[An online publication of the Milwaukee Lunar Reclamation Society, a chapter of the Moon Society and of the National Space Society & an Outpost of the Mars Society]

OUTBOUND #26, January, 2020

Featured this month: Jupiter's moon Europa & Mercury

Europa is one of the two most unique and special "moon worlds" in our Solar System (*along with Saturn's* ***Titan*** cf. next month's Outbound)
Each possibly homes to one of the 2 most alien life forms imaginable!

Our "stand in" mechanical "robo-explorers" for each: with special eyeglasses and gloves that let us see what they see, and touch and feel what they touch and feel, etc. in both cases, ***leading to profound "redefinitions" of "life as we know it"***
The top two Biological Discoveries of the Century, ***if not of all of human history!***

Getting human crews there: Europa via Callisto

Callisto is the only major moon of Jupiter that lies safely beyond Jupiter's radiation belt. *There, a ship bound for Europa, could be covered with an ice jacket preventing Jupiter's radiation belt from reaching any human crew inside.*

NASA is apparently too timid to do ***on location science*** on Europa' crust in its rusty streaks, and instead has only considered flyby orbiting craft.

An Outpost on Europa's ice crust: Drilling into Europa's Ocean

What we would look for (anything! What lies in Earth's oceans at parallel depths?)

√ Robonauts with "hands" and "eyes" and tools to explore Europa's Ocean under its icy crust, at various depths, including the ocean floor, and possible "air pockets" here and there under the thick ice cap. If any, what kind of "air"?

√ Methods to address the difficulty of keeping shafts drilled through Europa's ocean crust from closing or imploding: *strong stainless steel tubes? Perhaps, ???????*

√ What happens to life forms in Europa's ocean if you bring them in sealed buckets to the surface for further examination? *Will we have to examine any such life forms where they are, lest they "explode" if we bring them to the surface where pressures are much much less than what they are used to?*

√ Designs for a robot-tended Laboratory that remains under Europa's crust so that we can examine life forms in their customary environment? (Bringing them to the surface might well cause any Europan life forms to explode) (More about Europa in another future article.) ##. ==========

Three other challenging possibilities

Will we ever put puppet explorers on Jupiter's innermost highly volcanic moon, Io, (as well as on Europa's ice crust and in its ocean below, as well as on Saturn's extremely cold moon Titan?

Will these "puppet" explorers send out transmissions that let us "see" and "feel" what our "rogue explorers" "see" and "feel" in these environments both "off-limits" to warm-bodied creatures like ourselves?

By then, we will may have already used "rogue explorers" to explore lava tubes on the Moon, and ice deposits in the permanently shaded areas of craters above 30° latitude on the Moon.

DO check out these size comparisons of Earth to _! in the link below.

https://www.buzzfeed.com/daves4/reexamine-your-entire-life

Do check out this link!! **It doesn't stop here**

Our entire Solar System is not even a pin prick in comparison to our distance from the nearest star, which distance is in turn is a pin prick in comparison to the size of our galaxy, which in turn is a pin prick in comparison to the size of our universe. Which is only one universe among an infinite number of universes, i.e. The "Omniverse" (*this last "verse" foreseen by Peter Kokh, way back in August, 1961*) Meanwhile, we contribute what we can to the world we live in. ##

BASALT IS THE KEY

What all can be made out of basalt:
√ cast basalt, √ carved basalt, and √ basalt fiber
will allow us to forge settlements on the Moon, and also on Mars

Dave Dietzler of the St. Louis NSS chapter sends this list of
50 items that can be made of "BASALT STUFF":

1. plates, and dishes of various sizes
2. mugs
3. tea cups
4. bowls of various sizes
5. tea and coffee pots
6. serving trays
7. pitchers
8. decanters
9. counter tops
10. kitchen sinks
11. table tops
12. table legs
13. stools
14. chairs
15. bars
16. shelves
17. bottles of various sizes
18. jugs
19. hand basins
20. toilets
21. bath tubs
22. shower stalls
23. bidettes
24. planting containers
25. flower pots of various sizes
26. vases
27. lamps
28. water pipes & sewer pipes (may require centrifugal casting & joining with cement)
29. ash trays
30. paper weights
31. candle sticks
32. shelves

33. aquaculture tanks
34. floor, ceiling and wall tiles
35. bricks
36. blocks
37. towel racks
38. clothes racks
39. shower curtain racks
40. shower curtain rings
41. shower curtains from basalt fiber
42. drapes from basalt fiber
43. cushions of woven fiber stuffed with basalt fiber
44. mattresses of woven fiber stuffed with basalt fiber
45. rugs of basalt fiber??
46. statuary cast or carved
47. doors, swinging or sliding
48. handles and knobs for metal drawers
49. picture frames
50. mirrors, thin flat slabs with evaporated on aluminum coating

small items could be cast in 3D printed permanent iron molds
large items cast in expendable sand molds bound with sodium silicate. "

Thanks, Dave! (davedietzler@att.net***)***

It is what can be made of basalt that is the key of my first two books,

A Pioneer's Guide to Living on the Moon, already published
(and why Mare Frigoris is the place to start, not the Moon's South Pole)

A Pioneer's Guide to Living on Mars, now with the editor (James Burk) (Amazon)

Then **Book 3 "A Pioneer's Guide to the rest of the Solar System"**

Do I have a 4th book in mind after this 3 volume set?

Yes, the last book I hope to write, is pardoxically, the very first I started to sketch in my mind, ***not a part of the Pioneer's Guide set,*** but (tentative title "**The Omega Factor**") something I have been working on since Late August, 1961, age 23, living in London, England at the time. **A teaser:** our immense universe is but one of an infinite (not vast, nor "innumerable" but ***an "infinite" number of universes***.

And what makes them all tick is the same, "**The Omega Factor**." Another teaser: ***our universe and everything in it, is not "***~~pushed along~~***" but "pulled along."*** That's why I say "Omega Factor" (*last letter in the Greek Alphabet*) instead of "Alpha Factor" *(first letter in the Greek Alphabet)*." (Yes, I took a 3 year course in ***ancient Greek*** in college.)

But now, 82 as of 12/11/2019, whether I live long enough to publish this one is a gamble. But Book 3 should be out shortly, and then I will concentrate on this big one. PK

How did I get to be Life Member #2 of the National Space Society?

Well, I got a letter in the mail from **Wernher von Braun** who had just founded **the National Space Institute.** It was an invitation to join, $15 a year, **$100 for life**. Von Braun was life member #1, I was interested enough (and with no debts at the time) so I sent Von Braun my $100, And when NSI and the L5 Society merged to form the National Space Society, my life membership has been honored, ever since.

