ABOVE THE FOG

• BULLETIN OF THE SAN FRANCISCO AMATEUR ASTRONOMERS •

Vol. 67, No. 06 – October 2019

IN THIS ISSUE

01. SFAA PRESIDENT'S NOTE | OCTOBER SKIES

Fall is finally upon us, and Scorpius and Sagittarius begin their descent West at dusk. Saturn and Jupiter are also lower in the sky and will soon hide in the twilight. Luckily, Taurus the Bull and Auriga the Chariot are starting to rise in the East as it gets dark. And as Fall continues its progression into Winter in just a few months, soon Orion and Gemini will join the procession of constellations.

October is a strange time for urban astronomy enthusiasts. There are no bright constellations at the meridian in the early October evening. Our attention is split between the sights of the summer Milky Way, and the promise of bright, spectacular constellations, clusters and nebulas of Winter.

It is ironic that the best weather in San Francisco typically arrives in September and October, because if it wasn't for the planets and the Moon, there will hardly be anything to watch in the evenings during this time of clear and warm evenings.

But with the clear skies, it is possible to observe the Sun! And there is a transit of Mercury coming in early November. Please find details about this event in this issue. The transit happens in early morning and is already started by the time the Sun rises for us on the West coast, but it is still an interesting experience. You may want to rush order a solar filter for your telescope now if you have been thinking of getting one in the past! There will not be another transit visible from the West coast until 2049!

Clear skies,
P.J. Cabrera
President, SFAA

SFAA BOARD OFFICERS AND DIRECTORS		
President	P.J. Cabrera	president@sfaa-astronomy.org
Vice President	Liz Triggs	vice-president@sfaa-astronomy.org
Treasurer	Scott Miller	treasurer@sfaa-astronomy.org
Secretary	Bill Kircher	secretary@sfaa-astronomy.org
Directors	Matthew Jones, Tom Kellogg, Brian Kruse, Jessica Miller, Will Silberman, Douglas Smith, and Kate Cabrera	

*** * * Note: SFAA Membership Process * * ***

Current SFAA members can create a login account to the SFAA website to edit personal profile information, view membership status, and renew membership. Members will need the email address that was used to join SFAA as the login username, and members will need to create a password the first time they login.

An auto-renewal process is also available to make annual renewals easier and effortless.

The process to join SFAA will also change slightly with new members prompted for their personal profile information in addition to payment details.

02. SFAA & BAY AREA ASTRONOMY EVENTS

OCTOBER 2019 – DECEMBER 2019

Details: http://www.sfaa-astronomy.org/events

Wednesday, October 16, 7:30 pm – 9:15 pm
Meeting and Lecture, Randall Museum

Saturday, October 26, 6:30 pm – 2:00 am
Mt. Tam Members Night (arrive BEFORE sunset)

Thursday, November 7, 7:00 pm – 10:00 pm
City Star Party, Lands End at Point Lobos in San Francisco

Monday, November 11, 7:00 pm – 10:00 pm
SFAA Board Meeting, Location TBD

Wednesday, November 20, 7:30 pm – 9:15 pm
Meeting and Lecture, Randall Museum

Saturday, November 23, 6:30 pm – 2:00 am
Mt. Tam Members Night (arrive BEFORE sunset)

Saturday, December 7, 7:00 pm – 10:00 pm
City Star Party, Presidio at Parade Grounds in San Francisco

Wednesday, December 18, 7:30 pm – 9:15 pm
Meeting and Lecture, Randall Museum

Saturday, December 28, 6:30 pm – 2:00 am
Mt. Tam Members Night (arrive BEFORE sunset)

GET LIVE HELP WITH YOUR TELESCOPE!

* * * * * * * *

Are you a new telescope owner?

Or perhaps you could use some help with alignment, collimation, or other adjustments?

Like playing guitar or dancing the tango, learning to operate a telescope can, with great effort, be learned on your own.

However, it's much easier and more enjoyable to learn hands-on with experienced individuals.

Bring your telescope to a Star Party – we'll be happy to help!

BAY AREA ASTRONOMY EVENTS

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Long-time SFAA member, Kenneth Lum, assembles and reports a list of Bay Area Astronomy events. Check the following link for information and additional events: https://groups.yahoo.com/neo/groups/bayastro/info

03. SFAA 2020 BOARD OF DIRECTORS ELECTION

The SFAA elects Directors and Officers every December for the upcoming calendar year. The Directors and Officers constitute the Board of Directors, which is the SFAA's governing body.

The Board is responsible for:

- maintaining the membership roster;
- managing SFAA funds;
- organizing and publicizing events and activities;
- coordinating member volunteers; and
- communicating on the SFAA's behalf with the broader community.

Fortunately, the club has a stable cash flow and adequate reserves. Members' dues fund all SFAA-sponsored activities; unlike many non-profit organizations, SFAA Board members don't have to fundraise.

Board meetings are scheduled once a month. The first meeting of the year is a day-long retreat to plan for the year ahead. The remaining meetings take place during the evening on weekdays. Typically, the board convenes two online and one in-person meeting each quarter.

