera, light source, and the surface normal, as well as the reflectance properties of the surface to be reconstructed [Horn, 1989]. Spectral analyses are released on the calibrated and normalized Clementine UVVIS and NIR reflectance data [Eliason et al., 1999]. In this work, data from Chandrayaan-1's Moon Mineralogy Mapper (M^3) were used to derive spectral data that highlight mineralogical characteristics of lunar volcanic materials including volcanic glasses signature. The M^3 instrument is an imaging reflectance spectrometer that can detect 85 channels between 460 to 3,000 nm, and has a spatial resolution of 140 and 280 meters per pixel [Isaacson et al., 2011]. Data have been obtained through the M^3 calibration pipeline to produce reflectance with photometric and geometric corrections using image sets taken during the optical period OP2C1.

For deriving the spectral parameters, the photometrically corrected Level 2 data of the PDS imaging node have been used [Isaacson et al., 2011]. In order to characterize the 1,000 nm band, we use a continuum removal method that enhances the characteristic of the 1,000 nm absorption band and more accurately shows the position of the band center.

Table 2: Morphometric Properties of 21 Volcanic Constructs Examined in This Study.
Morphometric properties of the domes previously described, updated during this survey and the current study are reported in Appendix (Table 3).

Dome	Longitude	Latitude	Slope [°]	Diameter [km]	Height [m]	Class
Ma41	-50.34	16.64	2.9±0.2	7.4±0.5	190±20	H_2
Ma42	-48.22	15.11	1.0±0.1	5.1±0.5	50±5	H_1
Ma43	-47.91	14.93	2.5±0.2	2.2±0.5	50±5	H_1
Ma44	-50.39	15.65	2.4±0.2	11.2±0.5	240±20	H_2
Ma45	-49.18	14.83	0.7±0.1	5.3±0.5	35±5	H_1
Ma46	-51.51	14.77	4.4±0.4	15±0.5	580±60	H_2
Ma47	-51.32	15.02	3.8±0.3	6.4±0.5	225±20	H_2
Ma48	-52.07	14.89	4.9±0.5	7.1±0.5	320±30	H_2
Ma49	-52.46	14.1	3.5±0.4	6.5±0.5	200±20	H_2
Ma50	-52.61	14.79	3.9±0.4	5.2±0.5	180±20	H_1
Cone 2	-53.78	14.04	7.7±0.7	2.7±0.5	180±20	Cone
Ma51	-51.49	14.16	5.8±0.5	6.7±0.5	340±35	H_3
Ma52	-51.29	14.32	3.1±0.3	4.1±0.5	110±10	H_1
Ma53	-51.15	14.02	4.2±0.4	6.0±0.5	220±20	H_2
Ma54	-51.23	13.87	4.7±0.4	4.5±0.5	185±20	H_1
Ma55	-51.36	13.86	1.8±0.2	3.75±0.5	60±10	H_1
Ma56	-53.91	13.55	3.5±0.3	6.7±0.5	210±20	H_2
Ma57	-54.16	13.79	1.9±0.2	6.6±0.5	110±10	H_2
Cone 3	-53.25	13.17	5.4±0.5	1.8±0.5	85±10	Cone
Ma58	-53.74	12.56	4.6±0.4	7.4±0.5	300±30	H_2
Cone 4	-52.68	13.25	4.6±0.4	1.6±0.5	65±10	Cone

Region I: Comprised Between 47°-51° W and 14.8°-17° N

This region is characterized by the long and sinuous Rima Marius. Near Rima Marius are located two domes termed Ma41 and Ma42, while three other domes, Ma43 through Ma45, are further isolated domes (Figure 5 and figures 8 and 9). They display irregular shapes and summit craters in particular the large Ma44 (Figure 5). Ma42, Ma43 and Ma45 are domes of low height compared to other volcanic constructs (Table 2 and Figure 5) Based on the CCD images (figures 8 through10) and the GLD100 dataset (Figure 1), we obtain diameters of 2.2-11.2 km for these domes, moderate slopes of 2.4°-2.9° for Ma41, Ma43 and Ma44, and shallower slopes of 0.7°-1.0° for the domes termed Ma42 and Ma45 (Table 2). Likely further domes of low profile may be present in this region, but new images are necessary in order to confirm suspected bumps (at the present unverified).

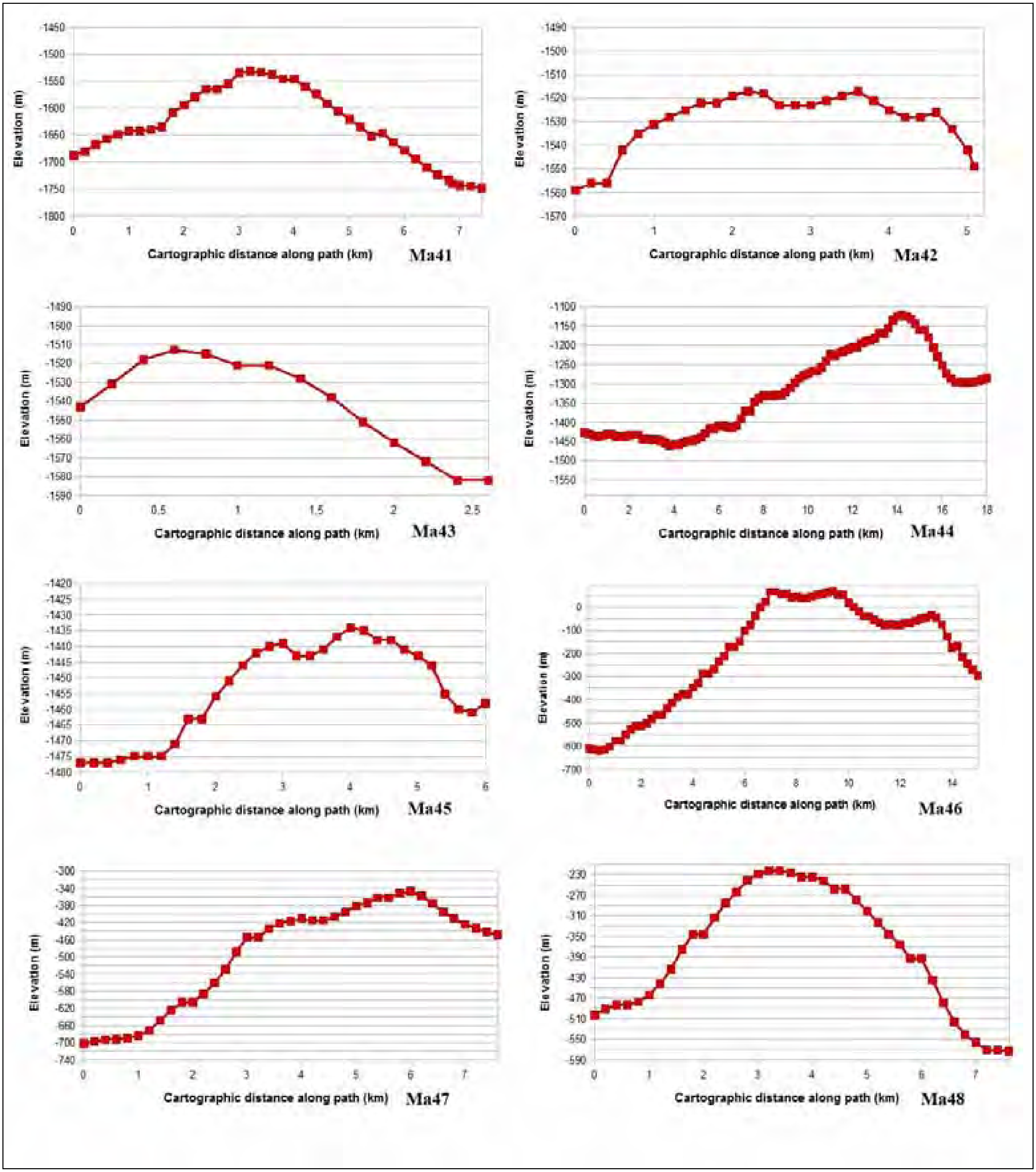


Figure 1. Cross-sectional profile in east-west direction based on GLD100 dataset for the examined domes and cones (Ma41-Ma48).

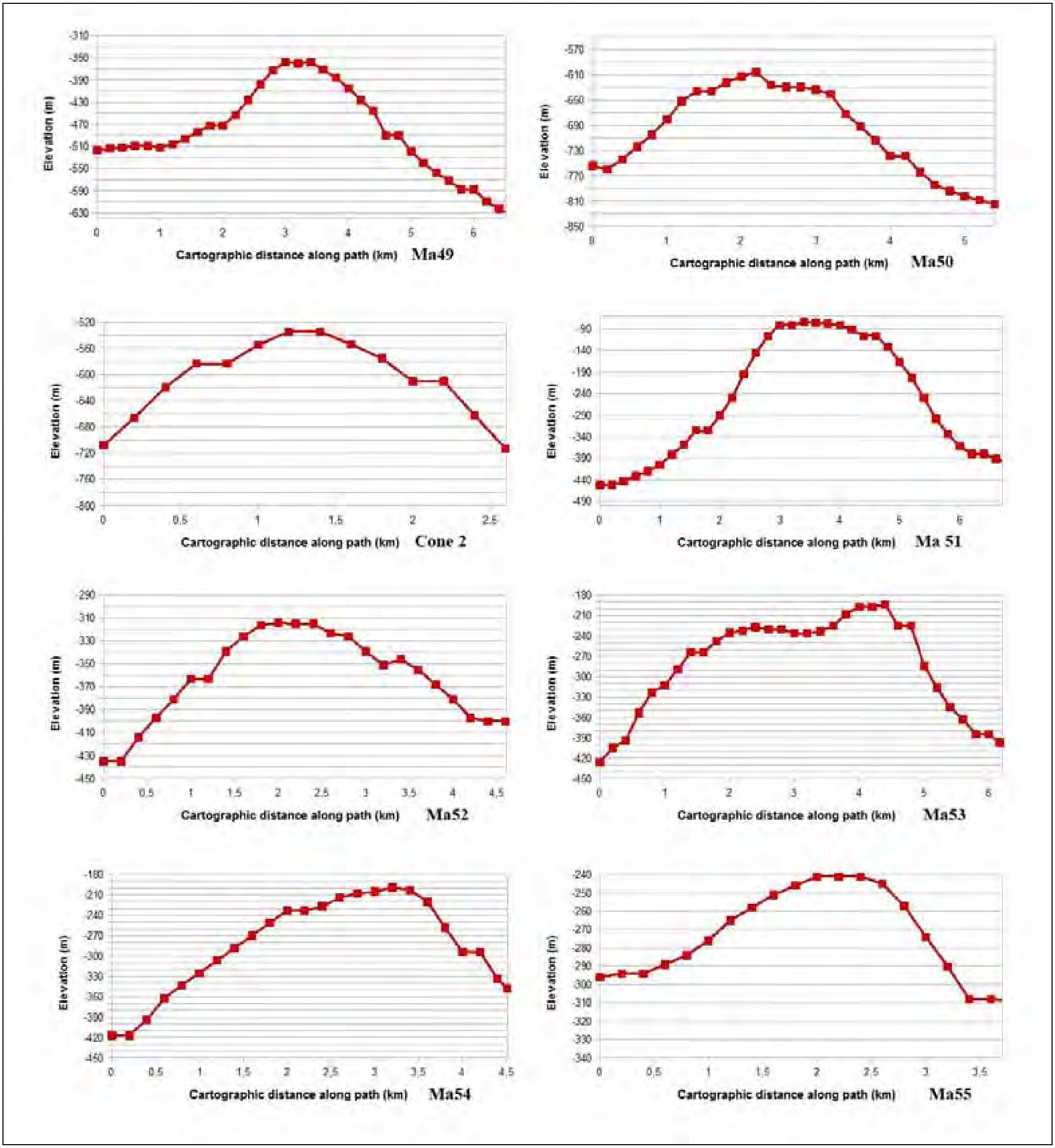


Figure 2. Cross-sectional profile in east-west direction based on GLD100 dataset for the examined domes and cones (Ma49-Ma55 and cone 2).

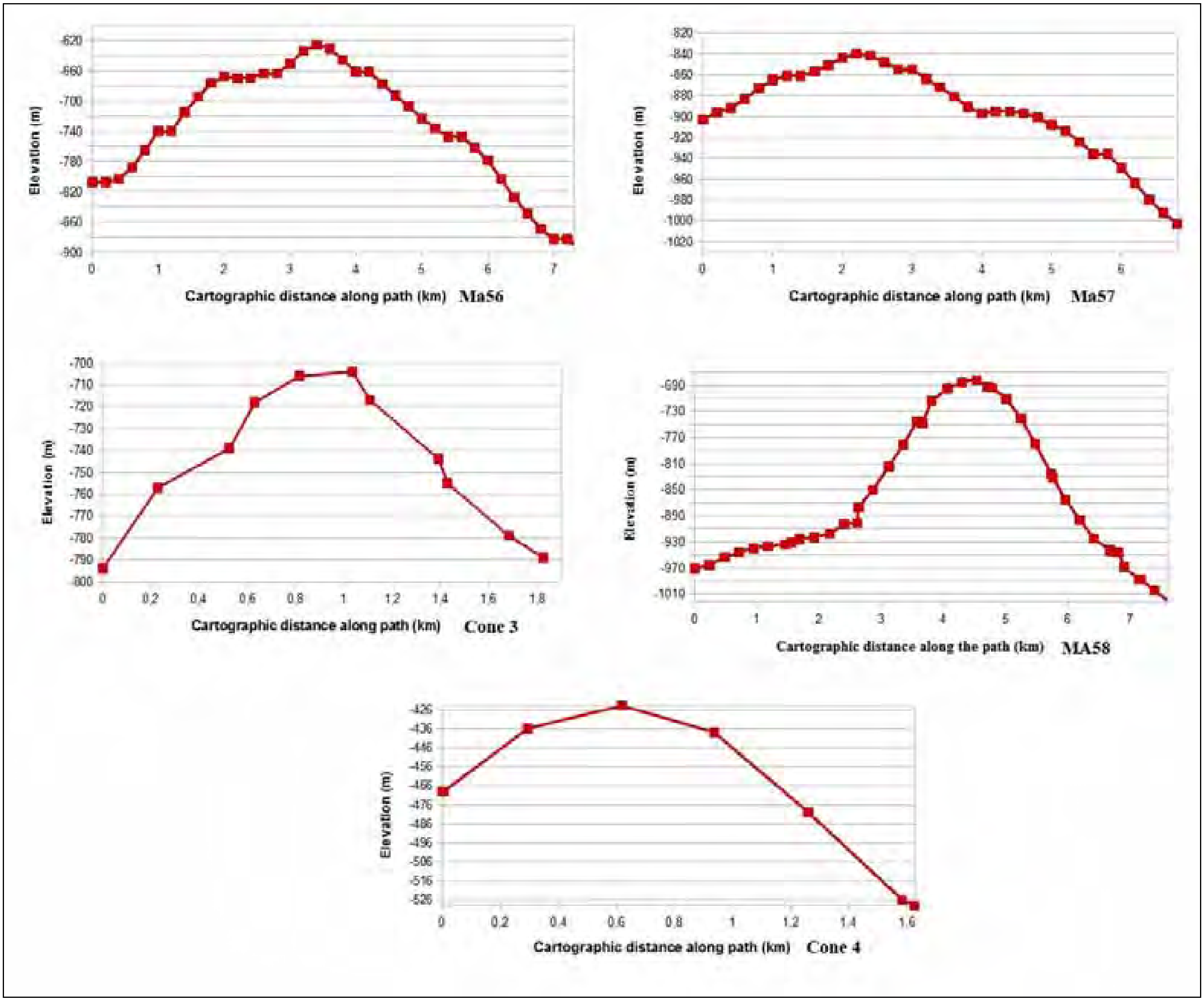


Figure 3. Cross-sectional profile in east-west direction based on GLD100 dataset for the examined domes and cones (Ma56-Ma58 and cones 3-4).