[https://en.wikipedia.org/wiki/Wernher_von_Braun]

I have had hard times since, and if it were not for that $100, I would not still be an active member of the National Space Society, and a member of the NSS Board of Advisors.In the meantime, I have been a very active member. *Peter Kokh*

"Great Laker" to the Core

Ahem! *When someone asks where I live, and I say in "Milwaukee" - they say "Oh, a Midwesterner!" And I say "No<u>OOO</u>!* ***The Midwest is that area that is drained into the Mississippi, Missouri, and Ohio rivers down to the Gulf of Mexico at New Orleans.***

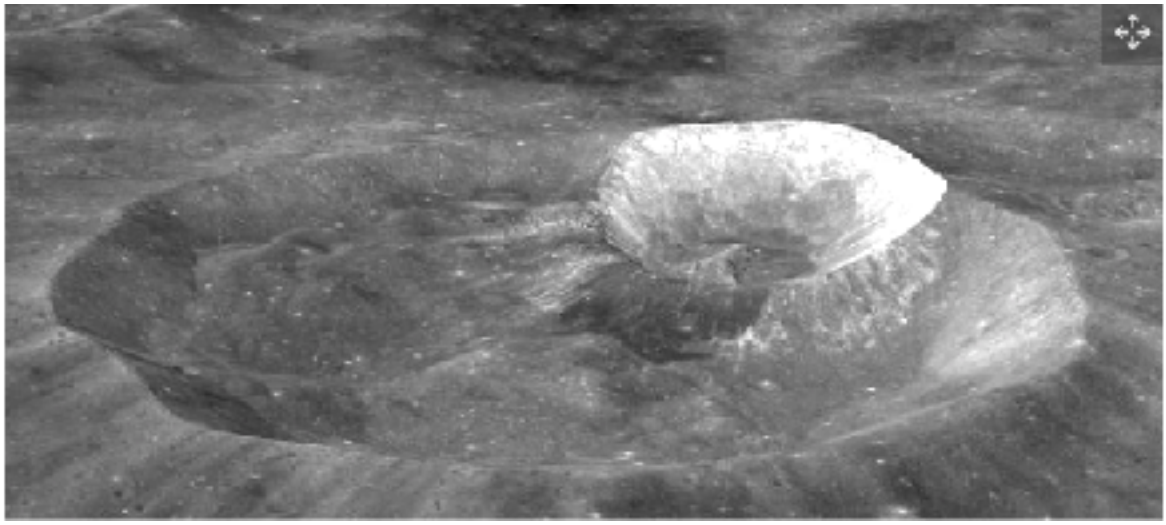
Milwaukee is on the Western shore of Lake Michigan, and all other areas that drain into the Great Lakes and down the St. Lawrence to the Atlantic, (we) <u>should have our own Area Name</u> Note: Chicago is split between the **Great Lake**s and the **MidWest.**

^ *Milwaukee is the red dot north of Chicago on Lake Michigan.*

So, I am a "<u>Great Laker</u>" and so are (some) <u>Chicagoans</u>, and those who live in <u>Detroit, Toledo, Cleveland, Erie, Buffalo</u>, etc.- *<u>not "Midwesterners</u>."* ***Add in <u>Niagara Falls, Toronto, Montreal, Trois-Rivières</u>*** *(whence my 1/4 French Canadian),* ***<u>& Quebec</u>!***

That the dictionaries and atlases haven't realized the real difference, does not make their mapping names appropriate. That my mother's maiden name Trudell is French Canadian tracing back to Trois <u>Rivières</u> on the St. Laurence River, fits in. PK

A **c r a t e r** with a crater on its edge



Wargo Crater (right), smaller and deeper, is an impact crater on the northwest edge of **Joule T Crater wider but not as deep** *on the far side of the Moon* is named for NASA's former chief exploration scientist Michael Wargo who made many contributions to exploration science in his 20-year career with NASA.

(**Our attempt at an explanation:** the wider, and relatively shallow crater was made by a heavier impactor that hit at a slower speed, while the smaller but deeper crater, was formed much later by a less massive object hitting the Moon at a much higher speed. **This pair deserves to be a "Lunar Global Park" - *PK***)
Published: February 5, 2018] The formation of Wargo crater had a big impact on its surroundings. An asteroid measuring several thousand feet in diameter slammed into the steeply sloping rim of Joule T crater (24 miles or 38 km in diameter) at hyper-velocity (3 to 12 miles per second) forming a crater over 3,000 feet (914 meters) deep. Massive amounts of instant magma crested the lower eastern rim and spread across the floor of Joule T.
The crater is named in honor of NASA's former chief exploration scientist, Michael Wargo.

You wouldn't want to have been on the scene at the time, not even on the farthest rim of the older shallower crater! (But maybe on a hovering space craft, a few hundred miles above, *and to one side!)* ##

Should "The Sun" have a Name?
What class does our Earth fall into?

It does, but we've made it a common name as we have "the Moon" (extending the use of the term "moon' (lower case), to satellites of other planets. If we were to do the same about planets discovered around other Stars by calling them "earths" small e, dropping "the.")

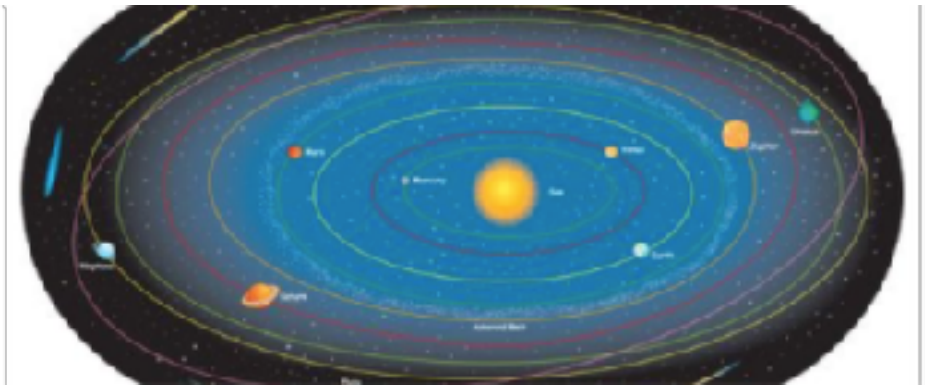
Capitalizing "the" takes care of the problem, as it does for "The Moon." (In this case, "earths" (small **e**) would mean **"earthlike worlds"** - vaguely similar in one or more of the following: √ size, √ relative distance from its sun, ***and the best definition is:***
√ A world of oceans & continents, or more simply, a world of shores, "shore worlds"?

In the past, I thought of giving Earth a name that does not mean "soil." For example - "Magellena" - after the first person to lead an expedition to circle our planet (and prove that it was round) **through its seamless Ocean** (singular), **or, we could call our seamless ocean, "Magellena,"** and refer to similar planets with both continents and oceans "**magellenoids,**" and prove that the world was round.

[Earth is our only "magellenoid" world, but someday, if we succeed in restoring Venus' ocean (combining Oxygen from the CO2 atmosphere, with Hydrogen from the solar winds to reconstitute its ocean.) cf. **"Rehabilitating" VENUS as a Human Destination"**
http://strabo.moonsociety.org/mmm/whitepapers/venus_rehabpaper.htm

A name for "*our*" "Sun"

My Choice: *lets give the Sun* ***a fitting name***, **"COPERNICA" -** named after **Copernicus, who was *first to realize that the Sun is the center of our system and that we (Earth) revolve about the Sun, not the Sun around Earth.***



I realize that few may support this christening, but that doesn't make this proposed name any the less appropriate. Nonetheless, we (the National Space Society) might gain Much Needed Publicity by promoting such an effort. We could circle a petition widely, not just in America, but world wide. And with some prominent, well known people, at the lead. If you have any ideas, contact me at **kokhmmm@aol.com** #

Jupiter's Great Red Spot has gotten smaller, but researchers say it's here to stay

Observations from the 1800s indicated that Jupiter's spot was once more than four times the diameter of Earth.

https://www.nbcnews.com/science/space/jupiter-s-great-red-spot-has-gotten-smaller-researchers-say-n1091936

November 26, 2019 ———— By Denise Chow

Jupiter isn't losing its most famous feature anytime soon.

The planet's **Great Red Spot** (**GRS**)— which appears as a prominent, flame-hued blemish on the gas giant, is ***a massive storm that has been churning on Jupiter for centuries.*** Despite observations over the past decade that suggest the storm's clouds are shrinking, researchers at the University of California, Berkeley, who have been studying the storm's behavior with computer simulations now say there is no evidence that the megastorm is dying. ***(I do remember it being significantly larger and redder!)***

I seem to remember when it was twice this size, in both height and width.