Any current member of the SFAA is eligible to run for the Board. Some of our current board members are not eligible to serve another term, so we need new people to run and fill vacant seats. We're interested in fresh ideas and perspectives to enhance the events and communications the SFAA offers to members and to the broader public. If you have been participating in SFAA activities and you have the time and energy to commit to helping direct the club's affairs, please consider running for the Board.

The responsibilities of SFAA Officers and Directors are described in greater detail in the Bylaws page on the SFAA website: http://www.sfaa-astronomy.org/sfaa-bylaws/.

If you are interested in running for a Board seat, if you have questions, or if you would like to nominate another member, please contact PJ Cabrera at president@sfaa-astronomy.org.

04. SFAA VOLUNTEER OPPORTUNITIES

VOLUNTEER OPPORTUNITIES

Contact: Will Silberman (volunteer@sfaa-astronomy.org)

Star Party Volunteers ▪ City Star Parties ▪ Mt. Tam Star Parties	Will Silberman (volunteer@sfaa-astronomy.org)
Snack Volunteers	Linda Mahan (speakerchair@sfaa-astronomy.org)
Marketing Volunteers	PJ Cabrera (president@sfaa-astronomy.org)
Above the Fog Volunteers	PJ Cabrera (president@sfaa-astronomy.org)

Star Party Volunteers

SFAA hosts 2 to 3 star parties every month throughout the year, including City Star Parties in San Francisco and observation nights on Mount Tamalpais. Between April and October, in partnership with Mt. Tam State Park, the Friends of Mt. Tam, and Wonderfest, SFAA provides telescope observing as part of a public monthly astronomy program. As a result, we need **experienced SFAA members to serve as volunteers for each of these events**. If you've been to a few star parties, you're familiar with the procedures, and you're able to commit to attending these events, **we can use your help**!

Volunteers are responsible for: checking weather forecasts prior to scheduled events, coordinating with other volunteers, providing cancellation notice due to inclement weather or dangerous conditions (e.g. forest fires). Volunteers are expected to arrive to events early, welcome and orient members, and hold a brief huddle for all telescope operators to review procedures and answer questions.

For Mt. Tam events, volunteers are tasked with:

- members night: ensuring every vehicle belongs to an SFAA member and has a parking pass; at the end of the night, volunteers make sure members understand how to lock the gate on the way out; and
- public astronomy program: coordinating with Friends of Mt. Tam volunteers to manage visitor parking.

Volunteers receive an e-mail once a month to coordinate on upcoming star parties. If you're interested in volunteering, or if you have questions, please contact Will Silberman at volunteer@sfaa-astronomy.org.

Snack Volunteers

SFAA needs volunteers to bring light refreshments to our monthly meetings and lectures at the Presidio Officers Club, on the **third Tuesday of each month**. Refreshments create a welcoming atmosphere for members and guests. Volunteers can donate snacks or provide receipts for expense reimbursement.

If you're interested in bringing refreshments, please send an e-mail to Linda Mahan at speakerchair@sfaa-astronomy.org and indicate which month(s) you can help with and what you'd like to bring.

Marketing Volunteers

SFAA needs volunteers to help post SFAA event updates to groups such as SFGate, SF FunCheap, Eventful, Bay Area Science, etc. If you're interested in marketing opportunities, please send an e-mail to PJ Cabrera at president@sfaa-astronomy.org.

Above the Fog Volunteers

SFAA distributes a monthly newsletter, *Above the Fog*. Volunteers are asked to submit an occasional article, astrophoto, and/or to serve as a member of the editorial team. If you're interested in contributing to these monthly newsletters, please send an e-mail to PJ Cabrera at president@sfaa-astronomy.org.

On behalf of the board of directors and your fellow SFAA members, thank you for your willingness to help out!

2019 Transit of Mercury

Fred Espenak

Observer's Handbook 2019, Royal Astronomical Society of Canada (http://www.eclipsewise.com/oh/tm2019.html)

On Monday, 2019 November 11, Mercury will transit the Sun for the first time since 2016. The transit or passage of a planet across the face of the Sun is a relatively rare occurrence. As seen from Earth, only transits of Mercury and Venus are possible. There are approximately 13 transits of Mercury each century. In comparison, transits of Venus occur in pairs with more than a century separating each pair.