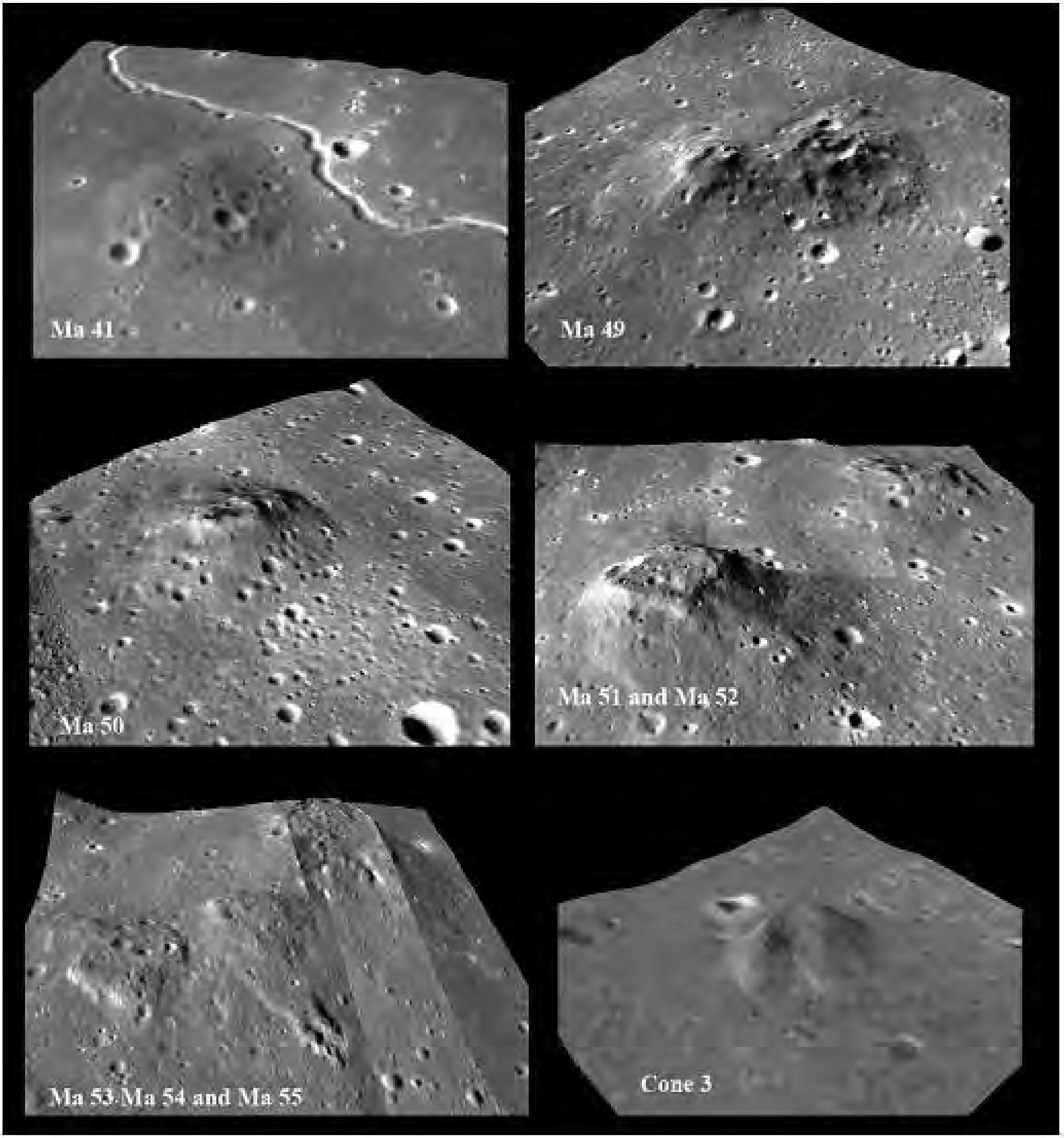


Figure 4. WAC draped on top of the global LROC WAC-derived elevation model (GLD100) for some examined volcanic constructs. The vertical axis is 5 or 10 times exaggerated.

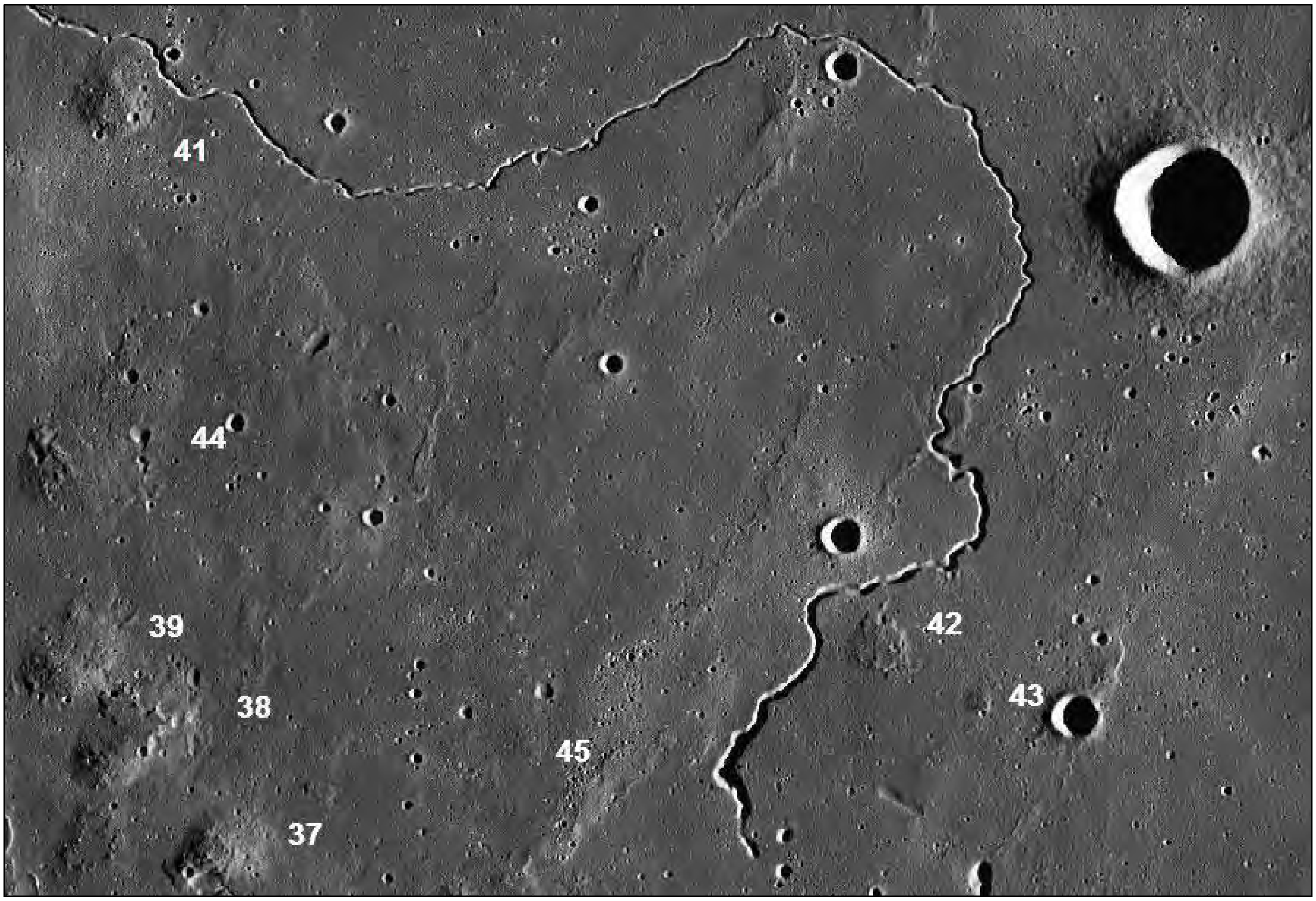


Figure 5. LROC WAC imagery of the region including Ma41-Ma45 (Region I). The other domes have been characterized in our previous report [Lena and Phillips, 2018].

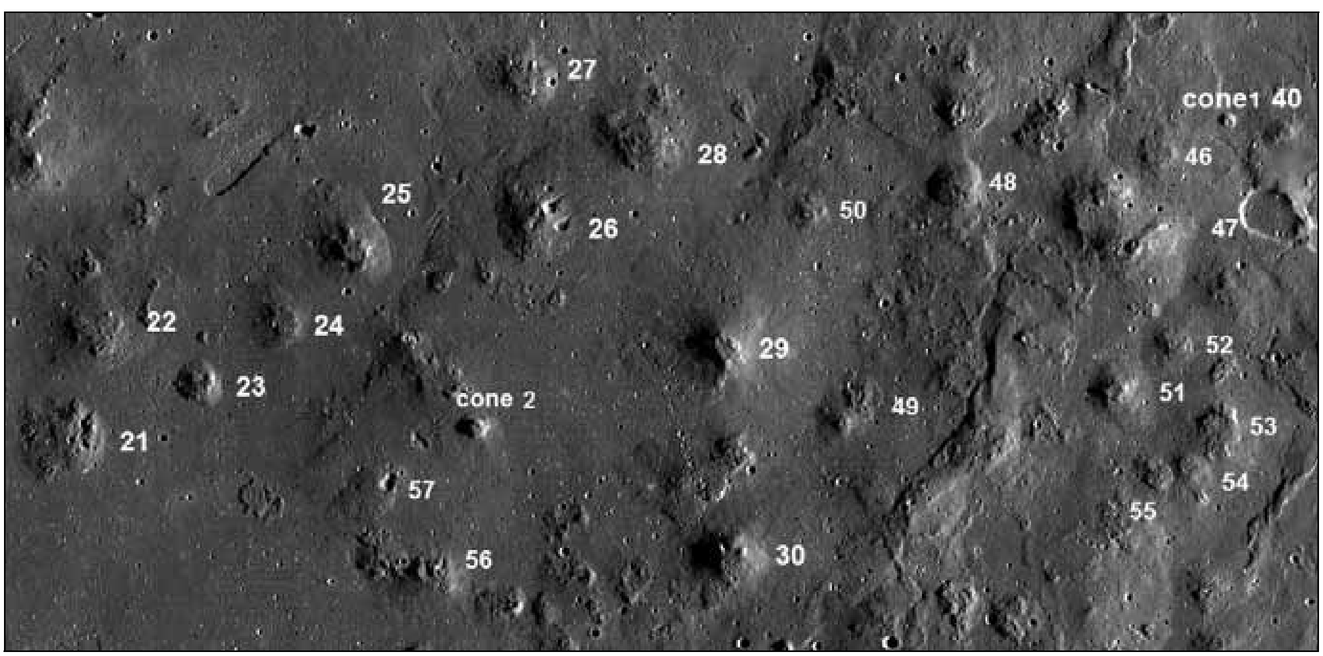


Figure 6. LROC WAC imagery of the region including Ma46-Ma57 (Region II). The other domes have been characterized in our previous report [Lena and Phillips, 2018].

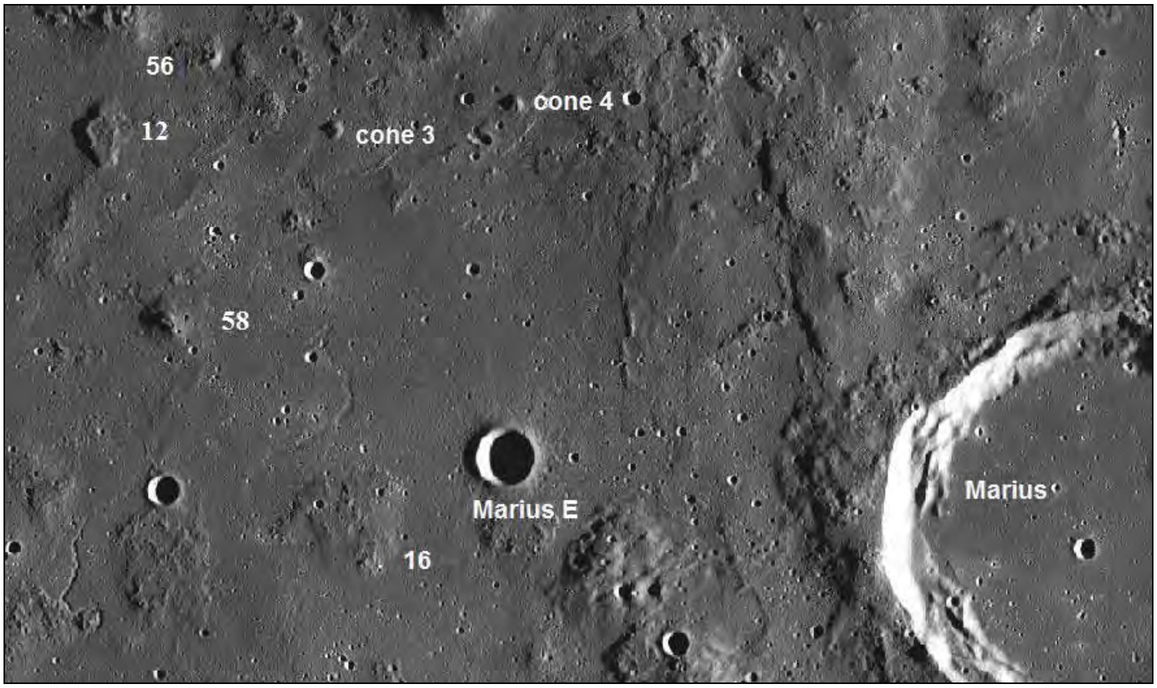


Figure 7. LROC WAC imagery of the region including Ma58-Ma59 and cones 3-4 (Region III). The other domes have been characterized in our previous report [Lena and Phillips, 2018].