"I would take all of that with a grain of salt," said Philip Marcus, a professor of mechanical engineering at Berkeley. "We feel confident that the sky is not falling."

Marcus and his colleagues presented their research at the 72nd annual meeting of the American Physical Society's Division of Fluid Dynamics in Seattle.

http://meetings.aps.org/Meeting/DFD19/Session/L13.1

1. [During 2019 the **G**reat **R**ed **S**pot (**GRS**) of Jupiter repeatedly shed large (100,000 km2) "chunks of itself as red flakes." Rather than the GRS "dying" as reported in the popular press, we have a more benign hypothesis tested with 3D numerical simulations. There are 2 distinct boundaries of the GRS (neither of which is coincident with the boundary of its cloud cover): (1) the boundary of its **potential vorticity (PV) anomaly**, and (2) **its last "closed streamline."** An isolated vortex has nested closed streamlines, both interior to it and exterior it. The latter circumscribe the vortex. However, an anti-cyclone embedded in an anti-cyclonic zonal shear only, has exterior closed streamlines near the PV boundary.
2. Farther from its Potential Velocity boundary, it has "open streamlines" that circumscribe the planet, not the vortex. The last close streamline contains at least one stagnation point. We show that when there is large area between the last closed streamline and the PV boundary, vortices "fed" to the GRS merge with it. However, when that area is small, vortices fed to the GRS will be expelled at or near a stagnation point. Thus, our explanation of the of recent Red Flakes is *that area between the PV boundary of the GRS and its last closed streamline has shrunk." [If you can understand that jargon, you are better than me! P. Kokh*]

Question: **How deep is this Red Spot? That might be a clue!**

Outbound Editor's remarks: [Will skiing enthusiasts one day make the trip out to Jupiter to try skiing down the Great Red Spot's "flanks?" To an avid skier like myself, such a challenge seems inviting. After all, "**one only lives once!**"

Seriously, why is there this monster cyclone in one area of Jupiter and nothing like it elsewhere on Jupiter? This begs for an explanation.

Do such cyclones come and go over very long periods of time?

Is there something beneath this Great Red Spot to which the GRS is anchored?

Did some asteroid or comet hit Jupiter and became anchored at this location.

Why is such a phenomenon only in one relatively small area of Jupiter, and in one hemisphere only? I have seen no explanations.

Is it Jupiter's "eye?" Is it hiding something below?

Will NASA ever send a probe devoted to answering all these questions?

In photos taken some years ago, the GRS was notably bigger. And I suspect that this is a clue to an answer.

There does not seem to be anything similar in the other three gas giant planets: Saturn, Uranus, and Neptune. ***Did Jupiter "swallow" something? Is this its "burp?" Or is the Red Spot just "sinking slowly?"***

Is there a connection to a solid or liquid core of Jupiter below?

If you (all readers) have seen any other explanations, please send them to me at KokhMMM@aol.com - many thanks! PK] ##

https://www.nasa.gov/feature/goddard/jupiter-s-great-red-spot-a-swirling-mystery

Meanwhile, it's a great focus for a captivating Science Fiction novel, and a blockbuster movie. But, if someone offers you a round trip ticket on a mission to unravel these mysteries, don't accept it (unless it's for free! of course! *Then perhaps, you should worry!)* **"I got swallowed by Jupiter's Giant Red Spot and lived to tell about it!" "The Jovian"** might out sell **"The Martian"** LOL! ***Go for it, no need for my okay!*** ##

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From One Swirl to the Next

Recently, it was called to my attention that I had published two December 2019 issues of OUTBOUND, #24 and #25, *What can I say, other than I enjoy writing about places that I won't live long enough to visit in person?*

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Myth 1) "Mercury is too Boring"

On first hearing, the suggestion of human settlements on the planet Mercury seems nothing short of ludicrous. Virtually every astronomy or space travel textbook we have read describes the planet as utterly hostile to human life. Generally described as a slightly larger Moon, Mercury is often ignored as being either too difficult to reach, too dangerous to live on, or just too plain plain. Let the unmanned probes go there. After all, Mars is more interesting. *But that depends on just what you are interested in!*

Any reasonable concept for human expansion beyond Earth must include hum drum activities like mining, energy production, manufacturing of common and exotic items, and the transport around of people and their stuff. This will be the case wherever we go. If we are wise, those of us who truly want to see bona fide human expansion into space - as opposed to mere exploratory visits - will weave the common, mundane issues into our planning. On that basis, we will do well to consider colonization of Mercury. Mercury is one of the most energy-rich planets in the Solar System

Energy is the key to whatever we want to do in space. *Historically, we have always sought out cheaper energy sources and have experienced economic booms when they are developed as money earners.*

So it will be in space. ***On Mercury, the energy situation is analogous to taking a shower under Niagara Falls:*** we'll most likely never use all of the available energy. In fact, if energy were the only criterion of concern, we would not even bother with Mars. ***With the possible exception of geothermal energy, Mars is wantingly poor in energy sources, having only 1/20th* the solar flux available on Mercury.*** [*solar flux varies with the inverse square of the relative distance from the Sun.]

Photovoltaic and thermodynamic power systems operating in Mars orbit would still have only 45%, on average, of the solar flux to work with as is available on The Moon. Systems operating on Mars surface would have even less owing to the atmospheric effects. While would-be Mars colonists can be assured of having enough

energy with which to survive, they will always be at the bottom of the well looking up, when it comes to Mercury.

Myth 2) "Mercury is too hard to reach: On the contrary Mercury could become the Grand Central Station for trips to the Outer Planets? (Jupiter, Saturn, Uranus, Neptune, Pluto-Charon)

Why wait for a window, and then for a long slow trip, when a timely swing around Mercury could put you in such a window, as well as speeding up your trip considerably?

This was the substance of an article we wrote back in 1970s.

The Planet MERCURY and "LOCATION, LOCATION, LOCATION"

"Location" can matter, and far from being a handicap, its all in favor of Mercury's economic potential. **It is Mercury's proximity to the Sun that endows it with an energy rich environment,** as well as with a very short orbital period.

That, in turn, is the reason:

Mercury has such short intervals between arrival and launch windows with all the other worlds in the Solar System. Its location will one day make it the Grand Central station/transport hub of the Solar System.

Myth 2: "Mercury is too hard to reach"

Which brings up the first of the three great myths about Mercury that have kept it out of the limelight these many years: the myth that Mercury is just too hard to reach. To best understand the issue of flight to Mercury, it is helpful to compare it with a flight to Mars. Suppose, then, we consider two missions, one to each. Both will have a crew of four. Both use identical engines, spacecraft and other equipment to the extent the different planets allow.

Both missions leave from Low Earth orbit. For the Mars-bound craft to reach Mars' orbit from Earth's orbit requires a delta-V (change in velocity) of 2.9 km/sec. *Not bad!* Its delta-V to enter orbit around Mars will be 2.6 km/sec, total 5.5 km/sec. Also not bad.

For the Mercury-bound mission, a delta-V of 7.5 km/sec is needed to reach that planet's orbit, and another 9.6 km/sec to go into orbit around Mercury: 17.1 km/sec total. This is more than three times what is needed for the Mars mission.

However, the inference that a manned mission to Mercury will require three times as much propellant as a mission to Mars does not follow.

