SPACE ODYSSEY

‘Red Seas’ of Mars: discovery of multiple ‘salt lakes’ shifts frontiers of planetary science

By Tiara Walters • 28 September 2020

Beneath the Martian south pole lurks a network of liquid-water bodies, hailed as a breakthrough insight into our sister world – and maybe even life beyond Earth.
A large web featuring a liquid lake and associated wet “patches”, potentially brimming with brine, has been detected several hundred metres below the south pole of Mars.

Speaking to *Daily Maverick*, world experts have hailed this discovery as “very compelling” and “exciting”, suggesting it might help direct the search for extraterrestrial life towards the Red Planet’s polar subsurface.

Radar research in 2018 by the same authors indicated a subglacial lake below the Martian south pole – a thick ice cap formed by layers of ice and dust. Native to the austral region known as Ultimi Scopuli, the subglacial lake was thought to be the first-ever stable body of liquid water encountered on Earth’s cold and hellishly dry twin.

But this attempt, though significant, left big questions unanswered. Was this a once-in-a-lifetime find? Caused, perhaps, by extraordinary circumstance? Or were there, indeed, liquid patches to be dived into elsewhere?

“The discovery of multiple lakes answers that question, showing that subglacial liquid water may be common,” lead author Prof Elena Pettinelli told *Daily Maverick*. 
Published in *Nature Astronomy* this week, the Roma Tre University-led study (https://www.nature.com/articles/s41550-020-1200-6) describes a 20km x 30km area of potent reflectivity, located some 1.5km below the Martian south pole.

*The bombshell detection of a stable patchwork of liquid-water bodies tips our knowledge of Mars into new and exciting territory*

It was detected aboard the European Space Agency’s *Mars Express* by the Italian Marsis (https://www.britannica.com/topic/Mars-Express) radar sounder through data collected over the past decade. Using bursts of radio waves to image buried geological structures, the instrument pulsed signals back from the Martian subsurface and ionosphere.

“We’re as confident as we can be,” beamed Pettinelli, an expert on the inner life of planetary structures and other solar-system bodies.

“We’ve examined every possible alternative interpretation of our data, but the only explanation consistent with the data is that the strong reflections observed by the radar come from distinct liquid bodies of water,” she says.

Liquid water on the Martian surface is an ephemeral thing, Pettinelli points out. It is “lost in space” as soon as it emerges on the hyper-arid planet’s surface — regardless of its origin. It can literally vanish from one spacecraft orbit to the next.

“These lakes are presently protected from escaping into space by the overlying ice,” she says. “The fact that we’re able to clearly detect the water in the same position over periods of years, tells us these lakes are long-term features in this region of Mars.”

The bombshell detection of a stable patchwork of liquid-water bodies tips our knowledge of Mars into new and exciting territory, according to Pettinelli and other experts interviewed for this report.

“This forces us to consider global processes of formation and stabilisation of the liquid water, which are essential pieces of the puzzle for our understanding of the past and present climate, geology and possible habitability conditions on Mars,” says Pettinelli.

The potentially salty nature of the “lakes”, however, means radio waves cannot penetrate below their surface, rendering it impossible to use this technique to measure actual depth.

**Liquid, liquid everywhere, perhaps a drop for life**
Back on Earth, satellite techniques have been employed to detect subglacial lakes in Antarctica and Greenland. In Antarctica, an icy nexus has even been explored in recent years, yielding results that rewrite the encyclopaedia of microbes.

Co-lead author Dr Sebastian Emanuel Lauro (also of Roma Tre University), Pettinelli and their colleagues applied these same techniques to further probe the Marsis data.

Zooming in on an ambitious area of $250\text{km} \times 300\text{km}^2$ in Ultimi Scopuli, the researchers managed to identify certain areas as “strips of dry material” – these, in turn, separated a filigree of smaller water patches from the main body.

“We acquired new data, achieving unprecedented radar coverage over the study area,” says Pettinelli. “We used a new method of analysis of the complete Marsis dataset, based on signal-processing procedures usually applied to terrestrial polar ice sheets.”