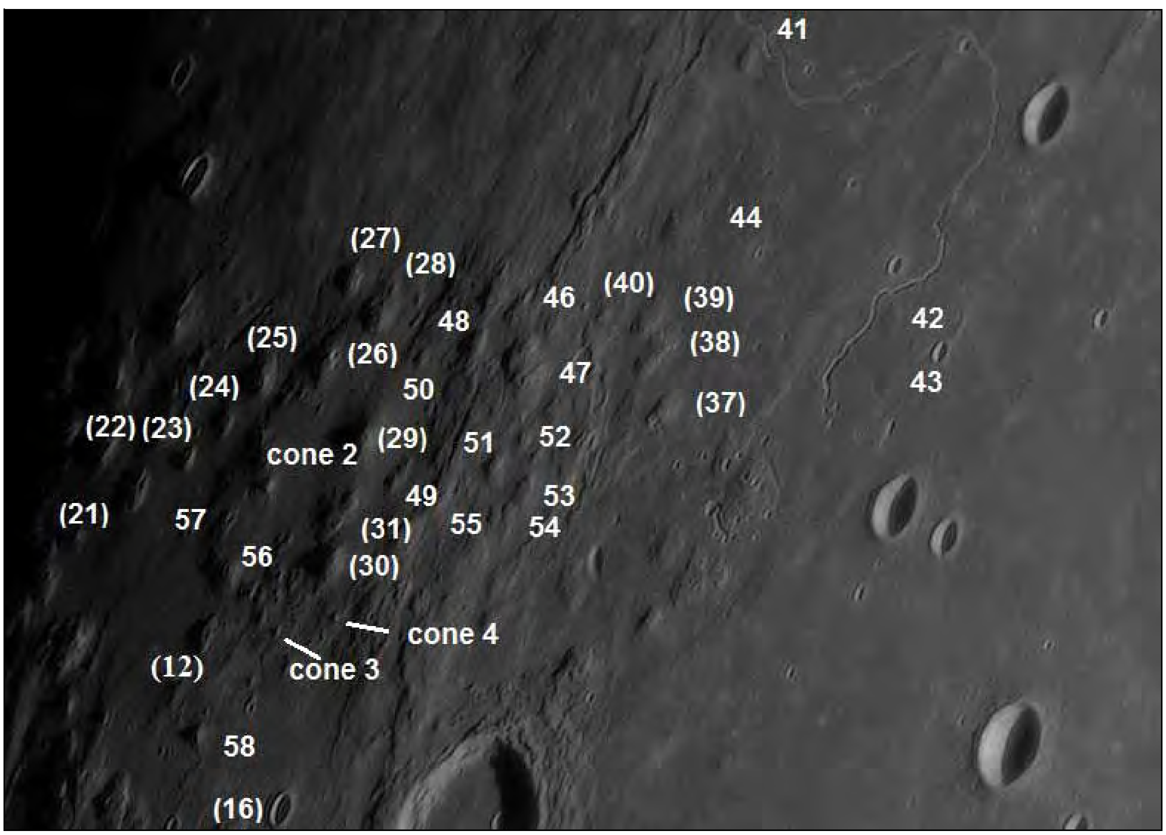
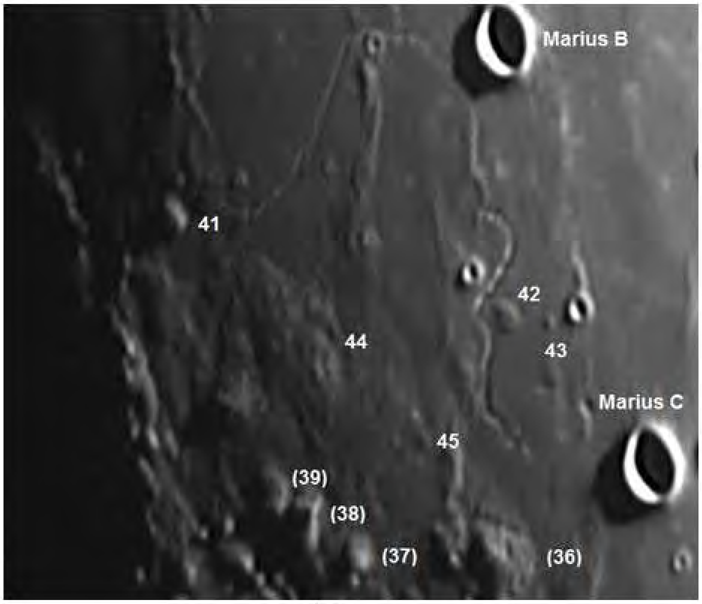
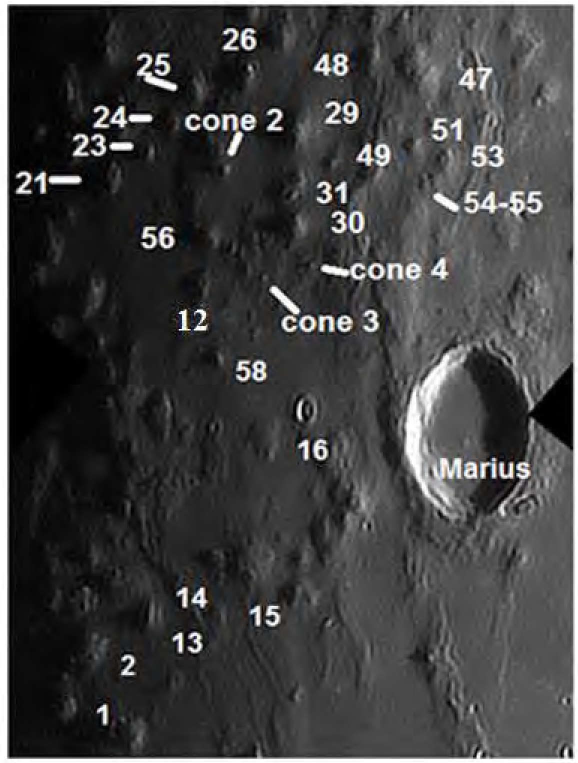


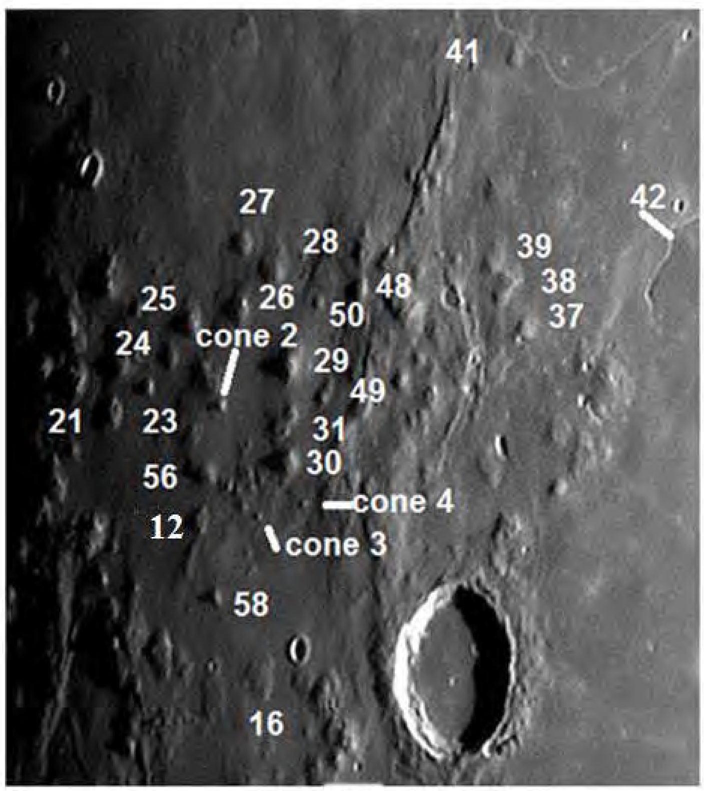
Figure 8. CCD image taken by Wirths on March 29, 2018 at 05:42 UT using a Starmaster driven Dobsonian 40 cm.



(a)

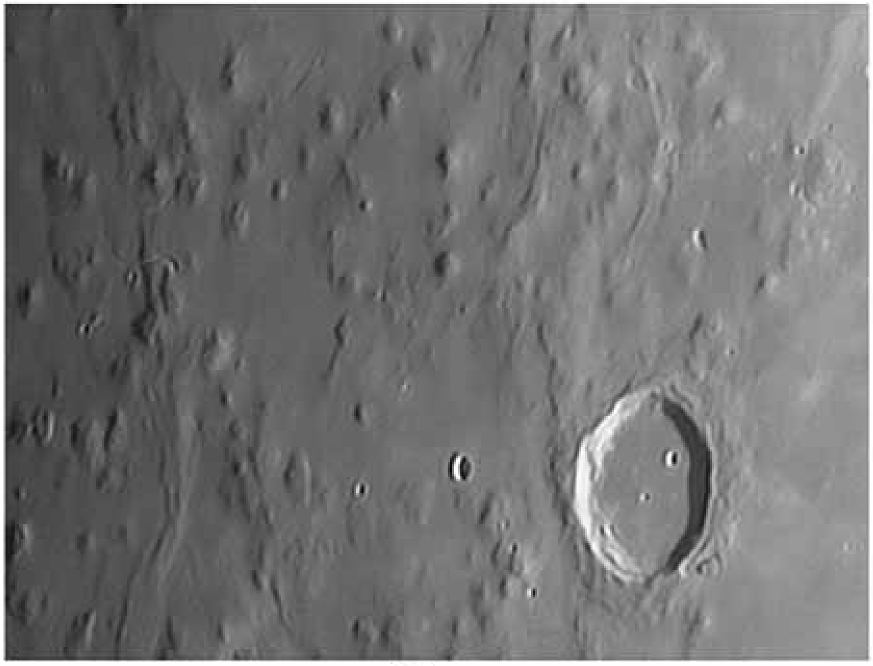


(b)

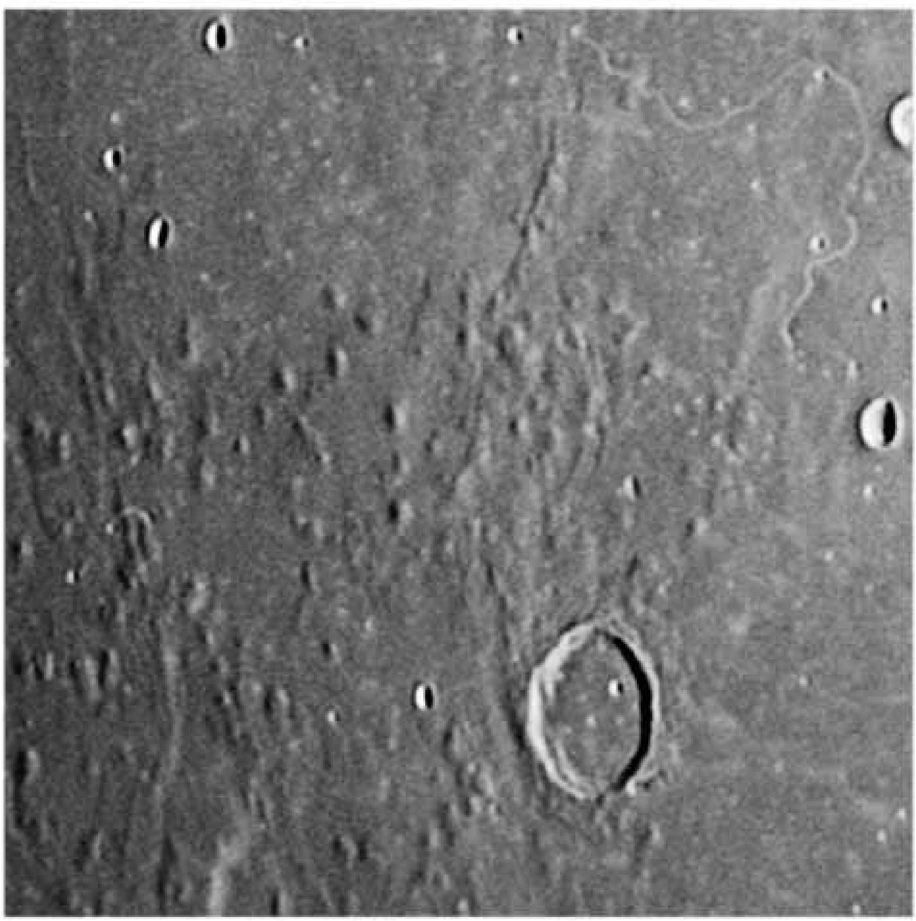


(c)

Figure 9. (a) Jim Phillips November 4, 2014 TMB 20 cm refractor, image taken under strongly oblique solar illumination angle. (b) Raffaello Lena January 28, 2018 23:15 UT Mak Cassegrain 18 cm. (c) K.C. Pau September 22, 2018 25 cm Newtonian telescope.



(a)



(b)

Figure 10. Marius hills under higher solar illumination angle, (a) Guy Leinen on January 18, 2019 at 17:53 UT using a Celestron C9.25 (235 mm). (b) Richard Hill on March, 15, 2013 02:08 UT using a TEC 8 in. (20 cm) Maksutov-Cassegrain. Note the large number of volcanic constructs described in this study.

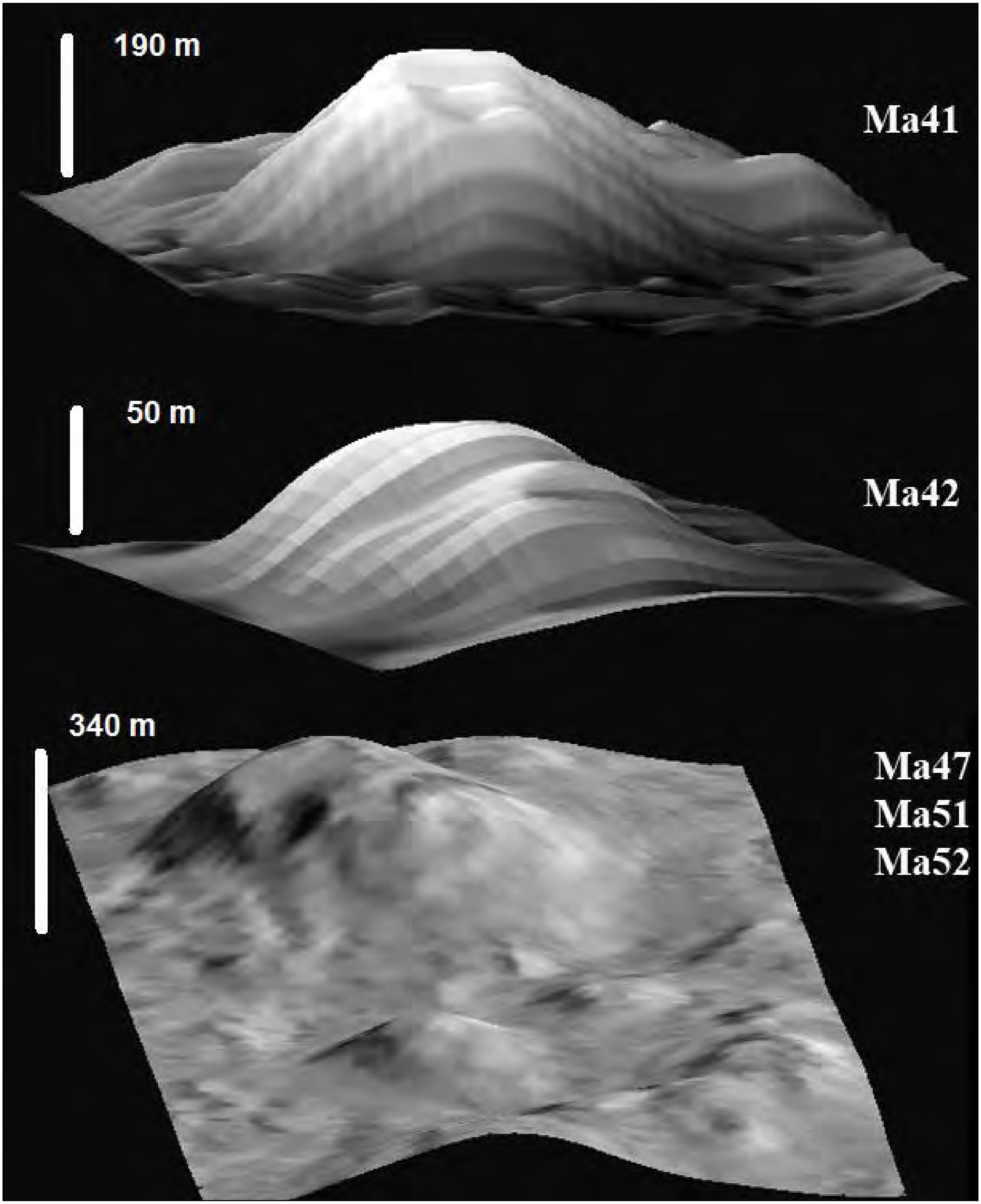


Figure 11. 3D reconstruction derived for the domes Ma41, Ma42, Ma 47, Ma51, and Ma52 based on shape from shading (SfS) approach using the CCD image taken by Wirths on March 29, 2018 at 05:42 UT (Fig. 8).The vertical axis is 10 times exaggerated.