Using a Hohmann transfer (most economic trajectory) as a baseline for both flights, the one to Mars takes 245 days while we reach Mercury in just 105 days. That translates to a need for only 42% as much food and other consumables needed for the Mercury flight as for the one to Mars. Food would be about 0.75 kilograms per person per day. The 4 person Marsbound crew needs 736 kg, the Mercury crew just 315 kg.

If we assume a 'standard' LOX/LH2 propulsion system, it will take approximately 1.88 kg of additional propellant and spacecraft structure to deliver one kilogram of payload to Mars orbit. The same system would need three times as much propellant/ structure mass to get a kilogram of payload to Mercury.

However, in terms of actual mass in LEO needed to the respective missions,the Mercury-bound craft would be carrying considerably less payload for a given crew size. In the end, a Mercury-bound ship would require less propellant mass than the delta-V figures above would suggest. An exact figure requires an iterative process for both missions which is really beyond the scope of this study. ***Our point is that a crew of four could be delivered to Mercury using a craft (with fuel) 25% lighter than a similar one headed for Mars.*** *(Note that* ***propellant mass would be utilized as radiation shielding during solar flares in both cases.****)*

Off-loading one crew member from the Mercury mission results in a further reduction of mass required. For a 3 person Mercury craft, the weight in (low Earth) orbit is roughly the same as for a 4 person Mars craft.

The point here is that ***mission duration has an equal part in determining mission cost and energy requirements.*** A manned flight to Mercury will still require more propellant [per kg of payload] than an equivalent mission to Mars The Mercury mission could use the same technology and same Earth-LEO vehicles at cost levels only slightly more than those for Mars. ***The assumption that we could _not_ do a Mercury mission at 'reasonable cost' is wrong.***

There is more.

If both spacecraft are ***solar-powered***, ***the Mercury vehicle will have a power system (presumably a photovoltaic array) weighing much less than thirty percent of its Mars counterpart.*** **A solar array designed to generate 10 kw at Earth's distance from the Sun would be 25 sq m in area; at Mars distance from the Sun 55 sq m; but at Mercury's distance, just 4 sq. m.** Power inverter systems would be the same mass in each case, but **the net difference in system mass is significant.** Each kg of array mass must be boosted from Earth with the requisite mass of propellant as outlined above.

A Mercury craft solar array mass is 1/20th the size and mass of that for the Mars craft. This is further to the advantage of a Mercury craft.

Going to Mercury is not necessarily cheaper than going to Mars. *Our point is that the delta-V figures do not give an accurate, or even fairly approximate, picture of what a manned flight to Mercury would actually cost. Nor for that matter, do delta-V figures give any indication of whether a transportation system can be operated profitably between a given pair of planets*. Of course, all of the foregoing assumes use of chemical propulsion systems. ***Now it happens that there is an alternative that can make Mercury settlement a very practical proposition - and even reduce the cost of settling Mars in the bargain.***

Solar sails hold the prospect of being able to deliver incredibly large payloads to Mercury orbit without expending massive amounts of expensive propellant.

Solar sails have numerous advantages *over any chemical system, including nuclear systems.* ***They are relatively low maintenance, completely reusable, totally insensitive to plane-change requirements and the usual launch window constraints, extremely flexible in their payload capacity and pose no risk to crews from either explosions or radiation exposure.***

A single Ares launch vehicle can deploy a solar sail 25 square kilometers in area, large enough to deliver a 400 metric tonne payload to Mercury in just 600 days. Three such payloads could be launched every year if need be. ***There is no chemical technology that can begin to approach this capability for any planet.***

In reality, there is no real likelihood of such massive payloads being sent anywhere. The Ares vehicle mentioned is designed to launch something like 150 metric tonnes to LEO. It would require at least three such launches thoroughly equal 400 tonnes. There is an argument that this is not particularly cost efficient.

With solar sails, the issue is more about how fast do we want to get our payload to Mercury. If solar sails have an Achilles' heal, it is that they can take a comparatively excessive amount of time to build up the velocities needed to reach Mercury. Ironically, and this is good news, ***riding a solar sail back from Mercury is a lot easier and faster, owing to its proximity to the Sun.*** As a transportation system comprised of several sails, more or less constantly in transit, the average payload could be reduced in size to enable faster transfers. ***Entire round trips lasting less than a year are easily achievable.***

Myth 3: "Mercury is too dangerous to live on"

Radiation on Mercury is considerably more severe than on the Moon or Mars Depending on its orbital position, ***Mercury can receive anywhere from six to ten times the radiation flux encountered on the Moon.*** By implication, that means people would build up radiation-induced damage at a proportionally greater rate. This in turn means ***a crew on Mercury would need much more radiation shielding to reduce dosage levels to a particular point than on the Moon.*** It also means that ***the crew could not be exposed to natural radiation levels on Mercury for as long as a lunar crew.*** But just how long could they go unprotected before accumulating a career limit dose?

There is remarkably little direct information on ionizing radiation effects on Mercury. Most writers on the subject tend to focus on thermal radiation and do not consider that ionizing radiation, by itself, is a hazard because of the damage it causes on the cellular level. ***Mercury's extreme heat would destroy any unprotected living tissue very rapidly; in mere minutes.*** Ionizing radiation, on the other hand, destroys by overwhelming the body's ability to repair itself. This takes a bit longer.

Excluding intense solar flares, calculations indicate that a crew could work on Mercury's surface for at least five weeks with only their spacecraft or their space suits

for protection. At that point, they would need to be under shielding -- as much as 15 meters of shielding, if it is composed only of Mercury regolith. **Five weeks is more than enough time for an experienced, well - equipped crew to build a small base under adequate shielding.** Training such a crew on the Moon prior to Mercury would be logical and beneficial.

To clarify ***the five-week limit,*** that would be ***the length of time it would take the crew to receive a cumulative dosage that would cause a substantial increase in their likelihood of developing life- threatening cancers. <u>It does NOT mean "five weeks and they are dead."</u>***

There are some estimates that go as low as only two days (but do not specify the level of protection needed) and others that go up to ten weeks. Uncertainty remains and this is the subject of more study. **<u>What is clear is that a crew would have a window of time to establish adequate shielding</u>.**

For a crew of four people with just two days working simultaneously, this works out to a total of 192 man-hours or 8 man-days - in which to get an initial base built. The more likely scenario is that only half that time would be productive. This still leaves ***four man-days of actual productive time to deploy the shielding: a worst case scenario that might not pass NASA safety rules.***

Material resources on Mercury are known to include all the same base elements found on the Moon: Silicon, oxygen, iron, aluminum, titanium, sulfur, calcium, potassium, and magnesium have all been identified as constituents of minerals that remain stable in Mercury's thermal environment. We do not yet know the exact details of abundances or distributions ***What we have learned has been gathered from interplanetary distances using spectrographic analysis. This implies the resources mentioned above must be in substantial supply if they can be detected from such a great distance.***

Importantly, hydrogen is also a proven resource on Mercury. We know that hydrogen is available as a constituent in Mercury's atmosphere from both space craft observation and spectrographic analysis. ***Properly described as an exosphere, the abundance of hydrogen there is paltry by almost any standard. Still, it is a constant supply as it is derived from solar wind sources and is available over the plate's entire surface. Superconducting ion 'scoops' deployed over large areas and running constantly can collect substantial quantities of hydrogen. Liquefying the hydrogen is an energy intensive proposition, but Mercury has the energy.***

The importance of this ***hydrogen***, diffuse as it is, cannot be overstated. First it means that ***people on Mercury are assured a self-sustaining source of water, even if the data indicating water ice at the poles is wrong. And it assures the ability to provide hydrogen fuel for flight into Mercury orbit, and, eventually, into interplanetary trajectories, favorably altering the economics of flight to / from Mercury in a big way.***

But Mercury rotates so slow that a day on Mercury is a month's long!