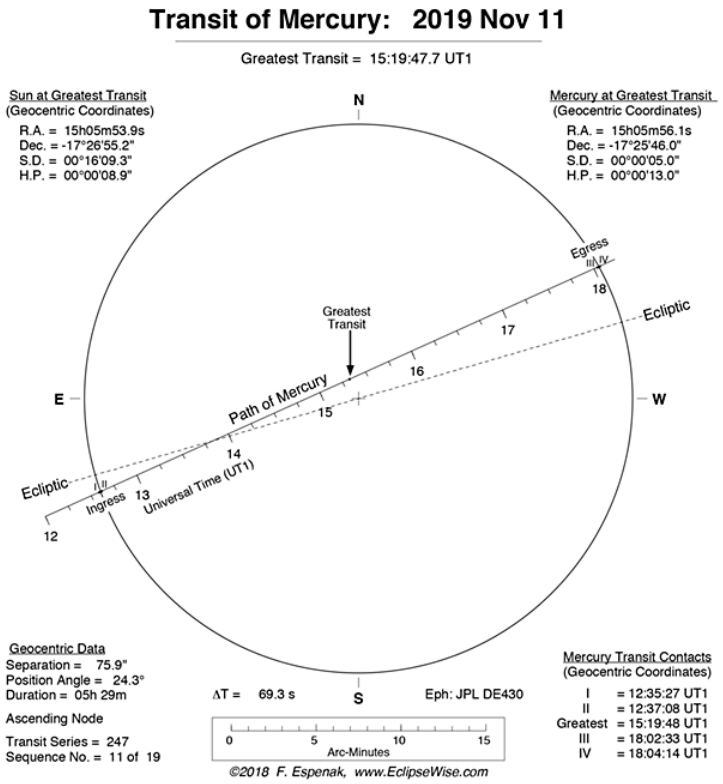
The principal events occurring during a transit are conveniently characterized by contacts, analogous to the contacts of an annular solar eclipse. The transit begins with Contact I, which is the instant when the planet's disk is externally tangent to the Sun. Shortly after Contact I, the planet can be seen as a small notch along the solar limb. The entire disk of the planet is first seen at Contact II when the planet is internally tangent to the Sun. During the next several hours, the silhouetted planet slowly traverses the brilliant solar disk. At Contact III, the planet reaches the opposite limb and once again is internally tangent to the Sun. Finally, the transit ends at Contact IV when the planet's limb is externally tangent to the Sun. Contacts I and II define the phase called ingress while Contacts III and IV are known as egress. Position angles for Mercury at each contact are measured counterclockwise from the north point on the Sun's disk.

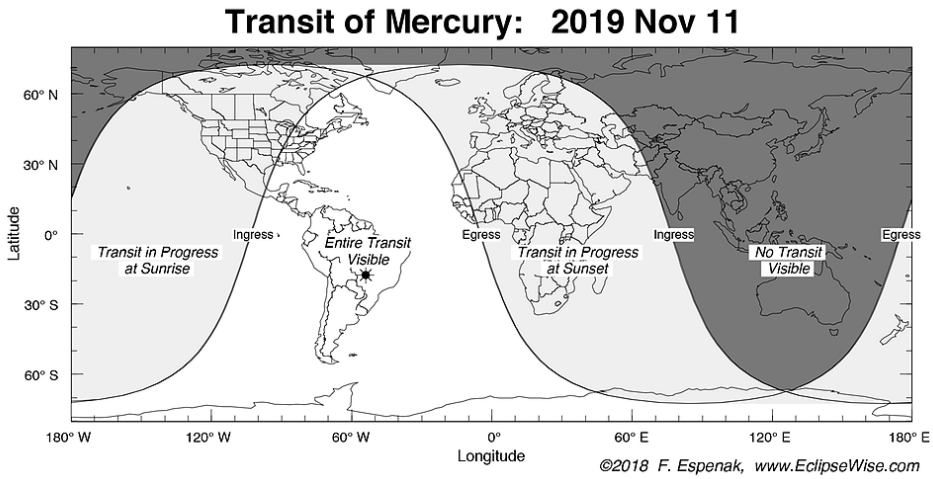
Table 1 gives the times of major events during the 2019 transit in Universal Time (UT1). Greatest transit is the instant when Mercury passes closest to the Sun's center (i.e., minimum separation). At this time, the geocentric angular distance between the centers of Mercury and the Sun will be 75.9 arc-seconds. The position angle is the direction of Mercury with respect to the center of the Sun's disk as measured counterclockwise from the celestial north point on the Sun.

Table 1: Geocentric Phases of the 2019 Transit of Mercury

Event	Universal Time	Position Angle
Contact I	12:35:27	109.8°
Contact II	12:37:08	109.8°
Greatest Transit	15:19:48	24.3°
Contact III	18:02:33	298.8°
Contact IV	18:04:14	298.7°

Figure 1 (to the right) shows the path of Mercury across the Sun's disk and the scale gives the Universal Time of Mercury's position at any instant during the transit. The contact times are listed along with the equatorial coordinates of the Sun and Mercury at greatest transit. Since the contact times are geocentric, they are only correct for an observer stationed at Earth's center. The contact times for any given location may differ from the geocentric times by up to 2 minutes. This is due to the effect of parallax since Mercury's 10 arc-second diameter disk may be shifted up to nearly 13 arc-seconds from its geocentric coordinates depending on the observer's exact geographic position.





The transit will be widely visible from most of Earth including the Americas, the Atlantic and Pacific Oceans, New Zealand, Europe, Africa and western Asia, as shown in Figure 2 above. None of the transit will be visible from central and eastern Asia, Japan, Indonesia, and Australia.