Region II: Comprised Between 51°-55° W and 13-15° N

In this quadrant (Region II), we have characterized further 13 volcanic edifices termed Ma46-Ma57, including another lunar cone termed cone 2 (Table 2), which lies on the summit of a low dome (Figure 6). Based on the CCD images (figures 8 through10) and the GLD100 dataset (figures 1 through 3), we obtain diameters of 4.1-15 km for these domes, moderate slopes of 3.1°-4.9° for most of the volcanic constructs (Ma46-Ma50, Ma52-Ma54 and Ma56) and steeper slope of 5.8° for Ma51 (Table 2). The edifices termed Ma55 and Ma57 (Figure 6) have shallower slope of 1.9°. The small volcanic cone 2 has been well imaged by telescopic CCD images (figures 8 and 9). The domes examined are characterized by spectra with a 1,000 nm absorption centered at 980-1,009 nm and 2,000 nm absorption centered at 2,120-2,220 nm, thus indicating a basaltic signature (Lena and Phillips, 2018). On the contrary, Ma56 shows the 1,000 nm absorption band centered at longer wavelength (1,058 nm) and 2,000 nm absorption band centers shifted to shorter wavelength (1,910 nm). The M^3 data show that the spectrum of Ma56 is halfway between the volcanic glasses and the mare basalts,

Lunar Dome Classification System

Effusive Domes

Class A domes are small and shallow and formed by high-TiO_2 lavas of low viscosity, erupting at high effusion rates over very short periods of time, resulting in edifices of low volume.

Class B domes consist of lavas of intermediate to high viscosity and moderate TiO_2 content, erupting at low to intermediate effusion rates. If the effusion process continues over a long period of time, steep flank slopes and high volumes may occur (class B_1), while short periods of effusion result in shallower edifices of lower volume (class B_2).

Class C domes are formed out of low-TiO_2 (class C_1) or high-TiO_2 (class C_2) lavas building up edifices of large diameter but shallow flank slope. These at shapes are due to low lava viscosities and high effusion rates.

Class E domes represent the smallest volcanic edifices formed by effusive mechanisms (diameter < 6 km). In analogy to class B, the class E domes are subdivided into subclasses E_1 and E_2, denoting the steep-sided flank slope larger than 2° and the shallow edifices of this class, respectively.

Class D comprises the very complex, shallow but large and voluminous edifices Arago α and ß, which were most probably formed during several subsequent effusion stages, while classes A-E describe simple, likely monogenetic effusive domes.

Class G comprises the highland domes, which have highland-like spectral signatures and high flank slopes of 5°–15°, represented by Gruithuisen and Maairan highland domes.

Class H is represented by the non-monogenetic Marius domes, subdivided into three different classes. Small domes of less than 5 km diameter belong to subclass H_1. The irregular shapes of domes of subclass H_2 with more than 5 km diameter and flank slopes below 5° indicate a formation during several effusive episodes. Domes of subclass H_3 have diameters comparable to those of monogenetic class B_1 domes, but their flank slopes are all steeper than 5° and reach values of up to 9°.

Putative Intrusive Domes

Lunar domes with very low flank slopes differ considerably from the more typical lunar effusive domes. Some of these domes are exceptionally large, and many of them are associated with faults or linear rilles of presumably tensional origin, while they do not show summit pits. A reliable discriminative criterion is the circularity of the dome outline: these domes are elongated and with low slopes (< 0.9°). The putative intrusive domes have circularity values below 0.8, while the circularity is always higher than 0.9 for the effusive domes having flank slopes below 0.9° and displaying effusive vents.

Class In1 comprises large domes with diameters above 25 km and flank slopes of 0.2°–0.6° and have linear o curvilinear rilles traversing the summit.

Class In2 is made up by smaller and slightly steeper domes with diameters of 10-15 km and flank slopes between 0.4° and 0.9°.

Class In3 comprises low domes with diameters of 13-20 km and flank slopes below 0.3°.

indicating a glass spectral signature likely mixed with basalts material.

The spectrum of the lunar cone 2 shows the 1,000 nm absorption band centered at 1,020 nm and the 2,000 nm absorption band centered at 2,180 nm. The M^3 data show a classic basaltic signature without significant evidence of volcanic glasses signature, or glasses could be intermixed with large amounts of basalts (figures 12 and 13, adapted by the work of Besse et al. 2014).

Region III: Comprised Between 51°-55° W and 11.5°-13.4° N

The region west of the crater Marius and Marius E is characterized by the presence of another sinuous rille (Figure 7). The dome Ma58, located at coordinates 53.74° W and 12.56° N, with a base diameter of 7.4 km ± 0.3 km, displays the presence of a dome superimposed on another low dome. We have recognized two small and isolated lunar cones termed cone 3 and cone 4. Based on the CCD images and the GLD100 dataset, we obtain diameters of 5.5 and 7.4 km and moderate slopes of 2.4°and 4.6° for these two domes. The lunar cones have smaller diameters of 1.6 and 1.8 km, their height amount to 65 and 80 m, yielding average flank slopes of 4.6° and 5.4° (Table 2).

Lunar cones come in many shapes and sizes: examples include circular (Osiris in Mare Serenitatis), breached cones with a short sinuous rille disappearing into the mare (Isis in Mare Serenitatis), or cones that are elongated and aligned along a rille [Lena et al., 2013]. The presence of lunar pyroclastic constructs implies that gas may be released from the erupted magma, causing disruption of the magma and subsequent dispersal of the clasts [Weitz and Head, 1999]. Cone 3 is a breached cone, a characteristic shared by further lunar cones. These two small cones can be compared with the cones Isis and Osiris. Cone Isis, located in Mare Serenitatis (18.96°N, 27.48°E), is 1.7 km in diameter and is also C-shaped, smooth-sided, and has a gap and a lava channel. Isis is 60 m in height and has a slope of 4.0°. Osiris is another similar volcanic construct, ~2.3 km in diameter, located southeast of Isis (18.64°N, 27.64°E). It does not have a gap in the cone wall. The smaller volumes for the lunar cones imply that their construction rates were low and their magma chambers were smaller and at shallower depths than is typical for the terrestrial cones [Wood, 1979].

In the CCD telescopic images, two lunar cones are detectable as small undefined hill-like features. The breached lunar cone 3 displays a spectrum (Figure 12) with a 1,000 nm absorption centered at 1,020 nm and a 2,000 nm absorption centered at 1,940 nm. Thus, also for cone 3, the spectrum shows a glass signature mixed with a basaltic signature (Figure 13).

Domes in Marius Shield: Statistical Analysis

All domes examined are part of larger volcanic province of the Marius Shield as introduced by Spudis et al. [Spudis et al., 2013]. Shield volcanoes typically have both radial and circumferential fissure zones, which serve as pathways for magma to get to the surface and erupt lava. Parasitical cone and dome building often occurs near the summit and on the flanks of such features during the latter stages of shield growth [Spudis et al., 2013].

The Marius domes are subdivided into three different classes.

- Small domes of less than 5.5 km diameter belong to subclass H_1.
- The irregular shapes of domes of subclass H_2 with more than 5.5 km diameter and flank slopes below 5° indicate a formation during several effusive episodes.
- Domes of subclass H_3 have diameters comparable to those of monogenetic class B_1 domes, but their flank slopes are all steeper than 5° and reach values of up to 9° [Lena and Phillips, 2018].

Domes of Class H_1

The domes termed Ma42, Ma43, Ma45, Ma50, Ma52, Ma54 and Ma55 show diameters <5.5 km and flank slopes <5°. Domes previously classified of class H_1 [Lena and Phillips, 2018] are Ma5, Ma24, Ma38 and Ma40. At the present, and based on our studies carried out on the Marius Shield, the dome of class H_1 with the lower slope angle (only 0.7°) is Ma45, while Ma54 is the volcanic construct with higher slope (4.7°). Based on our available data, 18% of the analyzed domes belong to class H_1.

Domes of Class H_2

The domes termed Ma41, Ma44, Ma46-Ma49, Ma53 and Ma56-Ma58 show diameters >5.5 km and flank slopes <5.5°. Domes previously classified of class H_2 [Lena and Phillips, 2018] are Ma2-Ma4, Ma6-Ma17, Ma20-Ma22, Ma28, Ma31, Ma32-Ma37 and Ma39. At the present, and based on our studies carried out on the Marius Shield, the dome of class H_2 with the lower slope angle are Ma33 and Ma57 (1.9°), while Ma2 is the volcanic construct with higher slope (5.10°). Based on our available data, 60% of the analyzed domes belong to class H_2, demonstrating that in the wide Marius shield, domes of different shapes and slopes occur together.

Domes of Class H_3

Only the dome termed Ma51, examined in the current study, belongs to class H_3: it has a base diameter of 6.7 ± 0.5 km and flank slope of 5.8°. Domes previously classified of class H_3 [Lena and Phillips, 2018] are Ma1, Ma18-19, Ma23, Ma25-27 and Ma29-30, which have flank slopes steeper than 5.5° and reach values of up to 9°. At the present, and based on our studies carried out on the Marius Shield, the dome of class H_3 with the lower slope angle is Ma1 (5.7°), while Ma29 is the volcanic construct with higher slope (9.0°). Based on our

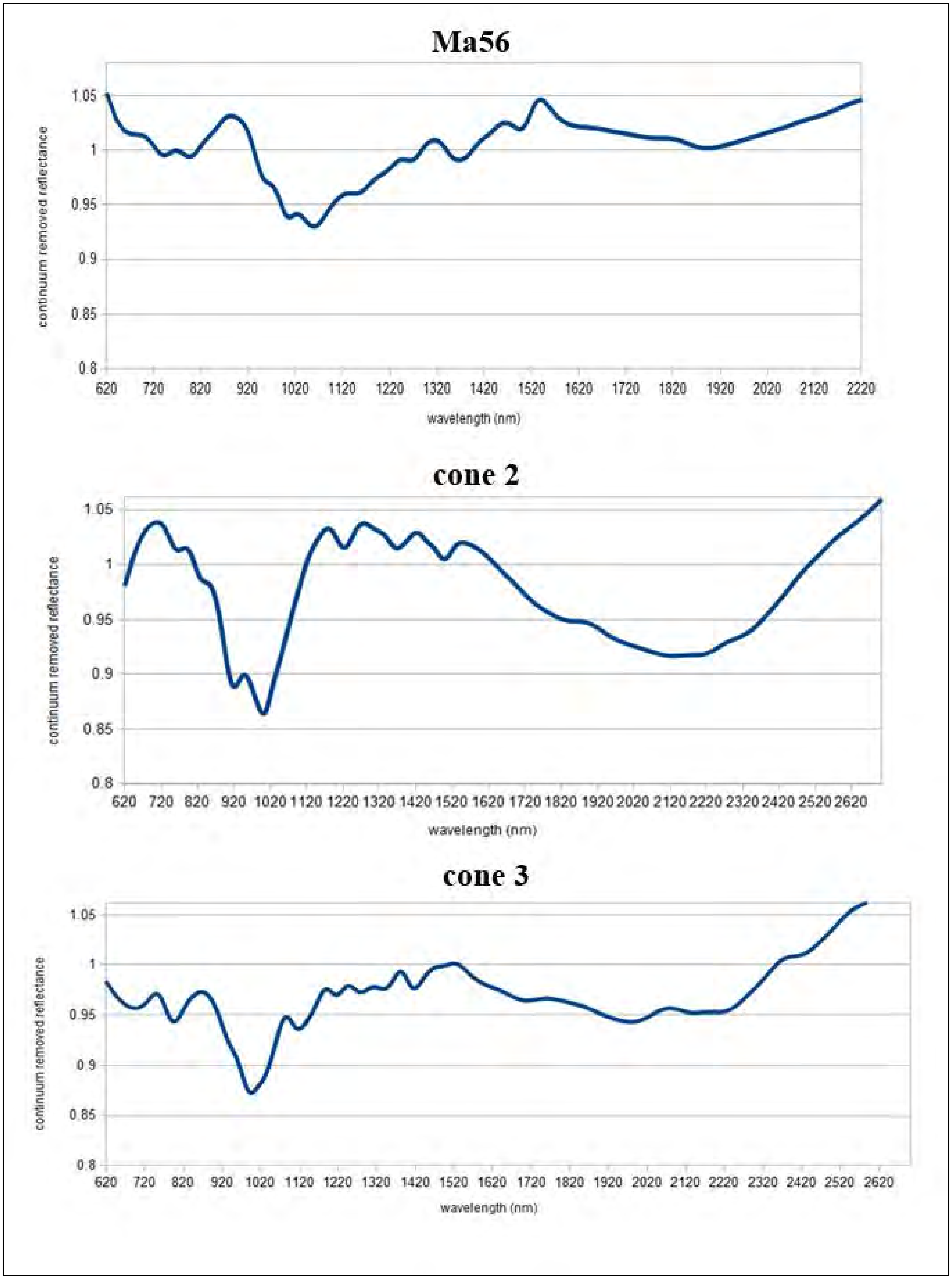


Figure 12: M^3 spectral analysis of the dome Ma56 and the lunar cones 3-4.

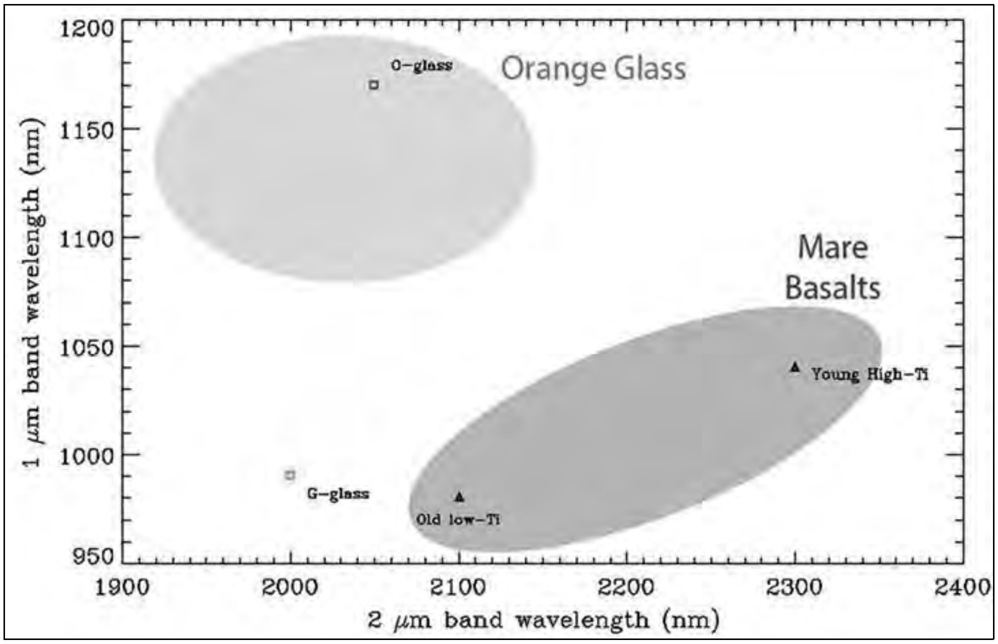


Figure 13: Diagram of the band position at 1 and 2 µm (1000 and 2000 nm).