Mercury's day night cycle is (one full day-night cycle) equals 176 Earth days—just over two 88-day long years on Mercury. Mercury's axis of rotation is tilted just 2 degrees with respect to the plane of its orbit around the Sun. That means it spins nearly perfectly upright and so does not experience seasons like many other planets do.

One thing I learned from my mother is that ***"if you look at something and only see disadvantages, you are looking at it wrong!"***

"The Sunrise Express"

And indeed, we could build railroad tracks around Mercury's equator, and put a "moving settlement" (engine and a chain of passenger cars, including kitchen etc.) and keep running about 60 miles per hour = 96 kph) and you could follow the pace of the night/day line and easily keep the cars' interiors at "room temperature." There could be a second train also, "The Sunset Express."

This pace would allow some give and take: go a little faster, and you could stop the train to walk around or look at something interesting.

North Polar Ice and an lava tube entrance

A significant feature of Mercury is that its axis is perpendicular to its orbit, not offset as on Earth and Mars. This means there are no "seasons" on Mercury. ***At any given location, Mercury's "weather" is always the same.***

A moving outpost is not the only option. Near Mercury's North Pole, NASA found a cave entrance, most likely a lavatube entrance, as well as ice, and we would make that the first outpost on Mercury (in addition to the night/day terminator train.) ##

Why hotter Mercury may have polar ice while the colder Moon may have little

AVAILABILITY: It is quite clear that fewer comets intrude into the deeper regions of the Sun's gravity well where Mercury orbits than visit the orbit of the Earth-Moon system.

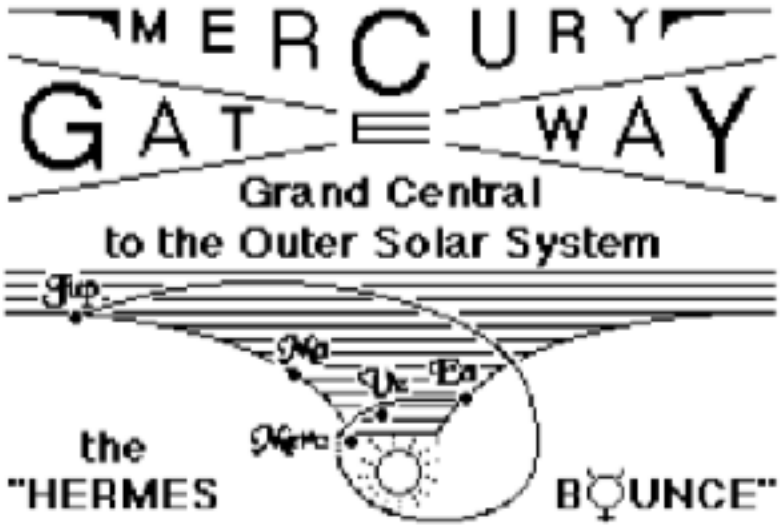
HOWEVER: ***Mercury may be much more effective in snaring approaching comets than the Moon.*** Mercury's mass is 5 times that of the Moon. Further, **its deeper gravity well** presents a much greater "cross section" expressed as an angular fraction of its orbit, in fact *a "target" comparable to Earth's, some thirteen times as great as that of the Moon*.

FURTHER: Two factors work together to make Mercury much more efficient in holding on to cometary volatiles.

✓ Mercury's gravity is 2.3 times that of the Moon.

✓ Its sunset to sunrise "nightspan" period is more than 6 times longer than the Moon's, giving volatiles released by comet impacts that much more time to migrate to the polar permashade cold traps.

Opening Mercury could lead to faster trips (with longer windows) from Earth/Moon to the outer planets.



For Science Fiction, there has never been a problem with opening up the outer Solar System. “Simply” a matter of inventing faster rockets, atomic ones probably. In fact, Mars represents the limit of “doability” of chemical rockets for crewed expeditions.

No plausible improvements will extend this margin in any practical sense. Chemical rockets cannot carry enough fuel to take expedition-sized payloads much further. More, maximum efficiency travel times in Hohmann transfer orbits (without which chemical rockets could not even take crews to Mars) mean many months in space and unwelcome total exposure to solar flares and cosmic radiation.

Nuclear rockets are still largely on the drawing boards, but promise faster trips to Mars, doable trips to the Main Asteroid Belt. But even for them, trips to outer planets may be unacceptably long, ... and infrequent. For any vehicle must await proper planetary orbital alignments - the “window. ”Some Trip Window Frequencies (bidirectional) and average Hohmann travel times (both in 30 day months)

between		window travel frequency	time
Earth/Moon	**Mercury**	**3.45**	**3.51**
Earth/Moon	Mars	25.87	8.63
Mercury	Mars	3.36	5.6
Earth/Moon	Ceres	3.09	12.01
Earth/Moon	Jupiter	13.30	33.27
Mars.	Jupiter	27.21	37.56
Ceres.	Jupiter	91.81.	48.43
Mercury	**Jupiter**	**2.99.**	**28.36**

Earth/Moon	Saturn	12.60.	73.65
Mars	Saturn	24.46.	79.20
Ceres	Saturn	66.56	92.96
Jupiter	Saturn	241.9.	121.8
Mercury	**Saturn**	**2.96**	**67.33**

Similar results for Uranus, Neptune, and Pluto-Charon

And this does not involve human outposts on Mercury, although there probably will be. We could harness solar power that much closer to the Sun and further boost the speed of ships outbound to Mars and beyond. Anyone who studies this list should quickly get the idea, that, Delta V and fuel cost aside, The quickest way to get from anywhere to anywhere else in the Solar System might be to "detour" via Mercury.

What about alignments? So what if you get to Mercury and have just missed a window to Jupiter. Another will open up in just 3 months, an insignificant delay parked in Mercury orbit.

Ah, but Delta V and fuel cost do matter, you say! My point is that ***much of the extra Delta V needed to do the detour by way of Mercury can be managed by free deceleration into orbit around Mercury, and free acceleration into a trans destination trajectory*** **— free courtesy of giant solar lasers in orbit about Mercury.**

In going to Mars or Ceres this presents a problem. The Mercury-boosted ship will arrive with a great deal of excess momentum. This will require a lot of fuel to shed. **But ships going out to any of the moons around any of the Outer System gas giants, can shed that excess momentum free in an aerobrake maneuver through the upper atmosphere of the gas giant (Jupiter, Saturn, Uranus, Neptune).**

In fact, the only Delta V that need be provided for by fuel carried on board is that for the boost in toward Mercury, and the landing fuel at the destination moon that would be the same in either case. The benefits would be astounding.

"LEAVE ANYTIME & GET THERE MUCH MUCH SOONER VIA MERCURY"

Building such a giant laser facility near Mercury would be something for a "United Planets" government. It would establish a transportation infrastructure that will open the gates of human expansion into the Outer System, √ in search of energy (e.g. Helium-3 from Uranus), √ the ultimate in tourist experiences (Saturn's rings), raw materials for terraforming (water, hydrogen, nitrogen, carbon), and exploratory knowhow.