The transit begins before sunrise for observers in western North America. The transit ends after sunset for Europe, Africa, western Asia, and the Middle East. Regions where the entire transit is visible include eastern North America, Central and South America, and the Atlantic Ocean. Tables 2 and 3 (see below) list predicted contact times and the corresponding altitude of the Sun for a number of cities in Canada and the USA, respectively. Contact times for additional cities in Canada and the USA as well as other nations can be found online. Predicted contact times and the corresponding altitude of the Sun:

- United States, see Table 3 here: http://www.eclipsewise.com/oh/oh-tables/tm2019-Tab03.pdf
- Canada, see Table 2 here: http://www.eclipsewise.com/oh/oh-tables/tm2019-Tab02.pdf

[**editor's note**: the tables are also available in the appendix below]

Observing the Transit

Since Mercury is only 1/194 of the Sun's apparent diameter, a telescope with a magnification of 50x or more is recommended to watch this event. The telescope must be suitably equipped with adequate filtration to ensure safe solar viewing. The visual and photographic requirements for the transit are identical to those for observing sunspots and partial solar eclipses. Amateurs can make a useful contribution by timing the four contacts at ingress and egress. Observing techniques and timing equipment are similar to those used for lunar occultations. Since poor seeing often increases the uncertainty in contact timings, an estimate of the possible error associated with each time should be included. Transit timings and geographic coordinates of the observing site (measured from GPS) should be sent to Dr. John E. Westfall (johnwestfall@comcast.net), ALPO Transit Section, 5061 Carbondale Way, Antioch, CA 94531.

White light observations of Contacts I and IV include a small bias since Mercury is only visible after Contact I and before Contact IV. However, if Hydrogen-alpha filtration is available, the planet may be visible against either prominences or the chromosphere before and after Contacts I and IV respectively.

Observations of Contacts II and III also require amplification. They're actually the instants when the planet appears internally tangent to the Sun. However, just after the real Contact II, the so-called black drop effect is seen. At that time, the transiting planet seems to be attached to the Sun's limb by a thin column or thread. When the thread breaks and the planet is completely surrounded by sunlight, this was sometimes called Contact II, but really is delayed by some seconds, up to a minute. Contact III occurs in exactly the reverse order. Atmospheric seeing often makes it difficult to measure contact timings with a precision better than several tens of seconds.

06. SFAA LECTURE SERIES | OCTOBER 16, 2019

EXPLORING PLANETARY SURFACES WITH NASA'S SOLAR SYSTEM TREKS
BRIAN DAY, NASA SOLAR SYSTEM EXPLORATION RESEARCH

Join Brian Day, of NASA's Solar System Exploration Research Virtual Institute, for a presentation on Exploring Planetary Surfaces with NASA's Solar System Treks. Learn about NASA's Solar System Treks project that is producing a suite of online interactive visualization and analysis portals. There are now seven web portals in the program available to the public. This list includes portals for the Moon, Mars, Vesta, Ceres, Titan, and recently Mercury. All of these are unified under a new project home site with supporting content. In this talk, Day will discuss ways that students and members of the public can use these portals to conduct their own explorations of planetary surfaces, measuring diameters of craters, creating elevation profiles of peaks and valleys, and plotting traverse paths.

Brian Day works at NASA's Solar System Exploration Research Virtual Institute where he serves as Lead for Lunar and Planetary Mapping and Modeling. He has participated in various Mars analog field studies in extreme, Mars-like environments here in Earth. He previously served as Education and Public Outreach Lead for the LCROSS and LADEE robotic missions to the Moon. In 2007 he flew on NASA's Aurigid MAC mission to record debris from Comet Kiess burning up in Earth's upper atmosphere.

Randall Museum
199 Museum Way, San Francisco, CA 94114
7:00 pm Doors Open & Light Refreshments | 7:30 pm Club Announcements | 7:45 pm Speaker
SFAA'S GENERAL MEETINGS OCCUR ON THE 3RD WEDNESDAY OF EACH MONTH

07. UPCOMING SFAA LECTURES 2019

NOVEMBER 20TH I MARK SHOWALTER, FELLOW, SETI INSTITUTE

Exploring Ultima Thule: Humanity's Next Frontier

NASA's New Horizons mission made history when it flew by the Kuiper Belt object nicknamed Ultima Thule, on January 1st, 2019. This is the first contact binary object ever observed "in the wild" and provides an amazing glimpse into our primordial solar system.