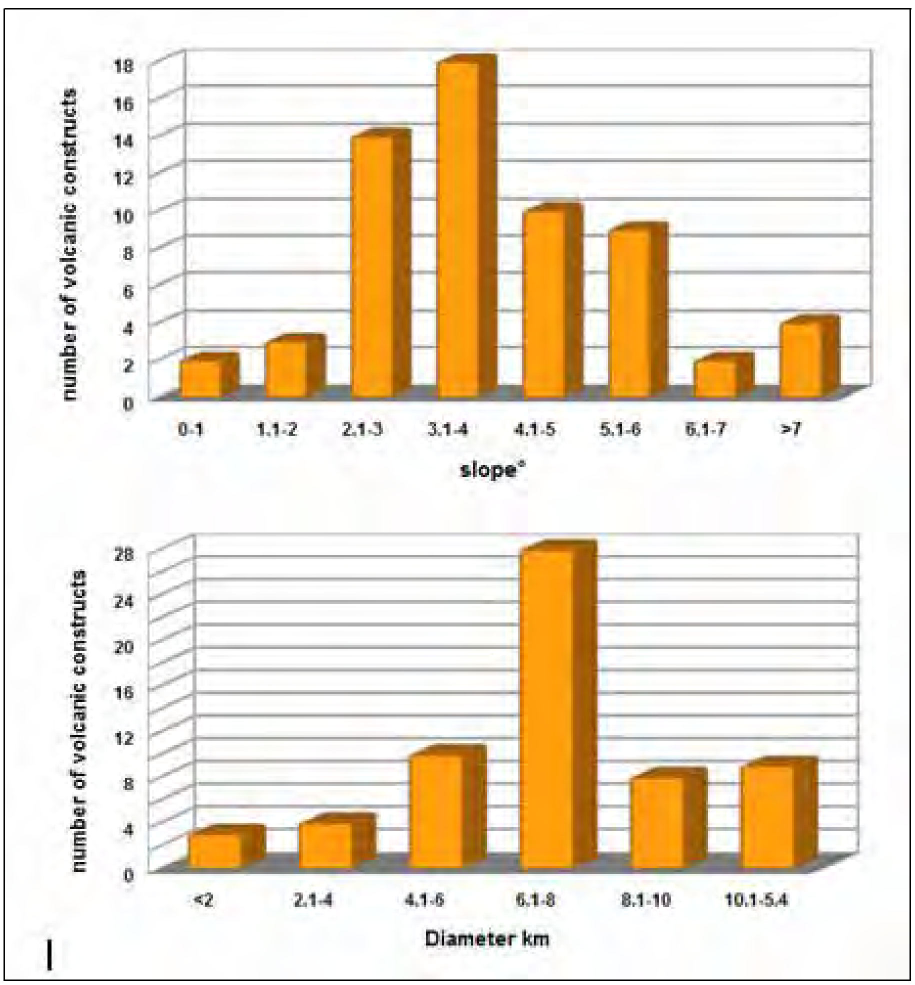


Figure 14: Histograms of (top) slope° and (bottom) diameter km of the domes/cones mapped in Marius Hills region.

available data, 16% of the analyzed domes belong to class H_3.

Lunar Cones

The monitoring conducted allowed us to characterize a total of four lunar cones in the Marius Shield. Cone 2 is located on the summit of a low dome 40 m high. It would be interesting to receive new images in order to verify if these subtle details can be resolved using Earth-based telescopes of smaller diameters. We obtain diameters of 1.8-2.7 km for the lunar cones examined during our survey with steeper slopes of 4.6°- 7.7°. Based on our available data, 6% of the analyzed volcanic constructs belong to isolated lunar cones.

Morphometric Parameters

Morphometric parameters, like slope and diameter, are estimated for all the mapped domes and cones. The steepness (flank slope) of the volcanic constructs varies between 0.7° and 9.0° (Figure 14), indicating that most of the domes/cones fall into the range 2.1°-4.0° (32 domes) and 4.1°-6.0° (19 domes). These two ranges include 82% of the examined features. The diameter frequency of the volcanic constructs indicates that most of the domes/cones (28 features) fall into the range 6.1-8.0 km corresponding to 45% of the examined features (Figure 14).

Mapping of Lunar Domes

The topographic variations over the whole region are examined in detail for identification of localized topographic highs. During our survey we have now characterized a total of 62 features. The majority of domes are aligned along the NW-SE oriented wrinkle ridges, at the edge/flank of topography. A map of Marius Hills volcanic complex region is shown in Figure 15 (Appendix), including 62 domes/cones mapped using both CCD telescopic image and Lunar Reconnaissance Orbiter's Wide-Angle Camera (LRO-WAC) imagery. Further volcanic constructs under investigation are outlined by red dots: they will be characterized in another future report.

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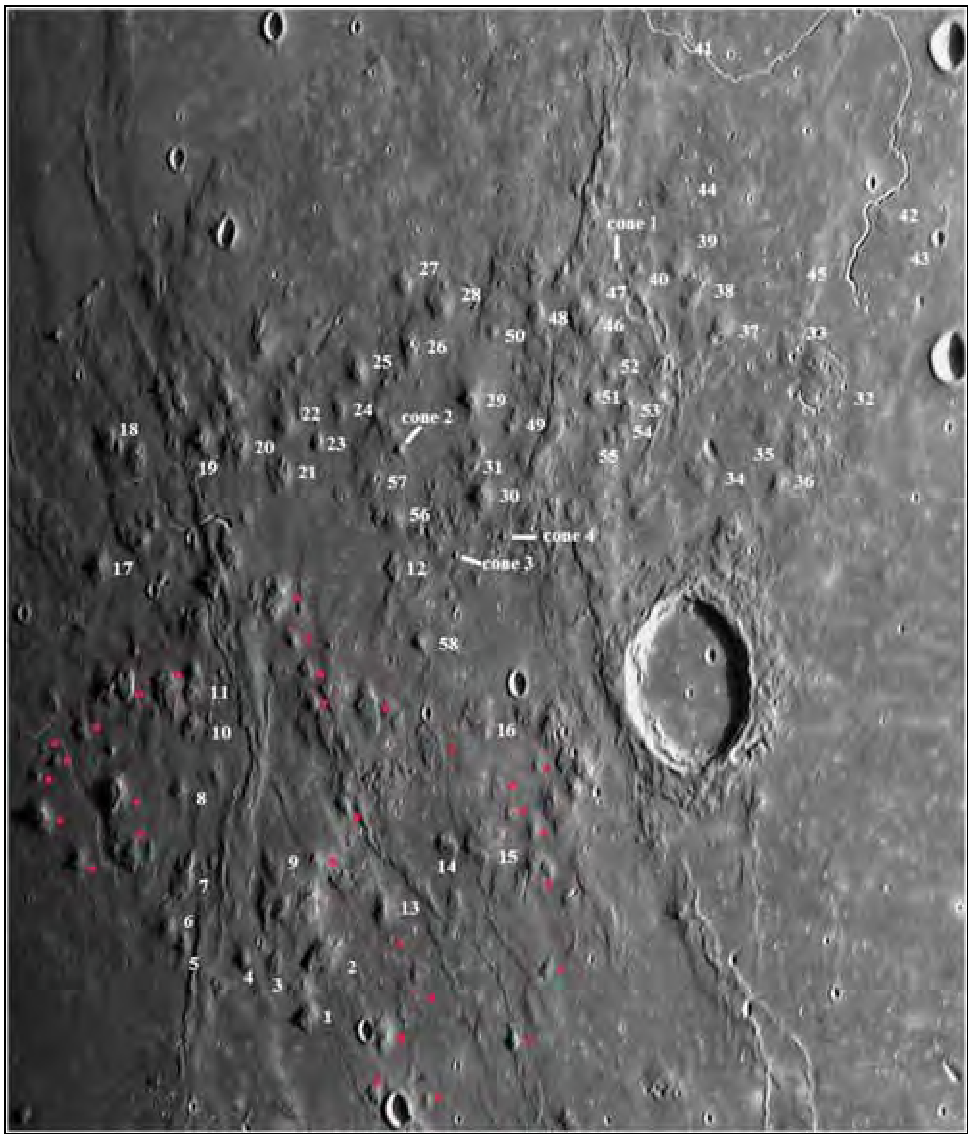

Figure 15. Map of Marius hills region with domes/cones identified during the survey. Further volcanic constructs, under investigation, are outlined by red dots. Image by M. Wirths using a Starmaster driven Dobsonian 40 cm. Note the quality of the image and the details detected on the summit of several domes. More than 100 volcanic constructs are identified in the Marius shield.

Appendix

Table 3: Some data regarding coordinates, diameters and heights of Ma1-Ma40 have been updated, during the survey and the current study, using Quickmap LRO global basemap (*http://target.lroc.asu.edu/da/qmap.html*) and GLD100 dataset.

Dome	Longitude	Latitude	Slope [°]	Diameter [km]	Height [m]	Class
Ma1	-55.65	9.88	5.70±0.5	7.8±0.5	380±40	H_3
Ma2	-55.38	10.33	5.10±0.5	12.1±0.5	530±50	H_2
Ma3	-55.94	10.32	2.10±0.2	6.4±0.5	120±15	H_2
Ma4	-56.30	10.43	3.90±0.4	6.1±0.5	210±20	H_2
Ma5	-56.96	10.58	3.50±0.4	5.9±0.5	180±20	H_1
Ma6	-57.16	10.72	3.40±0.3	6.1±0.5	180±20	H_2
Ma7	-57.00	11.10	2.90±0.3	9.2±0.5	230±20	H_2
Ma8	-56.85	11.74	3.80±0.4	6.4±0.5	200±20	H_2
Ma9	-55.80	11.06	2.80±0.3	8.1±0.5	200±20	H_2
Ma10	-56.50	12.20	4.20±0.4	7.5±0.5	260±30	H_2
Ma11	-56.58	12.49	3.50±0.4	10.9±0.5	330±40	H_2
Ma12	-53.98	13.14	3.90±0.4	6.4±0.5	220±20	H_2
Ma13	-54.52	10.58	5.30±0.5	7.8±0.5	360±40	H_2
Ma14	-53.74	11.02	2.70±0.3	7.5±0.5	180±20	H_2
Ma15	-53.35	10.99	3.90±0.4	14.2±0.5	440±50	H_2
Ma16	-53.16	11.90	2.20±0.2	11.2±0.5	220±20	H_2
Ma17	-57.58	13.51	3.90±0.4	10.4±0.5	350±35	H_2
Ma18	-57.34	14.47	5.80±0.5	7.9±0.5	400±40	H_3
Ma19	-56.11	14.30	5.60±0.5	8.5±0.5	420±40	H_3
Ma20	-55.72	14.25	3.00±0.3	9.7±0.5	250±20	H_2
Ma21	-55.19	13.97	3.20±0.3	8.9±0.5	250±20	H_2
Ma22	-55.11	14.34	4.20±0.4	7.3±0.5	260±30	H_2
Ma23	-54.74	14.19	6.50±0.5	4.5±0.5	260±20	H_3
Ma24	-54.44	14.39	3.70±0.4	5.8±0.5	190±20	H_1
Ma25	-54.20	14.65	5.80±0.5	7.5±0.5	380±40	H_3
Ma26	-53.60	14.75	8.50±0.8	7.1±0.5	530±50	H_3
Ma27	-53.62	15.26	6.10±0.6	6.5±0.5	350±35	H_3
Ma28	-53.18	15.09	4.20±0.4	11.5±0.5	420±40	H_2
Ma29	-52.93	14.28	9.00±0.9	7.2±0.5	570±60	H_3
Ma30	-52.88	13.54	8.30±0.8	7.4±0.5	540±50	H_3
Ma31	-53.00	13.88	2.95±0.3	6.2±0.5	170±20	H_2
Ma32	-49.06	14.04	2.10±0.2	15.4±0.5	270±30	H_2
Ma33	-49.29	14.22	1.90±0.2	10.0±0.5	170±20	H_2
Ma34	-50.42	13.46	2.40±0.2	9.5±0.5	200±20	H_2
Ma35	-49.68	13.67	2.70±0.3	9.0±0.5	210±20	H_2
Ma36	-49.36	13.51	3.60±0.4	7.6±0.5	240±30	H_2
Ma37	-50.11	14.45	3.60±0.4	8.0±0.5	250±25	H_2
Ma38	-50.39	14.76	5.00±0.5	5.5±0.5	245±25	H_1
Ma39	-50.50	14.98	3.20±0.3	6.1±0.5	170±20	H_2
Ma40	-50.94	15.07	2.30±0.2	3.0±0.5	65±10	H_1
Cone 1	-51.11	15.12	5.10±0.5	1.8±0.5	80±10	Cone

The ALPO Lunar Section

Who and What is the Lunar Meteoritics Impact Search Program

By Brian Cudnik, coordinator,
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Online Features

Left-click your mouse on the author's e-mail addresses in blue text to contact the author of this article.

About Brian Cudnik

Originally, from Cleveland, Ohio, I have been interested in astronomy for over 44 years and had made my first informal observations of the Moon 40 years ago this upcoming July. I became a more serious observer some five years after that, doing casual lunar viewing with a 2.4-inch refracting telescope, then upgrading to a 4.5-inch reflector in preparation for the appearance of Halley's Comet in 1986. I have been a visual observer of lunar and planetary objects and phenomena since, continuing to this day. Since I began to observe the planets regularly through the 4.5-inch, then a 10-inch Dobsonian that I acquired in 1987, the Moon became a secondary interest. This would continue to be the case until the observation of a meteoroid impact on the moon on 18 November 1999 that changed my interests dramatically.

I grew up in Northeast Ohio where I started my observing "career" in the early 1980's from a reasonably dark suburban backyard. From this location, I observed a number of comets, all the major planets, a dozen or so minor planets, dozens of deep sky objects, and a few aurora displays. I moved to Flagstaff, Arizona, in 1990 to attend Northern Arizona University, earning a degree in Physics and Astronomy in 1994. The time spent in Flagstaff (1990-1995) included my first taste of professional astronomy, work on several projects, and time working with Gene and Carolyn Shoemaker on their *Palomar Asteroid and Comet Survey*. I was working with them when the Shoemaker-Levy comet was discovered; the USGS Astrogeology office where they work was abuzz with excitement as clearer pictures of this "squashed comet" came in from *Spacewatch*. We soon learned that the comet was on a collision course with Jupiter, with multiple impacts predicted to happen the third week of July 1994. By

Brian Cudnik with his "family" of Lunar Meteoritic Impact Search equipment. His setup for doing lunar meteor observations and stellar occultations consists of a Celestron 11-inch telescope, a KPC-135 low light video camera (similar to Watec 902H), a KIWI-OSD with a GPS time inserter, and finally a TV-VCR combo

then, I was assigned to another project, imaging the planets Jupiter and Saturn with narrow-band methane filters. We watched the aftermath of the impacts evolve in the weeks following the eventful five days, when 21 objects crashed into Jupiter. My first taste of the Internet involved looking at fresh Hubble Space Telescope pictures of the dark splotches on Jupiter along with the plume of the "G" impact event.

From 1994 to 1995, I took a year off school to apply to graduate programs. During this time, I got engaged to, and then married my wife Susan. Shortly after our honeymoon, which involved a road trip to the Arctic Circle in Alaska just before the June solstice, we moved to San Diego, where I attended San Diego State University. There I earned my Master's degree in Astronomy in 1998. For my thesis, I observed Comet Hale-Bopp over a one-year period with narrow band filters typically used for comet observations (C_2, C_3, and CN, along with their continuum filters). After successfully defending this thesis and meeting the requirements to graduate, we moved to Houston, Texas, where I took a job at Rice University as a research assistant with C. R. (Bob) O'Dell, the so-called "Father of the Hubble Space Telescope". For the short 3.5-month tenure with him, I assisted with research involving HST imagery; however, things did not work out, so he released me from this position.

Shortly after moving to Houston in 1998, I began to appreciate the value of sharing my observations – especially visual ones – with an organization that works with both amateur and professional astronomers. That organization was none other than our own, the ALPO, which I had known about for years but had not given much consideration to. After appreciating more fully what ALPO is about, I gathered all my Jupiter observations and sent them to Richard Schmude, our longtime Jupiter Section coordinator, prior to using the official observing form. Since this initial analog data download, I have made all of my Jupiter observations using the official ALPO reporting form and I continue to do so to this day.

Thanks to the coordination efforts of David Dunham, past president of IOTA (International Occultation Timing Association) and others, the attempts to document Leonid meteoroids impacting the Moon with confirming observation pairs was successful. With this confirmation of the Lunar Leonid impact on the Moon in 1999, which was one of six such events, interest revived in the ALPO community for a dedicated program to monitor the Moon for flashes created by lunar meteors. The *Lunar Meteoritic Impact Search Program* section was formed in February 2000 and has been in operation ever since then with me as the sole coordinator.

After a brief appointment as Outreach Technician at Rice University in collaboration with the Burke Baker Planetarium at the Houston Museum of Natural Science, I took a position at Prairie View A&M University (part of the Texas A&M University System) as Research Assistant/"Senior Observer" with their new Solar Observatory. Dr. Tian sen Huang was the project manager. I worked on this project from 1999 to 2001, and then transferred to Physics (after cuts in grant funding to this project) as laboratory manager from 2001 to present. Over the years, my role has changed; today I am now Laboratory Coordinator II and Adjunct Instructor, having taught many classes over the years.