Because ships arriving at Mercury will have to wait up to 3 plus months for a reboost to their destination, there will be a major service market in orbit about the planet. This will include √ ship repairs (engines, environmental systems, bio-sphere systems), √ warehousing, √ trading, √ transshipments, √ health care, √ entertainment and √ diversion, √ surface excursions and stays, even √ continuing education courses. And ***all the more interesting things that are usually found in wide open international marketplaces.***

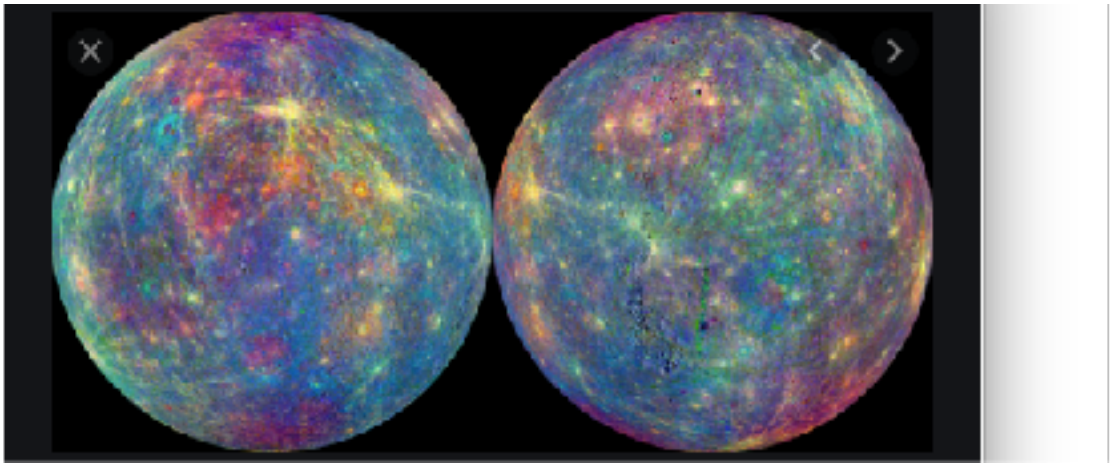
"**<u>Mercury Gateway</u>" could over time grow to become the nerve center, financial center, trading center, even the political center of the Solar System.**

Yes it's hot!, Yes it's dry! Yes it's barren! But so what! ***Mercury's location deep down the throat of the Sun's gravity well and its location in very bright space (averaging seven times as much light and heat from the Sun as reaches Earth/Moon) — these are the real estate pluses that will make this unsuspected oasis in the solar desert bloom and boom.***

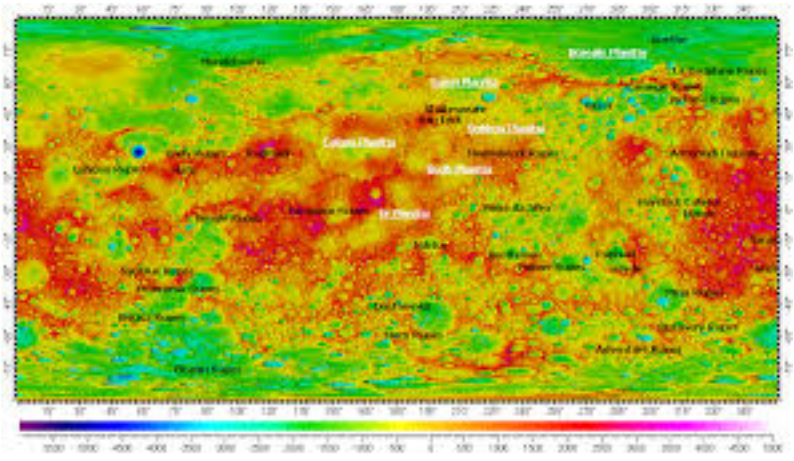
First, of course, **nuclear rockets will have to come on line, and mature.**

Next, **economic motives must surface that would drive the expansion of the human economy into the Outer Solar System**.

Finally, some taxing authority has to build the necessary facilities in Mercury orbit. Then this "god of speed" will be not only speedy himself, but impart some of that swiftness to us mortals and our "**Quicksilver Fleet**"

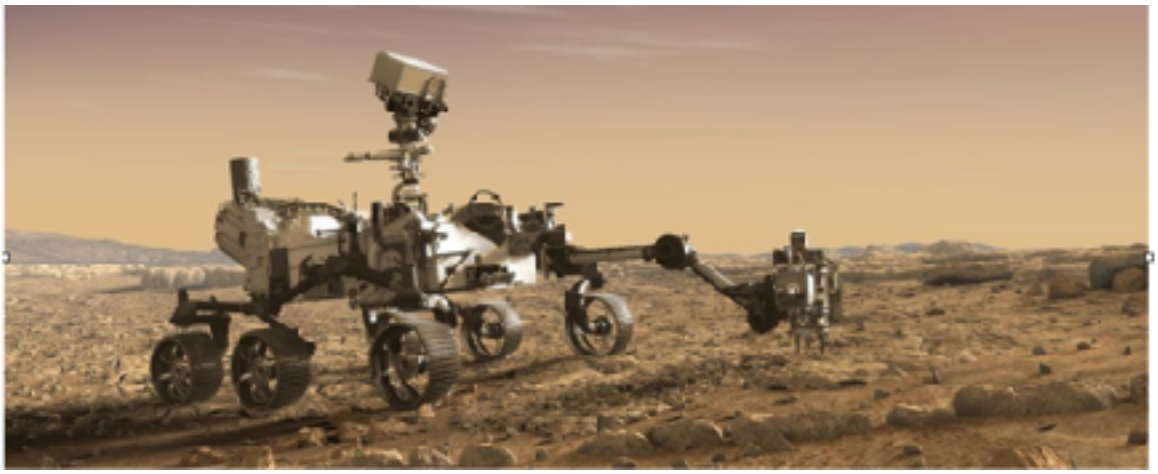


In between the Moon and Mars in size



"Via Mercury"- it's a detour that makes sense! PK

How NASA's next 2020 Mars Rover will Search for Life



https://www.space.com/mars-2020-rover-alien-life-hunt.html

The strategy involves matching geochemistry with structure.

Spotting signs of long-dead life is a tall order for a lonely robot on a faraway world, but NASA's next Mars rover should be up to the challenge, mission team members said.

NASA's 2020 Mars rover is scheduled to launch next summer and touch down in February 2021 inside the Red Planet's 28-mile-wide (45 kilometers) Jezero Crater, ***which scientists think hosted a lake and river delta in the ancient past.***

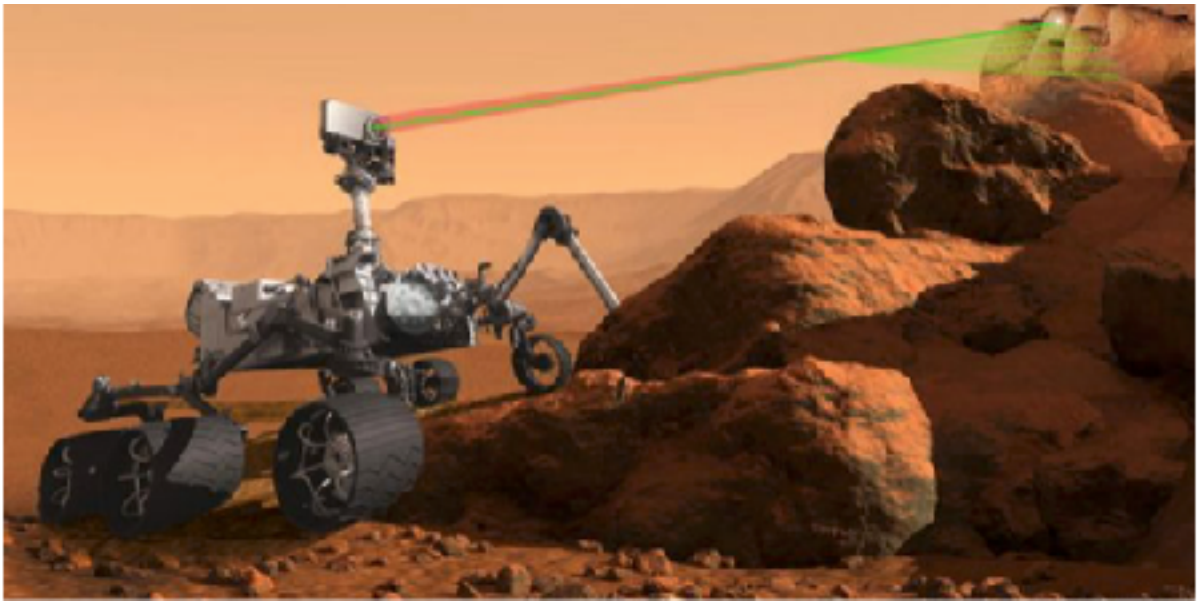
The six-wheeled robot will then scour the area for potential biosignatures. This work will consist of observing Jezero rocks in fine textural detail and using several spectrometers to map geochemistry precisely onto that texture, Mars 2020 deputy project scientist Katie Stack Morgan told reporters today (Dec. 10) here at the annual fall meeting of the American Geophysical Union (AGU).