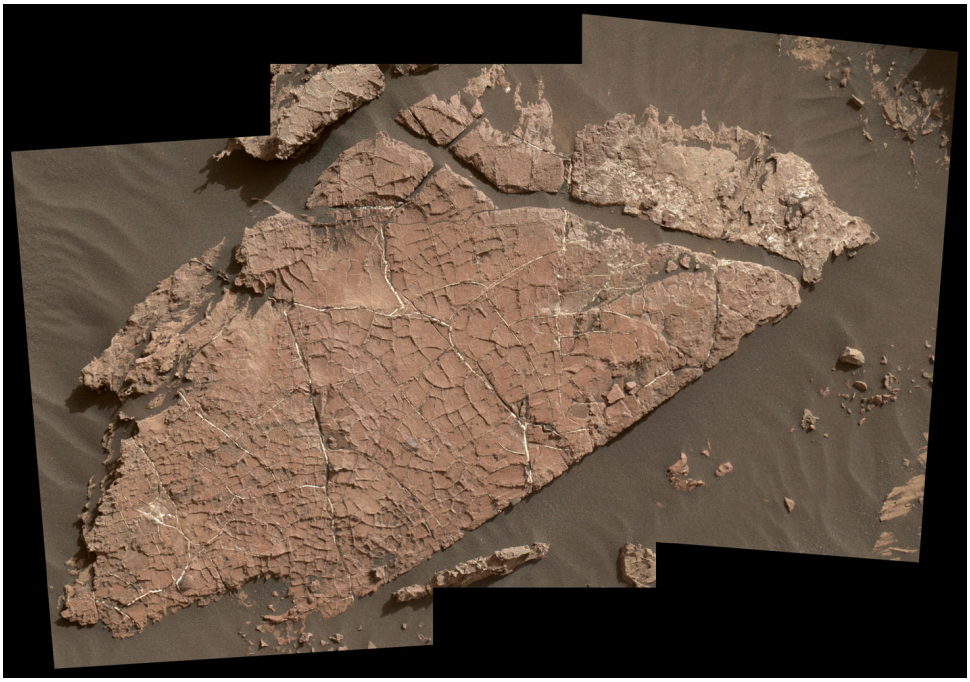
DECEMBER 18TH I KEVIN BUNDY, UCO LICK, UC SANTA CRUZ

Mapping the Lives and Deaths of 10,000 Nearby Galaxies with MaNGA

The SDSS-IV MaNGA survey is obtaining resolved spectroscopy for thousands of nearby galaxies, providing new insights on key questions regarding galaxy growth, the regulation of star formation, and its eventual suppression through "quenching." MaNGA maps the largest integral field survey of galaxies ever conducted.

Randall Museum
199 Museum Way, San Francisco, CA 94114
7:00 pm Doors Open & Light Refreshments I 7:30 pm Club Announcements I 7:45 pm Speaker
SFAA'S GENERAL MEETINGS OCCUR ON THE 3RD WEDNESDAY OF EACH MONTH

NASA's Curiosity Rover Finds an Ancient Oasis on Mars



The network of cracks in this Martian rock slab called "Old Soaker" may have formed from the drying of a mud layer more than 3 billion years ago. The view spans about 3 feet (90 centimeters) left-to-right and combines three images taken by the MAHLI camera on the arm of NASA's Curiosity Mars rover.

Credit: NASA/JPL-Caltech/MSSS

If you could travel back in time 3.5 billion years, what would Mars look like? The picture is evolving among scientists working with NASA's Curiosity rover.

Imagine ponds dotting the floor of Gale Crater, the 100-mile-wide (150-kilometer-wide) ancient basin that Curiosity is exploring. Streams might have laced the crater's walls, running toward its base. Watch history in fast forward, and you'd see these waterways overflow then dry up, a cycle that probably repeated itself numerous times over millions of years.

That is the landscape described by Curiosity scientists in a Nature Geoscience paper published today. The authors interpret rocks enriched in mineral salts discovered by the rover as evidence of shallow briny ponds that went through episodes of overflow and drying. The deposits serve as a watermark created by climate fluctuations as the Martian environment transitioned from a wetter one to the freezing desert it is today.

Scientists would like to understand how long this transition took and when exactly it occurred. This latest clue may be a sign of findings to come as Curiosity heads toward a region called the "sulfate-bearing unit," which is expected to have formed in an even drier environment. It represents a stark difference from lower down the mountain, where Curiosity discovered evidence of persistent freshwater lakes.

Gale Crater is the ancient remnant of a massive impact. Sediment carried by water and wind eventually filled in the crater floor, layer by layer. After the sediment hardened, wind carved the layered rock into the towering Mount Sharp, which Curiosity is climbing today. Now exposed on the mountain's slopes, each layer reveals a different era of Martian history and holds clues about the prevailing environment at the time.

A guide to Gale Crater: https://youtu.be/Q-uAz82sH-E

"We went to Gale Crater because it preserves this unique record of a changing Mars," said lead author William Rapin of Caltech. "Understanding when and how the planet's climate started evolving is a piece of another puzzle: When and how long was Mars capable of supporting microbial life at the surface?"

He and his co-authors describe salts found across a 500-foot-tall (150-meter-tall) section of sedimentary rocks called "Sutton Island," which Curiosity visited in 2017. Based on a series of mud cracks at a location named "Old Soaker," the team already knew the area had intermittent drier periods. But the Sutton Island salts suggest the water also concentrated into brine.

Typically, when a lake dries up entirely, it leaves piles of pure salt crystals behind. But the Sutton Island salts are different: For one thing, they're mineral salts, not table salt. They're also mixed with sediment, suggesting they crystallized in a wet environment - possibly just beneath evaporating shallow ponds filled with briny water.

Given that Earth and Mars were similar in their early days, Rapin speculated that Sutton Island might have resembled saline lakes on South America's Altiplano. Streams and rivers flowing from mountain ranges into this arid, high-altitude plateau lead to closed basins similar to Mars' ancient Gale Crater. Lakes on the Altiplano are heavily influenced by climate in the same way as Gale.

"During drier periods, the Altiplano lakes become shallower, and some can dry out completely," Rapin said. "The fact that they're vegetation-free even makes them look a little like Mars."