My setup for doing lunar meteor observations and stellar occultations consists of a Celestron NexStar 8-inch telescope (though an 11-inch is shown in the image…the first of many upgrades), a KPC-135 low light video camera (similar to Watec 902H). The video is sent though a KIWI-OSD with a GPS time inserter, then to the TV-VCR combo where the video, with time insertion, is recorded to VHS. It has been a few years since I have used this setup due to the busy-ness of life and waiting for an upgrade to more modern equipment, but the upgrade will soon happen in conjunction with the Solar Observatory Addition project that is nearing completion on campus.

Notable Mentions

Over the 19-year history of the ALPO Lunar Meteoritic Impact Search Program, we have seen much development in the observations of lunar meteors. This section has coordinated the efforts of many observers over the years and has collaborated with a number of individuals and groups (mentioned below) who have been active in the observations of lunar meteors. ALPO-LMIS has received reports of over 100 lunar meteoroid impact candidates over the years; a catalog of these is currently being developed. One group from NASA-Marshall Space Flight Center started systematic observations of the Moon in 2005 and from then through April 2018 have logged 435 lunar impact candidates (mostly observed in two separate telescopes). Dr. Anthony Cook, who coordinates the ALPO Lunar Transient Phenomena Program, has helped tremendously over the years; he also works with the British Astronomical Association and works in the Department of Physics, Aberystwyth University, United Kingdom.

Others who have contributed significantly over the years include the Swiss-Italian group: Lena Raffaello, Iten Marco and Sposetti Stefano, among others. In addition, Antonio Mercatali and his observers, of the Unione Astrofili Italiani (UAI) group (www.uai.it) have submitted observations over the years. Another individual instrumental in lunar meteor observations is George Varros, who has a very useful web page describing his setup and observing program (*http://www.lunarimpacts.com/lunarimpacts.htm*).

And still another is Robert Spellman (*http://www.angelfire.com/space2/robertspellman/*), who has observed, by video, a number of meteoroid impacts himself. More recently, the ROCG (Remote Observatory of Campos dos Goytazes) group in Brazil have been reporting confirmed observations of lunar meteor impacts. Observers within this group include Tiago Augusto, Torres Moreira and Carlos Henrique Barreto. There is also a group funded and coordinated by the European Space Agency (ESA) known as NELIOTA which stands for "NEO Lunar Impacts and Optical Transients. They have logged 58 lunar meteor impacts since observations began in 2017 and have funding to continue through 2021.

Finally, MIDAS (Moon Impacts Detection and Analysis System) has been operation for 10 years and has documented a number of events. ALPO-LMIS collaborates with all of these organizations and groups.

ALPO-LMIS has and will continue to encourage monthly observations of the Moon for meteor impact flash detection. I send out an alert at the start of each quarter, along with updating the ALPO-LMIS web site, with the dates of the evening and morning portions of the monthly campaign along with information on any showers – great or small, active and peaking – during this time. A typical run starts with the evening part, about three to four days after New Moon, continues through First Quarter and up to two or three days after First Quarter. The run picks up again in the predawn hours, from two to three days prior to Last Quarter up to four or three days before New Moon. Special attention is given when these periods coincide with a peak in a significant annual shower such as the Perseids or Geminids. We also will monitor the Moon in total eclipse for meteor impact flashes. Observations are coordinated with other groups so that we can collaborate and ask for confirming observations as needed. This will be the format going forward for some years to come.

The ALPO Lunar Section

Lunar Meteors – What We Know After 20 Years

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Online Features

Left-click your mouse on the author's e-mail addresses in blue text to contact the author of this article.

Abstract

It has been nearly 20 years since the first scientifically confirmed meteoroid impact observation has been documented on the lunar surface. It has been nearly 25 years since the series of impacts by the Shoemaker-Levy comet stained Jupiter with dark splotches and Earth-based observers with fascination. Impact observations are fascinating in their own right, with work in the lab doing the most to inform us of their true power and nature. However, it is the natural impact phenomena that truly inspires awe and wonder as we see the "powers of the heavens" on display. With the Moon less than a quarter million miles away, it is the best place, outside of Earth, to observe the results of collisions between objects whose speed cannot be replicated in our best laboratories. In this paper, I reflect on two decades of observations and research into the lunar meteor phenomena and summarize some of what we have learned. I will also consider present day observing programs and what can be done in the near future.

Figure 1. Lunar meteoritic impact flash that occurred just after the start of totality during the January 21, 2019 event.

Introduction

Since November 18 and 19, 1999 when several impact events of magnitudes between +3 and +7 were witnessed by video tape and naked eye, hundreds of such events, confirmed from various sources, have been documented by various groups. The occurrence of lunar meteor phenomena seems to be rather common, but the random nature of these events and the very brief duration of the visible flashes make it quite challenging to observe lunar meteors in real time. In fact, Sigismondi and Imponente (2000a) refer to the Moon as "the best laboratory for studying the meteor showers" due to the Moon's large collecting area visible from Earth).

Shortly after the confirmed lunar Leonid events, in early 2000, the Lunar Meteoritic Impact Search section was formed with the author of this paper as primary coordinator. ALPO established this section to encourage greater participation in observation of the Moon in search of impact flashes. Since 2000, not only participants with ALPO have observed the Moon for these fleeting flashes, but also a significant number of groups, both professional and amateur, have begun to monitor the Moon regularly for flashes of light arising from the impact of meteoroids.

Each month, the Moon is favorably placed for the observation of lunar meteor flashes on its dark hemisphere by ground-based telescopes. This takes place primarily during the waxing phases of the crescent Moon in the evening sky when the side facing the Earth faces into the oncoming stream of solar system debris. That is, as the Earth orbits the Sun, "dragging" the Moon right along with it, the side of the Moon facing Earth during the evening part of the phase cycle plows into debris, much like a car or truck driving through a snowstorm. From several days past New Moon to a day or two past First Quarter, the darkened portion of the Moon is favored for observation. Since most lunar meteors are relatively faint, these are obscured by the sunlit surface of the Moon on the dayside. The night side of the Moon is different, providing a darker background to increase contrast between the impact flash and the earth-lit surroundings.

The waning phases are also useful but not as productive as we are watching the side of the Moon that faces away from the oncoming meteoroid stream. However, many impact events have been observed on the dark part of the waning Moon. Not only are impacts observed during the monthly phase cycles of the Moon, but several total lunar eclipses have also included meteoroid impact flashes as part of the "show"; two examples being the total eclipses of January 20, 2000 (Sigismondi and Imponente, 2000b), and, much more recently, January 21, 2019 (Figure 1).

Figure 2. Video frame from the 11 September 2013 meteoroid impact video taken with the MIDAS system, showing the impact flash near its brightest. Image courtesy of JM Madiedo and the MIDAS program.

Lunar Transient Phenomena in General and Meteoroid Impact Flashes Specifically

Historically, the Moon was thought to be geologically dead and changeless. Nonetheless, many observers over the centuries have reported localized changes on the Moon consistent with some sort of geologic activity. These changes took on the form of flashes, color changes, glows, localized hazes, clouds, plumes, and other manifestations, each lasting anywhere from a fraction of a second to several hours. These are referred to as Lunar Transient Phenomena, or LTP, which is defined as a change of some form on the Moon. Due to their tenuous and seemingly random nature, and lack of corroborating observations, LTP's have not been taken seriously from a scientific standpoint. Nonetheless, reputable observers with considerable visual observing experience have made many of the reported observations of LTP.

A large number of the more reliable of the LTP observations have been collected and documented in Winifred Sawtell Cameron's Lunar Transient Phenomena catalog (Cameron, 2006). The author of this paper extracted from this catalog events with high confidence (4 and 5 on a 1 to 5 scale where 1 means low confidence and 5 means high confidence), resembling meteoroid impacts, and gathered these in his book *Lunar Meteoroid Impacts and How to Observe Them* (2010). Manifestations of meteoroid impacts on the Moon included the following types of LTP (Cudnik, 2010): point flash of unspecified duration, single point flash, multiple point flash, long-duration point flash, dust cloud, localized obscurations, and dust plume.

ALPO founder, Walter Haas was interested in the possibility of observing meteoroid impacts on the Moon. At that time, it was commonly thought that meteors on the Moon resembled those seen in the sky, like a falling or shooting star but superimposed on the Moon's disk. Mr. Haas wrote about and searched for them in the late 1930's and early 1940's. The first formal project associated with ALPO was the "Lunar Meteor Search" which ran from 1955 to 1965. Robert M. Adams coordinated this program from 1955 to 1962, and then Kenneth Chalk took over until the program's conclusion in 1965. Despite as many as 40 interested observers participating and 6 progress reports submitted, the program never fulfilled its goal of obtaining simultaneous confirming observations of lunar meteor impacts (Westfall, 1997)

The Physical Nature of Lunar Meteoroid Impacts

Aside from the obvious evidence in the form of the pockmarked surface of the Moon (visible in binoculars) and other planetary bodies, evidence that meteoroid impacts take place to this day have been acknowledged before the November 1999 lunar Leonid observations. One key piece of evidence came with the Apollo seismic

Figure 3. The LCROSS spacecraft with Centaur Stage (Artist's visualization). Image courtesy of NASA.

experiments that operated on the Moon from 1970 to 1978. During each year of operation, this seismometer network recorded between 70 and 150 impacts of meteoroids ranging from 100 grams to 1000-kilogram mass range (Latham et al, 1973). However, even with this scientific evidence pointing to contemporary lunar meteoritic impact activity, the question remained as to whether the visible flash produced by such events would be bright enough to be seen (with a telescope) from the surface of the Earth.

This uncertainty remained up until the 1999 lunar Leonid observations and it arose from the fact that no one knew for certain how much of the impact energy was converted to seismic energy versus visible photons, a characteristic known as the luminous efficiency of impact. A meteoroid prior to encountering the Moon carries kinetic energy, or energy of motion, which is proportional to the mass of the object and its velocity, squared. Since the Moon does not have an atmosphere, meteoroids impact the lunar surface directly, with that kinetic energy almost instantaneously being converted to other forms of energy. One form of energy is the brief optical flash of light seen from hundreds of thousands of kilometers away. The fraction of the incoming meteoroid's kinetic energy that is transformed into luminous energy is defined as the luminous efficiency (Madiedo & Ortiz, 2018a). This parameter is also defined as the amount of electromagnetic energy in the 400 nm to 900 nm range that is released by an impact. If interpreted for other wavelengths, it is generally referred to as radiance efficiency.

Part of the radiation released during an impact event is due to the initial collision; the rest happens during the subsequent cooling of the impact plume and affected lunar surface. Since the kinetic energy of the impactor is the source of energy for the subsequent flash of light, all of this emission should be taken into account. Even so, there is much uncertainty due to the many factors that come into play when determining luminous efficiency and this may vary from impact to impact. Impact plumes are produced which the impact launches from the impact location to points relatively far from the newly formed crater. The visible flash, which usually lasts 0.1 second or less, is the initial expansion and cooling of the material making up this plume.

Madiedo and Ortiz (2018b) made the first attempt to determine the temperature of an impact plume. To do this, they analyzed the visible and NIR flux of an impact observed on 25 March 2015 at 21:00:16.80 UTC. The impact had a peak apparent visual magnitude to 7.3 magnitude in V and 5.1 magnitude in I and was observed with a 40 cm Newtonian reflector at La Hita Astronomical Observatory. Madiedo and Ortiz determined the impact temperature reached a maximum near 4000 K then suddenly dropped to 3200 K, where it remained for ~0.1 second before dropping to ~2900 K by the end of the flash. At this point the flash became too faint to observe and no further temperature analysis was available. For this particular impact, the luminous efficiency was 4.7×10^{-3} in the infrared, which is some 56% higher than that in the visible range. (Madiedo, et al., 2018; Bellot-Rubio et al., 2000; Ortiz et al., 2015).

Ongoing Efforts to Monitor the Moon for Impacts

Following the confirmed Leonid impact events of November 1999, interest was high in the lunar meteoroid phenomena. IOTA (the International Occultation Timing Association), which had a significant role in coordinating the 1999 lunar Leonid campaign, continued to put out the call for lunar meteor observations, along with ALPO once the LMIS section was formed in early 2000. The efforts netted a number of impact candidates but, with the exception of the impact flash observed during the January 2000 total lunar eclipse, no confirmed observations until the lunar Leonid campaign of November 2001. A pair of confirmed lunar Leonid impacts were observed during this time. The first non-Leonid confirmed meteor impact flash was observed by a team of Japanese observers in August 2004 during the annual Perseid meteor shower. The Moon was favorably placed during this time for Earth-based observers to witness meteoroid strikes on the Moon's dark surface.

Over the years, a number of groups and individuals have contributed to the database of observed meteoroid impact event candidates. Robert Spellman (website: reference 12) maintains a web page dedicated to lunar meteor impact observations and has several videos taken in 2008 and 2009 showing confirmed and unconfirmed impact events. George Varros (website: reference 13) also has a number of impact flash observations featured on his site. Groups from Italy and South America also have been active, as has been the British Astronomical Association with Dr. Tony Cook, who is the current coordinator of the ALPO LTP section.

The Moon Impacts Detection and Analysis System (MIDAS) is being developed from three astronomical observatories located in Spain: Sevilla, La Hita, and La Sagra (website: reference 14). This effort actually started as the first systematic attempt to document and confirm impact flash events in 1997 (Ortiz et al, 1999, 2000) and has since developed into the MIDAS system. Although a running tally of impact events recorded is not readily available, a number of notable events have been recorded, the most spectacular of which is the 11 September 2013 event (Madiedo, 2018). This event was observed at 20:07:28.68UT by two telescopes; the impact flash was unusually long (8.3 seconds) and bright (apparent peak visual magnitude of 2.9), making it the longest duration and brightest confirmed lunar meteor impact recorded to date by any survey. Figure 2 shows a frame grabbed from the video when the impact flash was near its peak brightness. Visually this one would have been obvious to the casual lunar observer watching with binoculars or a telescope at the right time.

NASA Marshall Space Flight Center (NASA-MSFC) began a program in 2006 to systematically monitor the Moon for meteoroid impacts after confirming a November 2005 event, likely from a member of the Taurid meteor complex. Since then, up until June 2018, the NASA-MSFC program documented 435 meteoroid impact events from many shower and sporadic meteoroid sources. Most of these have been confirmed but the website refers to these as “Impact Candidates” (website: reference 18). The program continues to this day, as the team observes the Moon with multiple telescopes during the waxing and waning phases each month.