Through picking up possible signatures of highly concentrated salts, the paper suggests that Ultimi Scopuli’s subglacial waters are made of perchlorate brines, a hypersaline solution.

This may explain the intriguing quality of the liquid water, which retains its fluidity despite its position beneath the freezing south pole – estimated to harbour a mean temperature of $-110^\circ\text{C}$.

In an interview with *Daily Maverick*, NASA’s Dr Chris McKay said that the study’s overall findings “confirm and extend the initial discovery”.

McKay was not part of the research, but is actively involved in planning for future Mars missions, including human exploration. He is a world authority on the origin of life, the evolution of the solar system and terraforming the Red Planet.

“An interesting aspect of this paper is the suggestion that the salty water may be in some sort of metastable state,” he says. In other words, the paper “sketches out a possibility that these very cold salt solutions could be supercooled. It’s known that regular water can supercool to below the freezing point”.

The hypersaline solution is called “metastable” because it can “survive for geologically significant periods”, says Pettinelli.

“Eventually it will turn to ice, but that could take a long time unless there is a suitable nucleating agent,” adds McKay.
Much of the rest of Mars’ water may be trapped in the mantle and frozen into the ice caps themselves, yet the hypersalinity hypothesis would be consistent with perchlorate brines previously spotted on the surface of the planet.

If life on Earth has taught us anything, it’s that, where you find liquid water, you generally find life.

This is “just speculation”, McKay stresses, while other researchers have maintained the Italian-discovered lake could have been created by heat effects such as magmatic activity.

“There is no direct evidence”, says McKay, that the subglacial lake system is, indeed, hypersaline.

“But it would be interesting if it was.”

Let’s say it was – would this mean we’re not alone?

The Italian study comes in the immediate wake of an international consortium claiming to have found a spectral signature on Venus normally belched out by microbial life on Earth. The announcement sent a clamour through global media and parts of the planetary-science community.

That spectral signature may be phosphine, present in the upper cloud decks of Venus at 20 parts per billion – but here is the thing. That study admits the phosphine markers are not “robust” evidence for life, “only for anomalous and unexplained chemistry” that may be resolved by visiting the Venusian atmosphere.

As poetic as the idea of tiny sun-powered aliens drifting about the clouds of Venus is, the evidence suggests that liquid water is still the holy grail of solar-system exploration.

“If life on Earth has taught us anything, it’s that, where you find liquid water, you generally find life,” Dr Kevin Hand of NASA’s Ocean Worlds Lab – which devotes itself to combing our universal neighbourhood for signs of life – told this reporter during his 2014 visit to South Africa.

The planetary scientist and astrobiologist said that Mars is a “wonderful, wonderful place to look for evidence of life as preserved in the rock record”.

Billions of years ago, he said, Mars likely weathered tumultuous climatic changes and may have had oceans, lakes and rivers.
“The conditions on Mars may have been such that life could have arisen and thrived on the surface,” he added.

Hand is also the author of a book, *Alien Oceans* (https://press.princeton.edu/books/hardcover/9780691179513/alien-oceans), released this year, which tracks the “epic quest to find life” on the outer solar system’s “water-rich moons”.

“Finding life beyond Earth would, I believe, initiate a revolution in biology, especially if we can find living life where we can examine its fundamental biochemistry,” he said.

“What makes it tick? Is it based on DNA and RNA, or is there some other game in town? And if there is some other way to get the business of life done, that opens a whole new window into this process we call life,” Hand argued.

This is why the Italian study’s suggestion of hypersaline, subpolar water is tantalising, because it provides more than a theory to illuminate the behaviour of liquids below a vast cap of ice.

The “possibility of extended hypersaline water bodies”, according to the study, is “particularly exciting because of the potential for the existence of microbial life”, such as extremophiles, anaerobes (organisms that don’t need oxygen for respiration) or even aerobes (oxygen-loving life).

**‘The microbial world has few limits’**

Reaction from within the scientific community was optimistic about the Martian subglacial network’s potential as a refuge for life.