Signs of a Drying Mars

Sutton Island's salt-enriched rocks are just one clue among several the rover team is using to piece together how the Martian climate changed. Looking across the entirety of Curiosity's journey, which began in 2012, the science team sees a cycle of wet to dry across long timescales on Mars.

"As we climb Mount Sharp, we see an overall trend from a wet landscape to a drier one," said Curiosity Project Scientist Ashwin Vasavada of NASA's Jet Propulsion Laboratory in Pasadena, California. JPL leads the Mars Science Laboratory mission that Curiosity is a part of. "But that trend didn't necessarily occur in a linear fashion. More likely, it was messy, including drier periods, like what we're seeing at Sutton Island, followed by wetter periods, like what we're seeing in the 'clay-bearing unit' that Curiosity is exploring today."

Up until now, the rover has encountered lots of flat sediment layers that had been gently deposited at the bottom of a lake. Team member Chris Fedo, who specializes in the study of sedimentary layers at the University of Tennessee, noted that Curiosity is currently running across large rock structures that could have formed only in a higher-energy environment such as a windswept area or flowing streams.

Wind or flowing water piles sediment into layers that gradually incline. When they harden into rock, they become large structures similar to "Teal Ridge," which Curiosity investigated this past summer.

"Finding inclined layers represents a major change, where the landscape isn't completely underwater anymore," said Fedo. "We may have left the era of deep lakes behind."

Curiosity has already spied more inclined layers in the distant sulfate-bearing unit. The science team plans to drive there in the next couple years and investigate its many rock structures. If they formed in drier conditions that persisted for a long period, that might mean that the clay-bearing unit represents an in-between stage - a gateway to a different era in Gale Crater's watery history.

"We can't say whether we're seeing wind or river deposits yet in the clay-bearing unit, but we're comfortable saying is it's definitely not the same thing as what came before or what lies ahead," Fedo said.

News & Media Contact
Calla Cofield
Jet Propulsion Laboratory, Pasadena, Calif.
626-808-2469
calla.e.cofield@jpl.nasa.gov
2019-182

San Francisco Amateur Astronomers
PO Box 15097
San Francisco, CA 94115

Application for New or Renewing Membership

1. Memberships, with dues payment, are for one year running from the member's join or renewal date.

2. New or renewal memberships sent in via USPS mail will have membership start date based on postmark date.

3. SFAA is a 501(c)(3) nonprofit organization. Membership dues are tax-deductible, as allowed by law.

This application is for:

☐ **New**

☐ **Renewing**

Name: _____

Address: _____

_____

E-mail: _____

Phone (optional): _____

Membership Type: ☐ Individual - $25.00 ☐ Family - $30.00 ☐ Student - $10.00

☐ Supporting - $75.00 ☐ Institutional - $40.00

(All dues tax-deductible as allowed by law)

☐ **Please mail me a Mount Tamalpais Parking Permit (1 per membership)**

To complete the membership process:

A. Print and fill out this form
B. Make check or money order payable to San Francisco Amateur Astronomers
C. Mail this form and payment to:

Treasurer, SFAA
PO Box 15097
San Francisco, CA 94115

Both new and renewing members will receive a verifying email from the SFAA upon completion of the membership process.

10. APPENDIX

Mercury Transit - predicted contact times and the corresponding altitude of the Sun for a number of cities in the United States