Related: NASA's Mars Rover 2020 Mission in Pictures

https://www.space.com/21900-nasa-mars-rover-2020-images.html

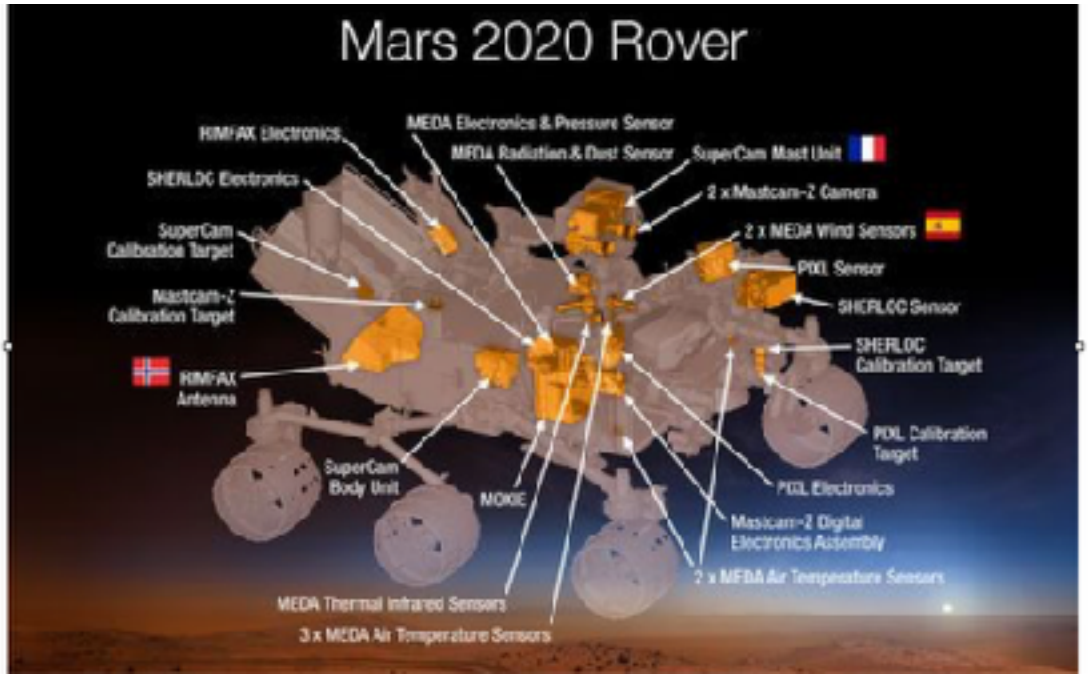
"It's our understanding of biosignatures in the rock record that it's that combination — texture and mapping of composition — that really allows you to build a strong case for a biosignature," said Stack Morgan, who's based at NASA's Jet Propulsion Laboratory (JPL) in Pasadena, California. "So, we are very much hoping that, with our payload, we can make a very strong case that there are biosignatures on the surface of Mars," should any exist, she added.

The new rover will carry more sophisticated, upgraded hardware and new instruments to conduct geological assessments of the rover's landing site, determine the potential habitability of the current environment, and directly search for signs of ancient Martian life — something no previous Mars mission has done.



This artist's illustration shows how NASA's Mars 2020 rover will use Supercam, a laser instrument that can provide imaging, chemical composition analysis, and mineralogy.

2020 can't come fast enough! This artist's illustration shows how NASA's Mars 2020 rover will use Supercam, a laser instrument that can provide imaging, chemical composition analysis, and mineralogy. ##



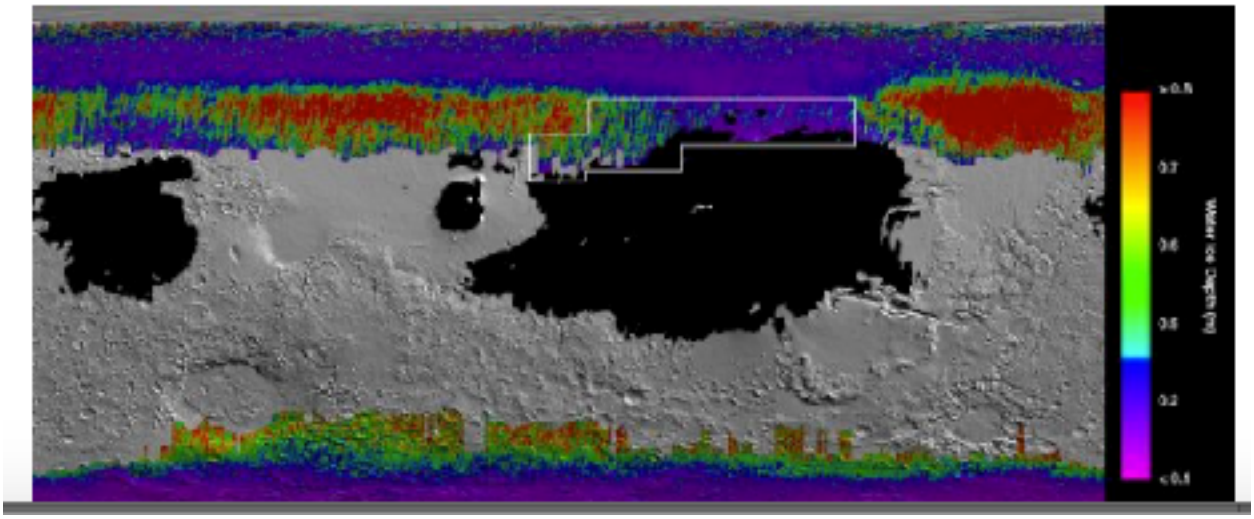
Let's wish this rover Great Success!
What it finds may alter our plans for human settlement,
as to <u>where on Mars</u>, and <u>with what resources</u>, ##

https://www.space.com/mars-water-ice-map.html

NASA's "Treasure Map" of Water Ice on Mars Shows Where Humans Should Land

The annotated area in this animation of the Red Planet is where NASA spacecraft have found near surface water ice that would be easy for astronauts to dig up. (image: NAS/JPL-Caltech)

NASA's wish is to follow the water on Mars just got a helping hand. Scientists have released a new global map showing water ice that is as little a 1 inch (2.5 cm) below Mars' surface.