> “I wasn’t that surprised to find liquid-water lakes, but I was very surprised to find a high microbial biomass – the microbial world indeed has few limits” – Priscu

“Decades from now humans may look back on these data as key steps in our search for life on Mars,” says Prof Bruce Bassett, a research astronomer at the South African Astronomical Observatory.

“It is a great example of science in action, moving from the first exciting breakthrough, through progressively clearer and clearer pictures and understanding.”
Following some 40 years probing frozen realms, the subglacial ecologist Prof John Priscu describes himself as an “eternal optimist on the presence of liquid water and associated life beneath ice sheets beyond Earth”.

His research has ranged from the caverns of Antarctica to the subsurface of Mars, and his efforts have taken us one step closer towards understanding how life may blossom in extreme places.

Priscu, a regents professor with Montana State University in the US, in 2013 led the team who drilled through 800m of West Antarctic ice to reach the frigid depths of Lake Whillans, part of a drainage network of 400 lakes in the continent’s bowels.

After Priscu and his team winched up the Whillans samples, they showed that the thousands of microbe species from that cavernous sphere may not have seen sunlight in tens of thousands, even a million, years. Theirs was a transformative effort – the first to hunt down life subsisting beneath Antarctica’s subglacial lakes, and a throbbing ecosystem at that.

“I wasn’t that surprised to find liquid-water lakes, but I was very surprised to find a high microbial biomass – the microbial world indeed has few limits,” he told Daily Maverick.

Priscu subsequently uncovered a thriving microbe community in nearby Lake Mercer. (Recently researchers revived aerobic bacteria from 100-million-year-old sludge off New Zealand’s coast.)

He investigated the Martian subsurface himself in a co-published 2007 paper for the journal *Astrobiology.*

Except for the right kind of liquid water, “all of the ingredients were there” – and now Priscu says the Italian study’s “deep brine pool may be the link to subsurface life-support on Mars”.

For him, the findings are “compelling” — an “important framework” in our search for life on our solar-system neighbour.

“*These results do indicate,*” McKay says, “*that the subsurface of Mars still holds surprises for us.*”

“As I have written in a number of papers on subglacial lakes beneath the Antarctic ice sheet, we would be in denial if we thought there was no liquid water beneath the ice caps on Mars,” he says. “As we continue to put together the puzzle of life on Mars, I’m optimistic we’ll
eventually find a subglacial ecosystem that supports microbial life there, much as we have seen on Earth.”

NASA’s McKay, however, is matter-of-fact about the paper’s suggestions of briny extraterrestrial organisms that may survive on Mars.

“With respect to biology, the salty solutions discussed in the paper are too salty for life,” he cautions. “In technical terms, the water activity is about 0.3 – well below the limit for any life on Earth, which is about 0.6 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4156692/).”

That is if the hypersaline solution sloshing in a liquid lake hundreds of metres below the Martian south pole one day proves to be just that.

Pettinelli argues that hypersaline environments, like Utah’s Great Salt Lake or Egypt’s Wadi El Natrun, “exist on every continent on Earth”. In 2018, two salty subglacial lakes were detected by radar waves in the Canadian Arctic. The first of their kind to be found on Earth, they are said to be utterly isolated, even representing microbial communities who have evolved on their own over geological time.

Moons other than our own, such as those of Jupiter and Saturn, are theorised to enclose salty, subglacial oceans under shells of ice.

Invariably, “regardless of the specific chemistry of the waters and of the oxygen content in the environments, microbiologists have found living bacteria and other micro-organisms in them”, says Pettinelli, but she cautions that some uncertainties remain.

“In Antarctica and Greenland, where the same radar technique has been used to detect subglacial lakes, the shape of the topography is one of the parameters that allows us to identify the presence of a lake,” she says. “Given the low vertical resolution of Marsis, we cannot determine the topographic variations of the bedrock.”

A hard-boiled scientist, however, can still dream.

“These results do indicate,” McKay says, “that the subsurface of Mars still holds surprises for us.” DM

Read Lauro et al’s full paper, “Multiple subglacial water bodies below the south pole of Mars unveiled by new Marsis data” (https://www.nature.com/articles/s41550-020-1200-6) in Nature Astronomy.
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