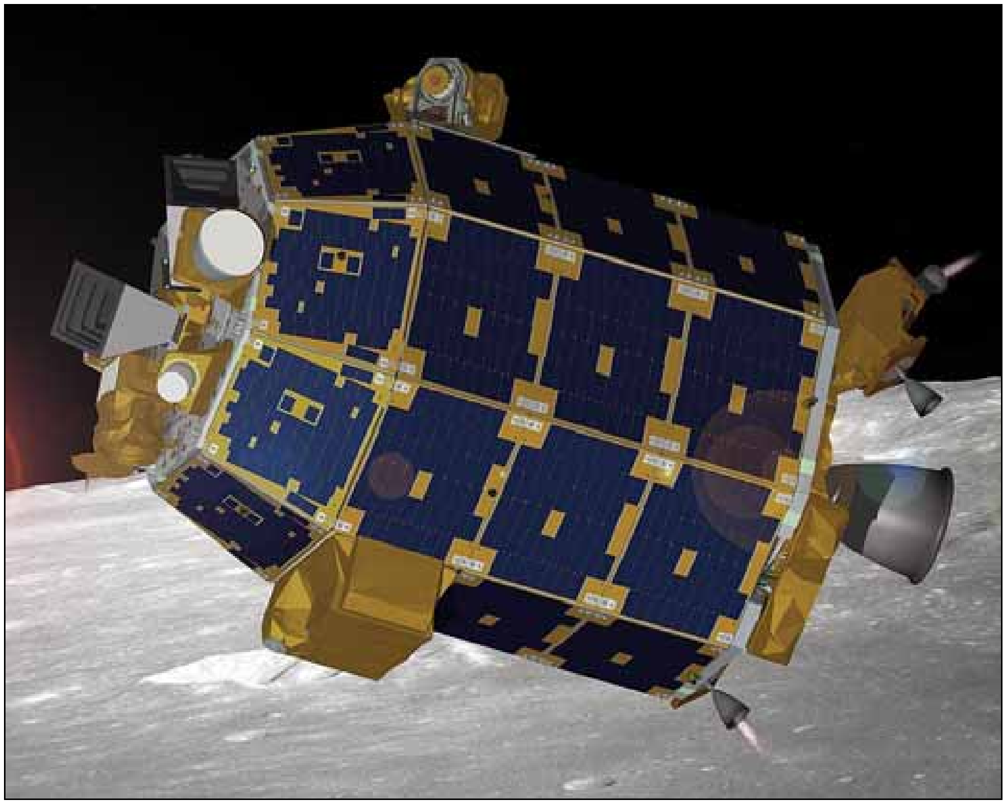

Figure 4. LADEE in orbit, artist's depiction. Image courtesy of NASA.

The European Space Agency (ESA) also funds a program to monitor the Moon, the NELIOTA (NEO Lunar Impacts and Optical TrAnsients) program, which ESA launched in February 2015 “to determine the distribution and frequency of small near-earth objects (NEOs) via lunar monitoring.” (Bonanos, et al. 2016). The program makes use of a 1.2 m Cassegrain telescope at Kryoneri Observatory. As of 2019 April 25, the program has detected 58 lunar impact flashes thus far (website: reference 20). The telescope is capable of observing in two wavelengths with a beam splitter porting the light to two sCMOS cameras operating in the R and I bands. This setup greatly enhances the validity of impact candidate observations but is still subject to false positives by satellite glints, etc. The system is set up so as to maximize the validity of the events observed. NELIOTA is funded to run until 2021.

The Swiss-Italian group of lunar observers (Marco Iten, Raffaello Lena, and Stefano Sposetti) have submitted a number of observations over the years. One interesting event occurred on 26 February 2015, close to the terminator. The impact peaked at visual magnitude +8.0 and lasted a fraction of a second; a diffuse glow in the same region lasted several seconds. I obtained a copy of the video of this event and showed it to impact expert H. Jay Melosh during the 2015 Lunar and Planetary Science Conference, and he agrees that this very likely shows a plume reflecting sunlight kicked up by a meteoroid impact (Melosh, 2015).

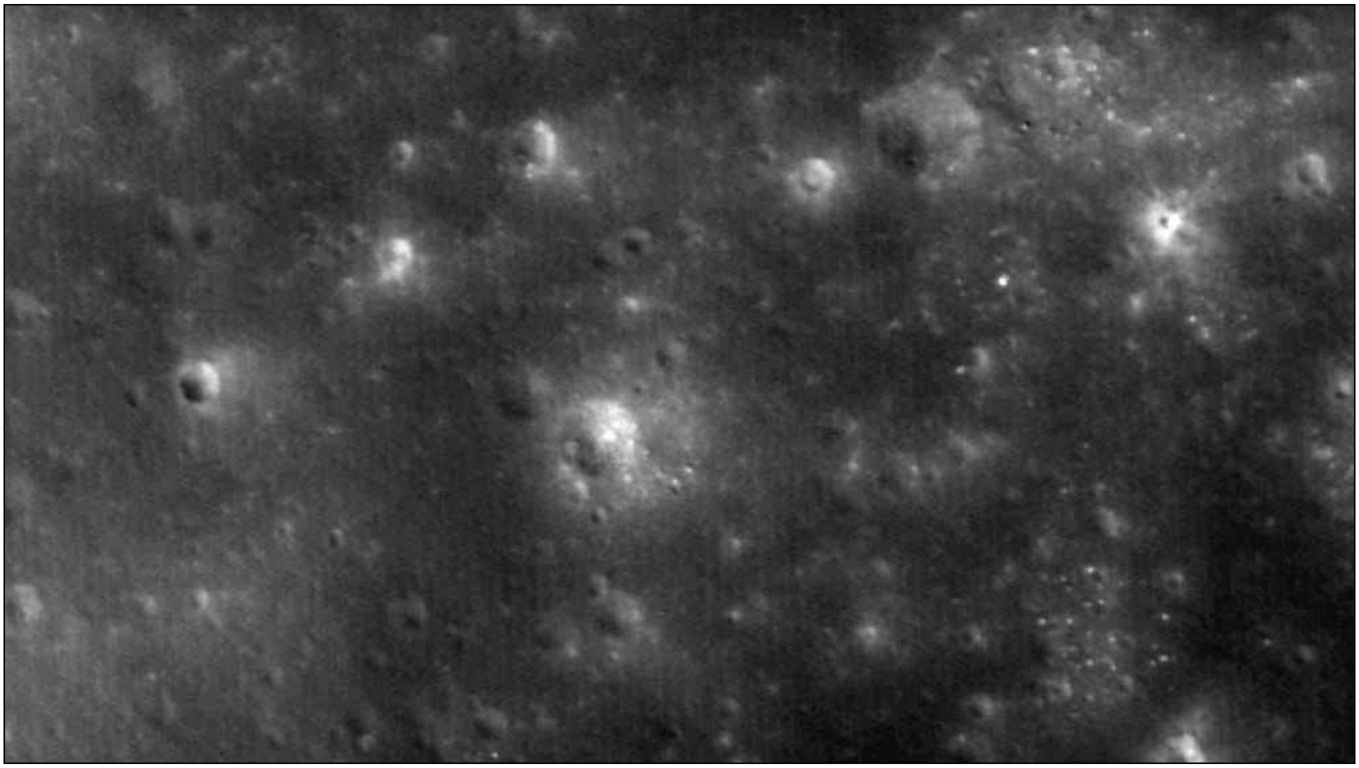

Figure 5a. Sundman V crater region before LADEE impact. Image courtesy of NASA/Goddard/Arizona State University.

Figure 5b. Sundman V crater region after LADEE impact. Image courtesy of NASA/Goddard/Arizona State University.

More recently, I have received reports of lunar meteor impacts from the ROCG (Remote Observatory of Campos dos Goytazes) and the Exoss Lunar Teams. Observers on ROCG team include Tiago Augusto, Torres Moreira, and Carlos Henrique Barreto. Two of these reported impacts occurred within less than an hour of each other on 19 July 2018 (21:53:35 and 22:29:07), another on 14 August 2018 (21:31:14, likely a Perseid) and five more during the Geminid meteor shower of 2018. One of the potential lunar Geminid meteors occurred at 23:40:22 on 12 December; and four more occurred on 15 December, at 00:13:36, 00:22:27, 00:59:30, and 01:05:06 (all times are UTC).

The ALPO Lunar Meteoritic Impact Search Section over the Years

After being established in 2000 the ALPO-LMIS has assisted with a number of efforts, professional and amateur, over the years. Prior to this, my first attempt at witnessing an impact of any form was when the Lunar Prospector spacecraft was commanded to make a controlled impact in a permanently shadowed crater in the lunar South Pole at 9:52:02UT on 31 July 1999. It had just finished a 19-month mission of investigating the Moon from a polar orbit. One objective was to look for deposits of ice in the permanently shadowed craters in the polar regions. (More information on the Lunar Prospector mission can be found at https://en.wikipedia.org/wiki/Lunar_Prospector). I watched visually with a 10-inch reflector for a plume but neither I, nor anyone else saw anything.

The SMART-1 mission, launched in September 2003, served as a test-bed for new small-spacecraft mission technology for the European Space Agency. The mission was useful not only in testing new technologies, but in helping to unlock the secrets of the history of the Moon. ALPO-LMIS became involved when the spacecraft was crash-landed in the Lacus Excellentie (ESA, 2010), I was able to secure ten committed observers (that I know of) to monitor the Moon during the impact. Of those who reported back, several were clouded out. Three observers (myself included) who were able to observe the region on the Moon at the time of the impact reported no unusual phenomena. The observations of each observer were video-based with GPS time insertion and telescopes of 8-inch to 11-inch aperture.

NASA launched the Lunar Reconnaissance Orbiter (LRO), along with LCROSS (Lunar Crater Observation and Sensing Satellite, Figure 3) on June 18, 2009. The main objective of LCROSS was to verify the presence of water ice in permanently shadowed craters near the lunar South Pole (More about LCROSS can be found at this website- https://en.wikipedia.org/wiki/LCROSS). The launch vehicle's Centaur upper stage was to crash land into Cabeus Crater while LCROSS watched. ALPO-LMIS coordinated a ground-based effort to monitor this part of the lunar surface for any impact plumes ejected by the event. Unfortunately observers who were able to view the Moon in clear skies were not able to see any sign of an impact at event time.

ALPO-LMIS collaborated with Mr. Brian Day of NASA Ames Research Center to monitor the Moon for meteoroid impacts in support of the LADEE (Lunar Atmosphere Dust Environment Explorer, Figure 4) mission to the Moon. (More about LADEE can be found here - https://en.wikipedia.org/wiki/LADEE). LADEE was launched on September 7, 2013 onboard a Minotaur V rocket and operated for seven months. It orbited the lunar equator to study the lunar exosphere, monitoring, among other parameters, the change in dust level from altitudes ranging 25 km to 80 km. The mission, after a 28-day extension, ended on April 18, 2014, with a crash-landing on the far side of the Moon, near the eastern rim of Sundman V crater. A number of observers participated in this campaign to monitor the moon, and I have received several reports of impact candidates observed in early December 2013 and early January 2014, three of which had been confirmed by members of the Swiss-Italian team. To my knowledge, I am not aware of any definitive correlation between impact events observed from the ground and increases in the dust content of the lunar exosphere. Figures 5a and 5b show the location on the Moon where LADEE impacted, as imaged by LRO.

Conclusion: The Usefulness of Impact Observations

As has already been mentioned the Moon is an excellent laboratory to study hypervelocity impact phenomena, with meteoroids attaining impact velocities not yet achievable in Earth-based laboratories. Much science may be derived from these events, as we have already seen over the last fifteen years or so of observation and research into the lunar meteor phenomena. Several groups are maintaining ongoing and sustained observing programs to catalog the occurrences of lunar meteor impacts. These observations complement ground-based observations of terrestrial meteors and fireballs in providing a census of objects in the near-Earth environment. The Earth's atmosphere provides a "probe" to sample small particles, especially interplanetary dust, along with larger particles that produce fireballs from time to time. The Moon displays the impact flashes of larger objects, most of which are larger than the majority of what is routinely observed "burning up" in the Earth's atmosphere.

Although the "average" observer may not be equipped to explore the deeper physics of lunar meteoroid impacts, many are equipped to contribute to the science of these fascinating events. With the right equipment and approach, observers may document impact flashes on the dark side of the moon and add to the statistics of these events, complementing the professional groups' activities described above. ALPO-LMIS and other groups such as the International Meteor Organization (imo.net) may work together to assist efforts to count ground-based and Moon-based meteor impact events, contributing to the science of meteors and the knowledge of the contents of a meteoroid stream specifically and interplanetary space in general. Large lunar impacts, well observed and pinpointed accurately, may be linked to very fresh craters observed regularly by the Lunar Reconnaissance Orbiter and provide valuable insight into the evolution of small impact craters.

As has always been the case with the LMIS in particular and ALPO in general, observations of all forms are always welcome. Observers should keep in mind a few things as they participate, and refer to guides produced by this section as well as other sources and the author's book "Lunar Meteor Impacts and How to Observe Them". Visual observations are welcome and include a simpler setup of telescope, tape recorder, and shortwave radio broadcasting WWV; however, the challenge of maintaining an unblinking gaze at the earthlit part of the moon over extended periods of time is daunting. We suggest pairing with an observer equipped with video to enable unambiguous confirmation of any impact candidate. An impact observed by only one observer, visual or video, remains only an unconfirmed event unless independently confirmed by another. Observers are encouraged to participate whenever possible and submit their observations to the coordinator of this section, the author of this paper, using the contact information given on the ALPO-LMIS web page.

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The ALPO Lunar Section

Who and What is the Lunar Transient Phenomena Program

Dr. Anthony Cook

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Figure 1. Dr. Anthony Cook, coordinator of the ALPO Lunar Transient Phenomena Program.

I am proud to simultaneously serve as coordinator of the ALPO Lunar Transient Phenomena (LTP) program as well as the British Astronomical Assn's Lunar Geological Change Detection program; I am also Assistant Director of the BAA's Lunar Section. Both the ALPO and BAA programs involve detecting, confirming and analysing short-term changes on the Moon. Previously I experimented with high-resolution CCD imaging of Venus, Mars and Jupiter in the 1990's.

My research background originated from astronomy and mapping techniques gleaned from a bachelor's degree in Physics and Astronomy, a master's degree in Remote Sensing from University College London, and a PhD in Automated Digital Cartography from the University of South Wales (UK).

I have worked at various space research establishments including: the Rutherford Appleton Laboratory (UK) on Space Plasma modelling and a VAX computer system manager; at University College London (UK) on automated stereo matching of Viking Orbiter images; at the Institute for Planetary Exploration in Berlin, Germany, on Automated Planetary Cartography and GIS; and at the Smithsonian's Center for Earth and Planetary Studies in Washington, DC's National Air and Space Museum, on stereo matching of Clementine lunar images and Mariner 10 images of Mercury.

After spending five years working in the States, I then returned to the UK to lecture in Computer Science at the University of Nottingham, England, UK, and am now a lecturer in Physics at Aberystwyth University, Wales, UK.

Apart from astronomy as a hobby and profession, I am really passionate about stereo photography and video, trying to capture the world around us in 3D, for future generations.

David Darling

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I have always been interested in the night sky, ever since I can remember. I would watch the Echo satellite pass over in the night sky and see the northern lights. My interest in the Moon started in 1965 on Christmas night at age 13. My parents had given the family a small 30X Tasco telescope that sat upon a table top. Then two nights later I took it out to view the Full Moon and I was captivated. I have been drawn to the Moon ever since.

I got my education about our Moon by reading the many books on the subject. My favorite was *The Moon* by Patrick Moore. I was always fascinated about his observations concerning "TLP" ("transient lunar phenomena"). I later learned that in the U.S., the term was "LTP", for "lunar transient phenomena". Since I was using small-aperture telescopes at this time, I did not have my own encounter with these fleeting phenomena until I purchased my Cave 12.5-inch, f/5 Newtonian reflector.

My first encounter with lunar transient phenomena took place in May 1979. This began my 40-year odyssey of discovery. What I saw that evening while observing the crescent Moon Earthshine was a spectacular display or light show coming from the crater Aristarchus. The phenomena lasted only about seven minutes but at its brightest, I could see it with the naked eye. Through the eyepiece of my Cave reflector was a beam of blue light coming out of the eyepiece. It was the most incredible thing I had ever witnessed.

After this experience, I continued to monitor the Moon during all periods of lunation, thereby making my wife Edna an "astronomy widow". I averaged around 90 to 100 nights of observing each year. Over the years, I began reaching out to other observers by contacting them using *spaceweather.com*, a web site of individuals who posted pictures of the Moon and of lunar eclipses. I established an observing network and called it the "Lunar Transient Phenomena Network". My team of observers was small – only about 20 – but it continued to grow. I made contact with the ALPO LTP recorder Winifred S. Cameron and began a great exchange of ideas.