Table 3 – USA
Local Circumstances for Transit of Mercury of 2019 Nov 11

	External Ingress h:m:s	Sun Alt °	Internal Ingress h:m:s	Sun Alt °	Greatest Transit h:m:s	Sun Alt °	Internal Egress h:m:s	Sun Alt °	External Egress h:m:s	Sun Alt °
Albany, NY	07:36:03	8	07:37:44	8	10:20:13	27	13:02:40	27	13:04:21	27
Atlanta, GA	07:36:07	5	07:37:48	5	10:20:18	31	13:02:42	38	13:04:24	38
Austin, TX	--	-	--	-	09:20:23	26	12:02:49	42	12:04:30	42
Birmingham, AL	06:36:07	3	06:37:48	4	09:20:19	30	12:02:44	38	12:04:25	38
Boise, ID	--	-	--	-	08:20:26	7	11:02:59	26	11:04:41	26
Boston, MA	07:36:03	10	07:37:44	10	10:20:12	28	13:02:38	26	13:04:20	26
Chicago, IL	06:36:05	-1	06:37:47	-0	09:20:19	23	12:02:46	30	12:04:27	30
Cincinnati, OH	07:36:06	3	07:37:47	3	10:20:17	27	13:02:44	33	13:04:25	32
Columbia, SC	07:36:06	7	07:37:48	8	10:20:16	32	13:02:41	37	13:04:22	37
Dallas, TX	--	-	--	-	09:20:23	25	12:02:49	40	12:04:30	40
Denver, CO	--	-	--	-	08:20:24	16	11:02:54	32	11:04:35	32
Des Moines, IA	--	-	--	-	09:20:21	21	12:02:49	31	12:04:30	31
Detroit, MI	07:36:05	2	07:37:46	3	10:20:17	25	13:02:44	29	13:04:25	29
El Paso, TX	--	-	--	-	09:20:26	20	12:02:54	39	12:04:35	40
Hartford, CT	07:36:03	9	07:37:44	9	10:20:12	28	13:02:39	27	13:04:20	27
Honolulu, HI	--	-	--	-	--	-	08:03:13	17	08:04:54	17
Houston, TX	--	-	--	-	09:20:22	28	12:02:47	43	12:04:29	43
Indianapolis, IN	07:36:06	1	07:37:47	2	10:20:18	25	13:02:45	32	13:04:26	32
Jackson, MS	06:36:08	1	06:37:49	1	09:20:20	29	12:02:45	40	12:04:26	40
Kansas City, MO	--	-	--	-	09:20:21	22	12:02:49	33	12:04:30	33
Lincoln, NE	--	-	--	-	09:20:22	20	12:02:50	32	12:04:32	32
Little Rock, AR	06:36:07	-1	06:37:49	-1	09:20:21	26	12:02:47	38	12:04:28	38
Los Angeles, CA	--	-	--	-	07:20:28	10	10:03:00	34	10:04:41	34
Louisville, KY	07:36:06	2	07:37:47	2	10:20:18	27	13:02:44	34	13:04:26	34
Madison, WI	--	-	--	-	09:20:19	21	12:02:47	29	12:04:28	29
Memphis, TN	07:36:07	0	07:37:48	1	10:20:20	27	13:02:46	37	13:04:27	37
Miami, FL	07:36:07	12	07:37:49	12	10:20:15	40	13:02:38	45	13:04:19	44
Minneapolis, MN	--	-	--	-	10:20:20	18	13:02:50	28	13:04:31	28
Nashville, TN	07:36:07	2	07:37:48	3	10:20:19	28	13:02:44	36	13:04:26	36
New Orleans, LA	06:36:08	2	06:37:49	2	09:20:20	31	12:02:45	42	12:04:26	42
New York, NY	07:36:04	9	07:37:45	9	10:20:13	29	13:02:39	29	13:04:20	29
Norfolk, VA	07:36:05	9	07:37:46	10	10:20:14	32	13:02:39	33	13:04:20	33
Oklahoma City, OK	--	-	--	-	09:20:23	23	12:02:50	37	12:04:31	37
Omaha, NE	--	-	--	-	09:20:22	20	12:02:50	31	12:04:31	31
Orlando, FL	07:36:07	10	07:37:48	10	10:20:16	37	13:02:39	42	13:04:20	42
Philadelphia, PA	07:36:04	9	07:37:45	9	10:20:13	29	13:02:40	30	13:04:21	30
Phoenix, AZ	--	-	--	-	08:20:27	15	11:02:57	36	11:04:38	37
Pittsburgh, PA	07:36:05	5	07:37:46	5	10:20:16	27	13:02:42	30	13:04:23	30
Portland, OR	--	-	--	-	07:20:26	2	10:03:02	22	10:04:43	22
Providence, RI	07:36:03	10	07:37:44	10	10:20:12	29	13:02:38	27	13:04:20	27
Raleigh, NC	07:36:06	8	07:37:47	9	10:20:15	32	13:02:40	35	13:04:21	35
Richmond, VA	07:36:05	8	07:37:46	9	10:20:14	31	13:02:40	33	13:04:21	33
Rochester, NY	07:36:04	5	07:37:45	6	10:20:14	26	13:02:42	27	13:04:23	27
Sacramento, CA	--	-	--	-	07:20:28	6	10:03:02	29	10:04:43	29
St. Paul, MN	--	-	--	-	10:20:20	18	13:02:49	28	13:04:31	28
St. Louis, MO	06:36:06	-1	06:37:48	-1	09:20:20	25	12:02:47	34	12:04:28	34
Salem, OR	--	-	--	-	07:20:27	2	10:03:02	22	10:04:43	23
Salt Lake City, UT	--	-	--	-	08:20:26	11	11:02:58	30	11:04:39	30
San Antonio, TX	--	-	--	-	09:20:23	27	12:02:49	43	12:04:30	43
San Diego, CA	--	-	--	-	07:20:28	12	10:02:59	35	10:04:40	36
San Francisco, CA	--	-	--	-	07:20:28	5	10:03:02	29	10:04:43	29
San Jose, CA	--	-	--	-	07:20:28	6	10:03:02	30	10:04:43	30
Seattle, WA	--	-	--	-	07:20:26	1	10:03:02	20	10:04:43	21
Toledo, OH	07:36:05	2	07:37:46	3	10:20:17	25	13:02:44	30	13:04:25	30
Topeka, KS	--	-	--	-	09:20:22	21	12:02:50	33	12:04:31	33
Tulsa, OK	--	-	--	-	09:20:22	23	12:02:49	36	12:04:30	36
Washington, DC	07:36:05	8	07:37:46	8	10:20:14	30	13:02:40	31	13:04:21	31

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Mercury Transit - predicted contact times and the corresponding altitude of the Sun for a number of cities in Canada