[This map shows where the underground water ice is located on Mars. Cool colors (blue) represent water ice that is closer to the surface than the areas in warm colors (red), and black zones indicate areas where a visiting spacecraft would sink into fine dust on the surface. ***The area outlined in white represents the ideal region to send astronauts for them to dig up water ice.*** [Unfortunately, this map is difficult to line up with a map based on altitude. Nor a map showing areas where buried glaciers have been found. *Editor]*

The new map is based on data from two long-running spacecraft: NASA's **Mars Reconnaissance Orbiter** and **Mars Odyssey**. Each spacecraft used heat-sensitive instruments to find the ice, because buried ice changes the temperature of the surface. To be sure that it was ice they were seeing the scientists cross-referenced their work with other data — like ice seen in radar instruments and Mars odyssey's gamma-ray spectrometer, which is optimized for spotting water ice deposits.

The surface of Mars is a desert: water is scarce. That's because liquid water evaporates quickly in Mars' thin atmosphere. There have been reports of briny water flowing on crater walls, but **those "streams" are more likely dry dust flows.** Notably, there is **plenty of water ice locked up in Mars' polar caps**. But would not be a viable

solution for a lengthy mission because it would be too cold and dark ash the poles for a good part of the year.

Water did flow on Mars'surface in the ancient past, but that was because the atmosphere was much thicker back then. *The leading theory is that the Sun's particles gradually eroded the Martian atmosphere over the eons [billions of years] until the atmosphere was so thin that it could not support running water anymore*.

A paper based on the research was published December 10, 2019 in the journal **Geophysical Research Letters: Mars May Have Lots of Water Deep Underground**

https://www.space.com/mars-deep-groundwater-recurring-slope-lineae.html

Gigantic Ice Slab Found on Mars Just Below the Planet's Surface

https://www.space.com/30502-mars-giant-ice-sheet-discovery-mro.htmlsaASA

Mars Mystery: How Was Ancient Red Planet Warm Enough for Liquid Water?

https://www.space.com/35595-ancient-mars-atmosphere-liquid-water-mystery.html

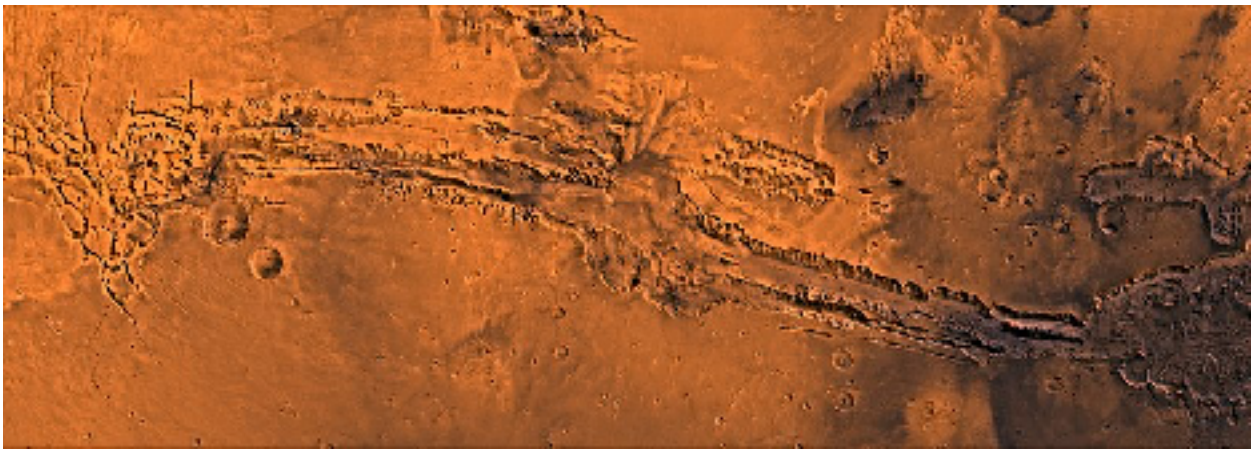
With data in hand, the research team located at least one promising landing spot for future astronaut missions: a big zone in the northern hemisphere's **Arcadia Planitia.** This area has a lot of glacial water ice close to the surface and is in the ideal location for a human Mars mission, because it is in a temperate, midlatitude region with plenty of sunlight, the research team wrote in a new study describing the findings.

And **Olympus Mons**, Mars' largest Volcano to the SSE of Arcadia, (now quiet but whose flanks are solid basalt. As we have stated before, ***"basalt and water" will be the foundation of a Martian frontier economy.***

A mission to this "Gigantic Ice Slab" is in order.

(A similar "buried glacier" has been found in Hellas planitia, the deepest basin on Mars, thus with the highest air pressure, and so where we will first learn to fly on Mars, and with a high basalt area to the NNE of this basin.)

To these two anchors of early Mars Settlement, we have another prize, one guaranteed to draw visitors from Earth as well as settlers "on vacation," Valles Marineris, Mars Super Canyon, some 3,000 miles long, very deep, and with many branches, that will be the #1 draw, both for Mars settlers "on vacation" and for visitors from Earth, many of whom may choose to make Mars heir home. ##



AURORAs are common in Mars Atmosphere

Mars now appears a much more beautiful place to settle!!!

But also showing that Mars' atmosphere is slowly wiping off into space.

[Editor: a case of "the good, the bad, and the ugly"]

A newly published study, to be presented Dec. 12 at the American Geophysical Union (AGU) meeting, reveals that a type of Martian aurora **originally detected** by NASA's MAVEN spacecraft is in fact the most common aurora on the Red Planet, Embry-Riddle Aeronautical University researchers said.

The study, co-authored by scientists at the University of Colorado Boulder's Laboratory for Atmospheric and Space Physics (LASP) and funded by the **MAVEN (Mars Atmosphere and Volatile EvolutioN) mission**, also suggests a way to track water loss and better understand how the Martian climate has changed over time.

Unlike the brilliantly colored auroras that dance across the night sky near the Earth's polar regions, the most common aurora on Mars is a dayside phenomenon called a proton aurora, explained Embry-Riddle Ph.D. candidate Andréa Hughes, lead author of a paper to be in the *Journal of Geophysical Research, Space Physics*.

Proton auroras on Mars form when the solar wind streams toward the massive hydrogen cloud around Mars. Positively charged protons get neutralized by grabbing electrons from hydrogen atoms. ***These energetic, fast-moving atoms interact with molecules in the lower atmosphere, emit ultraviolet light, making a proton aurora***.

"Observations of proton auroras at Mars provide a unique perspective of hydrogen and, therefore, water loss from the planet," co-author Dr. Edwin Mierkiewicz of Embry-Riddle said. "Through this research, we can gain ***a deeper understanding of the sun's interactions with the upper atmosphere of Mars and with similar bodies in our (solar system), or in another solar system, that lack a global magnetic field."***

The researchers found that ***proton auroras on Mars are more frequent and intense when levels of hydrogen escaping into the atmosphere were highest.*** In addition, co-author Mike Chaffin of the University of Colorado Boulder said, "the team spotted ***many more proton auroras on the dayside of Mars during the hot, dusty southern summer season, when Mars is closer to the sun."*** Proton auroras were ***spotted in 14 percent of all dayside observations*** in the dataset, ***and in more than 80 percent of dayside southern summer observations. [where the planet's deepest basin, Hellas, lies.***

Swirling dust and higher temperatures during the Martian southern summer cause water vapor to be lofted to high altitudes, where the sun's extreme ultraviolet light can split the water into hydrogen and oxygen. Because hydrogen is lightweight, it filters to the top of the Martian atmosphere and enriches the planet's surrounding hydrogen cloud, or corona. This "puffed up" hydrogen corona can more easily escape the planet and interact with incoming solar wind protons, producing more proton auroras during this season.##