In 1993 I was approached by an employee of National Aeronautics and Space Administration (NASA), whose name is lost in the fog of time, telling me about the upcoming Moon mission called the *Clementine*. He wanted to talk to me about this mission after hearing my presentation of Lunar Transient Phenomena at an astronomy convention my club had hosted. He thought it would be a great idea to monitor the Moon during the imaging period of the spacecraft. This concept is not new, since during the Apollo missions the Moon was monitored while the astronauts were orbiting the Moon; this program was called "Lunar International Observing Network" or LION.

My contacting observers for the upcoming mission went into overdrive and I sent out mass-mailings to all the astronomy clubs in the U.S. I also continued to send out emails to individuals who posted pictures of the Moon on spaceweather.com. We had over 200 observers, professional and amateur astronomers, from all over the world participating. I contacted Dr. Eugene Shoemaker, the principle investigator of the mission, about phoning him when an LTP event was reported to my network. Needless to say, the paperwork was considerable, with reports coming in and endless correspondence and "how-to" questions.

I decided to establish my observing manual and launched my web site under the name of "LTP Network". During this time, I also made contact with Dr. Patrick Moore, who had taken over the British Astronomical Assn TLP section to continue our telephone alerts if an event was observed. When Winifred S. Cameron retired from her position as recorder for the ALPO LTP section, I took over her position.

My second lunar mission was to coordinate ground-based observers for the Lunar Prospector mission in 1994. I got the green light from Dr. Alan Binder, the principle investigator, to call him if an event was detected. Once again, a great deal of

Figure 2. David Darling, assistant coordinator of the ALPO Lunar Transient Phenomena Program, with his 12.5-inch Cave Reflecting telescope sometime in late 1986

observations and many emails came in, making it a successful participation.

Several years later, I found that health issues were sapping my strength and I could no longer deal with the monster I had created. My carefully built web site server crashed or was shut down and I lost all my effort of 10 years.

I realize that a great amount of data lies in my filing cabinets and ring binders and needs to be published; hopefully, time will be kind and allow me the opportunity to complete this work.

During my 40 years of exploring this phenomenon, I discovered there is more of mystery about our Moon than I had ever assumed possible. But that will have to be revealed by future investigators who will continue to seek the truth about our nearest neighbor, the Moon.

The ALPO LTP Program

By Dr. Anthony Cook

A Lunar Transient Phenomenon (LTP) is general name for a short-term colour, brightness, obscuration change or flash(es), on the Moon. The current LTP program of the ALPO is based upon making sense of some 3,000 historical accounts of apparent transient changes on the Moon seen over the last few centuries, from Earth-based observers.

LTP have been the subject of several observing programs since the 1960's, such as the NASA-funded Moon Blink & Corralitos Observatory projects, the ARGUS-ASTRONET amateur radio network (used to alert observers to LTPs), the Smithsonian's LION project, and subsequent American Lunar Society/ ALPO/BAA telephone alert networks and monitoring campaigns. LTP monitoring were heightened during the Apollo, Clementine and Lunar Prospector missions.

All but one of these observing programs (Corralitos) seemed to support the notion that at least some LTPs were credible. Two NASA catalogs were produced: Barbara Middlehurst's "Chronological Catalog of Reported Lunar Events," published in 1968, and Winifred Sawtell Cameron's "Lunar Transient Catalog" from 1978. An extension to the 1978 catalog has also become available.

A statistical study of these data by Prof Arlin Crotts, published in the *Astrophysical Journal* seems to support that LTP sightings have a strong correlation with specific lunar features and may be related to sites of outgassing from mare edges. However although modern high-resolution imaging spacecraft such as NASA's Lunar Reconnaissance Orbiter had found evidence for 50,000 changes on the lunar surface, as described in a *Nature* journal paper in 2016, the vast majority were metre scale, and so would not be visible to Earth-based telescopic observers.

I suspect, however, that the few landslides or crater ejecta imaged that do indeed cover kilometer scales, and in theory could be resolved from Earth-based telescopes, might be so subtle in albedo and colour that we would have difficulty detecting them through telescopes. Also, these are permanent changes, unlike LTP which by definition are short-term.

On better news, several hundred confirmed impact flashes have been videoed on the lunar night side by observatories at NASA's Marshall Spaceflight Center, the MIDAS project in Spain, and ESA's NELIOTA telescope in Greece. So this may infer that some of the reports of single flashes of light that crop up in LTP catalogs could be meteoroid-related in origin.

The goals of the ALPO's LTP observing program are to investigate the circumstances of all past LTP reports to see if they hold any validity. The archive of past LTP reports encompass a time scale of several centuries compared to the relatively short time that spacecraft have been observing the Moon, and so may bear witness to more energetic impact events, or surface processes, than spacecraft have yet to record.

We do this by encouraging observers to record visually a description, sketch or image the appearance of specific surface features on dates and exact times during each month whereby the appearance will match that of past LTP reports, to within ±0.5°in terms of solar illumination. This helps us eliminate past reports where observers have been tricked by illumination effects, for instance, a rim that appears especially bright, or a shadow that appears greyish due to unresolved highland emerging into sunlight. Images captured can also be put through tests to simulate the effects of atmospheric spectral dispersion, seeing blur and chromatic aberration in order to see if these can explain colours or obscurations reported by past LTP observers.

Time-lapse imaging has also been used to check the validity of brightenings that past observers have occasionally reported with LTP in order to see if these are shadow- or sunward-slope-angle related. Dates and times of when to observe are detailed, for different geographical sites in the world at http://users.aber.ac.uk/atc/lunar_schedule.htm.Observing alerts, or requests to check recent observations, are given at https://twitter.com/lunarnaut . Detailed accounts and analysis of repeat illumination observations are summarized in the ALPO's Lunar Section's monthly newsletter *The Lunar Observer* (available at http://moon.scopesandscapes.com/tlo.pdf).

These repeat illumination observations are helping to remove the less credible reports from the ALPO/BAA catalog of LTP and lets us concentrate on interpreting statistics on the more reliable past reports.

For comparison we have also accumulated a database of 24,000 routine observations (no LTPs seen), and will be using this to find the most popular lunar features observed. This will help to avoid bias in interpreting why some lunar features have more LTP reports than others.

The great thing about our repeat illumination observing program is that we welcome observations from visual observers, sketches and high-resolution images that include a wide range of observer skills and equipment. Whatever you send in, we will make use of it, as this reflects the diversity of scope sizes, types and observing methods used in observations present in our LTP archive.

ALPO LUNAR SECTION: **Routine LTP Search Report Form** Page ….. of ……

Use this form for routine observations not requiring detailed notes.

Date (yyyy/mm/dd) 20…/..…../……. UT from ….:…. to ….:….
Name………………………..…………. Address……….………….…………………..…………....
Tel./Email………..………..……………… …………………………………………….….……….…
Telescope (type, size, eyepiece, x) ……………………..………...….……………………….…………….
Seeing (circle): I, II, III, IV, V Transparency (circle): V.Good, Good, Avg, Poor, V.Poor
Local conditions (e.g. temp, press, spurious colour)…………………………………..………………..
……………………………………………………………………………………………………...……
Observation type (circle if one type used or enter relevant abbreviation in the table below):
Blink (BLK), CCD (CCD), CED (CED), Earthshine (EAR), Eclipse (ECL), Filter (FIL), Impact Flash (IMP), Photography (PHG), Photometry (PHM), Polarimeter (POL), Spectrometer (SPC), Video (VID), Visual Inspection (VIS), Visual Intensity Scale (INT)

Feature Name	UTC From:	UTC To:	**Appearance and/or comments** (if brightness being measured, enter value in last column)	Obs. Type	Obs. Value

Office Use Only
Lon:
Lat:

Duration…..	Moon alt	Sub-sol lon	Sub-sol lat	Sub-observ lon	Sub-observ lat
Start					
End					

ALPO LUNAR SECTION: **Detailed LTP/Routine Report Form** An alert? (Y/N)
Use this form when your observations are too detailed to fit on the routine form

Date (yyyy/mm/dd) 20…/..…../……. UT from ….**:**.… to ….**:**….

Name……………………….………. Address……...……………….…………………….…...
Tel/Email………………………. ……………….………………………………….……
……………………………………………..………………………..……………...……
Telescope (type, size, eyepiece, x) ……………………..…….……………………………….

Seeing (circle): I, II, III, IV, V Transparency (circle): V.Good, Good, Avg, Poor, V.Poor
Local Conditions (e.g. temp, press, spurious colour)………………………..……..…..……..
…………………………………………………………………………………………..
Observation (circle): Blink, CCD, CED, Description, Drawing, Earthshine, Eclipse, Filter, Impact Flash, Photography, Photometry, Polarimeter, Spectrometer, Video, Visual Intensity
Further observation details (optional)…………………………………………………………
xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx Page ….. of …… xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

Office Use Only
Lon:
Lat:

Duration…..	Moon alt	Sub-sol lon	Sub-sol lat	Sub-observ lon	Sub-observ lat
Start					
End					

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Lunar Meteoritic Impacts Search Program

http://www.alpo-astronomy.org/lunar/lunimpacts.htm
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- **Monograph No. 3**. *H.P. Wilkins 300-inch Moon Map.* 3rd Edition (1951). Available as one comprehensive file

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(approx. 48 megabytes) or five section files (Part 1, 11.6 megabytes; Part 2, 11.7 megabytes; Part 3, 10.2 megabytes; Part 4, 7.8 megabytes; Part 5, 6.5 mb)

- **Monograph No. 4.** *Proceedings of the 45th Convention of the Association of Lunar and Planetary Observers. Wichita, Kansas, August 1-5, 1995.127* pages. Hard copy $17 for the United States, Canada, and Mexico; $26 elsewhere. File size approx. 2.6 mb.

- **Monograph No. *5.*** *Astronomical and Physical Observations of the Axis of Rotation and the Topography of the Planet Mars. First Memoir; 1877-1878.* By Giovanni Virginio Schiaparelli, translated by William Sheehan. 59 pages. Hard copy $10 for the United States, Canada, and Mexico; $15 elsewhere. File size approx. 2.6 mb.

- **Monograph No. *6.*** *Proceedings of the 47th Convention of the Association of Lunar and Planetary Observers, Tucson, Arizona, October 19-21, 1996.20* pages. Hard copy $3 for the United States, Canada, and Mexico; $4 elsewhere.File size approx. 2.6 mb.

- **Monograph No. 7.** *Proceedings of the 48th Convention of the Association of Lunar and Planetary Observers. Las Cruces, New Mexico, June 25-29, 1997.76* pages. Hard copy $12 for the United States, Canada, and Mexico; $16 elsewhere.File size approx. 2.6 mb.

- **Monograph No. 8**. *Proceedings of the 49th Convention of the Association of Lunar and Planetary Observers. Atlanta, Georgia, July 9-11,1998.122* pages. Hard copy $17 for the United States, Canada, and Mexico; $26 elsewhere.File size approx. 2.6 mb.

- **Monograph Number 9**. *Does Anything Ever Happen on the Moon?* By Walter H. Haas. Reprint of 1942 article. 54 pages.Hard copy $6 for the United States, Canada, and Mexico; $8 elsewhere.File size approx. 2.6 mb.

- **Monograph Number 10.** *Observing and Understanding Uranus, Neptune and Pluto*. By Richard W. Schmude, Jr. 31 pages. File size approx. 2.6 mb.

- **Monograph No. 11**. *The Charte des Gebirge des Mondes* (Chart of the Mountains of the Moon) by J. F. Julius Schmidt, this monograph edited by John Westfall. Nine files including an accompanying guidebook in German. Note files sizes:
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  Schmidt0204.pdf, approx. 32.6 mb;
  Schmidt0507.pdf, approx. 32.1 mb;
  Schmidt0810.pdf, approx. 31.1 mb;
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  Schmidt1416.pdf, approx. 28.2 mb;
  Schmidt1719.pdf, approx. 22.2 mb;
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- **Solar:** *Guidelines for the Observation of White Light Solar Phenomena*, *Guidelines for the Observing Monochromatic Solar Phenomena* plus various drawing and report forms available for free as pdf file downloads at http://www.alpo-astronomy.org solarblog.

- **Lunar & Planetary Training Section:** *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. Available as pdf file via e-mail or send check or money order payable to Timothy J. Robertson, 195 Tierra Rejada Rd., #148, Simi Valley, CA 93065; e-mail cometman@cometman.net.

- **Lunar:** (1) *The ALPO Lunar Selected Areas Program Handbook* (hardcopy, $17.50). Includes full set of observing forms. (2) *Observing forms*: Send a SASE for a hardcopy of forms. Both the Handbook and individual observing forms are available for download (as pdf files) at moon.scopesandscapes.com/ alpo-sap.html. Use of observing forms will ensure that all requested information is included with observations, but are not required. Various lists and forms related to other Lunar section programs are also available at moon.scopesandscapes.com. NOTE: Observers who wish to make copies of the observing forms may instead send a SASE for a copy of forms available for each program. Authorization to duplicate forms is given only for the purpose of recording and submitting observations to the ALPO lunar SAP section. Observers should make copies using high-quality paper.

- **Lunar**: *The Lunar Observer*, official newsletter of the ALPO Lunar Section, published monthly. Free at http:// moon.scopesandscapes.com/tlo.pdf or send SASE to: Wayne Bailey, 17 Autumn Lane, Sewell, NJ 08080.

- **Venus (Benton):** Introductory information for observing Venus, the comprehensive *ALPO Venus Handbook*, as well as all observing forms and ephemerides, can be conveniently downloaded as pdf files at no cost to ALPO members and individuals interested in observing Venus as part of our regular programs at http://www.alpo-astronomy.org/venus.

- **Mars:** Free resources are on the ALPO website at www.alpo-astronomy.org . Click on "Mars Section" in the left column; then on the resulting webpage, look for links to resources in the right column including “Mars Observing Form”, and "Mars Links". Under “Mars Links”, click on "Mars Observers Cafe", and follow those links to The New “Internet Mars Observer's Handbook.”

- **Minor Planets (Derald D. Nye):** *The Minor Planet Bulletin*. Published quarterly; free at http:// www.minorplanetobserver.com/mpb/ default.htm. Paper copies available only to libraries and special institutions at $24 per year via regular mail in the U.S., Mexico and Canada, and $34 per year elsewhere (airmail only). Send check or money order payable to “Minor Planet Bulletin”, c/o Derald D. Nye, 10385 East Observatory Dr., Corona de Tucson, AZ 8564l-2309.

- **Jupiter:** *(1) Jupiter Observer’s Handbook*, from the Astronomical

ALPO Resources

People, publications, etc., to help our members

League Sales, temporarily out of stock. (2) *ALPO_Jupiter*, the ALPO Jupiter Section e-mail network; to join, send a blank e-mail to *ALPO_Jupiter-subscribe@yahoogroups.com* (3) *Jupiter Observer's Startup Kit*, $3 from Richard Schmude, Jupiter Section Coordinator.

- **Saturn (Benton):** Introductory information for observing Saturn, including all observing forms and ephemerides, can be conveniently downloaded as pdf files at no cost to ALPO members and individuals interested in observing Saturn as part of our regular programs at *http://www.alpo-astronomy.org/saturn*. The former *ALPO Saturn Handbook* was replaced in 2006 by *Saturn and How to Observe It* (authored by Julius L. Benton) and it can be obtained from book sellers such as *Amazon.com*.

- **Meteors:** (1) *The ALPO Guide to Watching Meteors* (pamphlet). $3 per copy (includes postage & handling); send check or money order to Astronomical League Sales, 9201 Ward Parkway, Suite 100, Kansas City, MO 64114; phone 816-DEEP-SKY (816-333-7759); e-mail *leaguesales@astroleague.org*. (2) *The ALPO Meteors Section Newsletter*, free (except postage), published quarterly (March, June, September and December). Send stamps, check or money order for first class postage to cover desired number of issues to Robert D. Lunsford, 14884 Quail Valley Way, El Cajon, CA 92021-2227.

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