Table 2 – Canada
Local Circumstances for Transit of Mercury of 2019 Nov 11

	External Ingress h:m:s	Sun Alt °	Internal Ingress h:m:s	Sun Alt °	Greatest Transit h:m:s	Sun Alt °	Internal Egress h:m:s	Sun Alt °	External Egress h:m:s	Sun Alt °
Alberta										
Calgary	--	-	--	-	08:20:24	4	11:02:59	19	11:04:40	19
Edmonton	--	-	--	-	08:20:23	3	11:02:58	17	11:04:39	17
British Columbia										
Prince George	--	-	--	-	--	-	10:03:01	15	10:04:42	15
Victoria	--	-	--	-	07:20:26	-0	10:03:02	19	10:04:43	19
Manitoba										
Churchill	--	-	--	-	09:20:17	7	12:02:52	14	12:04:33	14
Winnipeg	--	-	--	-	09:20:20	13	12:02:52	23	12:04:33	23
New Brunswick										
Saint John	08:36:01	11	08:37:42	11	11:20:09	26	14:02:37	22	14:04:18	22
Newfoundland										
Gander	09:05:57	14	09:07:38	14	11:50:04	24	14:32:34	15	14:34:15	14
Saint John's	09:05:56	16	09:07:38	16	11:50:03	25	14:32:33	15	14:34:14	15
Northwest Terr.										
Inuvik	--	-	--	-	--	-	11:03:01	-0	11:04:42	-0
Yellowknife	--	-	--	-	--	-	11:02:58	9	11:04:39	9
Nova Scotia										
Halifax	08:36:00	13	08:37:42	13	11:20:08	27	14:02:36	22	14:04:17	22
Sydney	08:35:59	13	08:37:40	14	11:20:07	26	14:02:35	19	14:04:16	19
Nunavut										
Iqaluit	--	-	--	-	10:20:09	8	13:02:45	6	13:04:26	6
Ontario										
Gloucester	07:36:03	6	07:37:44	6	10:20:13	24	13:02:42	25	13:04:23	25
Hamilton	07:36:04	4	07:37:45	4	10:20:15	25	13:02:43	28	13:04:24	28
Kingston	07:36:03	6	07:37:45	6	10:20:14	25	13:02:42	26	13:04:23	26
Kitchener	07:36:04	3	07:37:45	4	10:20:16	24	13:02:43	28	13:04:24	28
London	07:36:04	3	07:37:46	3	10:20:16	25	13:02:43	28	13:04:25	28
Mississauga	07:36:04	4	07:37:45	4	10:20:15	25	13:02:43	27	13:04:24	27
Ottawa	07:36:03	5	07:37:44	6	10:20:14	24	13:02:42	25	13:04:23	25
Peterborough	07:36:04	4	07:37:45	5	10:20:15	24	13:02:42	26	13:04:24	26
St. Catharines	07:36:04	4	07:37:45	5	10:20:15	25	13:02:43	28	13:04:24	28
Saint Thomas	07:36:04	3	07:37:46	4	10:20:16	25	13:02:43	28	13:04:24	28
Sarnia	07:36:05	2	07:37:46	3	10:20:16	24	13:02:44	29	13:04:25	28
Sault Ste. Marie	07:36:04	-0	07:37:45	-0	10:20:17	20	13:02:46	25	13:04:27	25
Sudbury	07:36:03	2	07:37:45	2	10:20:16	22	13:02:44	25	13:04:25	25
Thunder Bay	--	-	--	-	10:20:18	17	13:02:48	24	13:04:30	24
Toronto	07:36:04	4	07:37:45	4	10:20:15	25	13:02:43	27	13:04:24	27
Windsor	07:36:05	2	07:37:46	3	10:20:17	25	13:02:44	29	13:04:25	29
York	07:36:04	4	07:37:45	4	10:20:15	25	13:02:43	27	13:04:24	27
Prince Edward Is.										
Charlottetown	08:36:00	12	08:37:41	12	11:20:08	26	14:02:36	20	14:04:18	20
Quebec										
Chicoutimi	07:36:01	6	07:37:42	7	10:20:11	22	13:02:41	21	13:04:22	21
Drummondville	07:36:02	7	07:37:43	7	10:20:12	25	13:02:40	24	13:04:21	23
Gatineau	07:36:03	5	07:37:44	6	10:20:13	24	13:02:42	25	13:04:23	25
Hull	07:36:03	5	07:37:44	6	10:20:14	24	13:02:42	25	13:04:23	25
Montreal	07:36:02	7	07:37:44	7	10:20:13	25	13:02:41	24	13:04:22	24
Quebec	07:36:02	7	07:37:43	7	10:20:12	24	13:02:40	22	13:04:21	22
Sainte Foy	07:36:02	7	07:37:43	7	10:20:12	24	13:02:40	22	13:04:21	22
Sherbrooke	07:36:02	8	07:37:43	8	10:20:12	25	13:02:40	24	13:04:21	24
Trois Riviares	07:36:02	7	07:37:43	7	10:20:12	24	13:02:40	23	13:04:22	23
Saskatchewan										
Regina	--	-	--	-	09:20:22	9	12:02:55	22	12:04:36	22
Saskatoon	--	-	--	-	09:20:22	7	12:02:56	20	12:04:37	20
Yukon Territory										
Dawson	--	-	--	-	--	-	10:03:03	2	10:04:44	2
Whitehorse	--	-	--	-	--	-	10:03:03	5	10:04:44	6

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