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Fresh perspectives for Mars exploration

Is Mars exploration stalling? The unused 2022 and 2024 launch windows send some warning signs. A revitalized approach could orient a new phase of exploration and complement the long-awaited sample return process.

At the time of the publication of this editorial, we are well into the 2024 Martian launch window. This period, which occurs approximately every 26 months, is when all Mars launches are scheduled because the favourable orbital configuration between Earth and Mars allows substantial fuel saving. This year, however, no missions will aim for the red planet. Only EscaPADE was scheduled, but eventually pulled at the last minute. The choice of EscaPADE was in itself revealing: a sort of 'mini cluster' with two twin smallsats named Blue and Gold deployed to study Mars's plasma environment and its reaction to solar wind, it is planned to be the payload of the first launch of Blue Origin's New Glenn rocket. That NASA is willing to risk sending EscaPADE on the maiden launch of a rocket is indicative of the relatively low stakes NASA has in the mission. EscaPADE is surely going to provide exciting new plasma science, but it hardly has the popular resonance of a rover like Perseverance or a multi-instrument orbiter like ESA's Trace Gas Orbiter.

Considering that no spacecraft left for Mars in the 2022 launch window either, one could wonder what has happened to the flurry of activity of the past 30 years that culminated in the launch of three satellites in 2020, which included the first Chinese and the first Emirati missions to Mars. One of the reasons is surely the gear-up, and consequent transfer of funding, for the complex mission that will return a sample from Mars (MSR). The MSR has turned into a sort of contentious endeavour, with cost overruns, mismanagements and a recent damning independent report that forced NASA to go back to the drawing board, reduce the complexity of the mission and explore alternative solutions to contain the costs and the delays. Equally seriously, at least part of the scientific community is concerned about the MSR absorbing too much money and hindering planetary exploration as a whole, although of course many others are awaiting the unique information a sample from Mars could provide. An added geopolitical element complicates the issue, as China is aiming at getting the first Martian sample at timescales comparable to MSR.

In addition to these planning and logistical issues, there is perhaps a more fundamentally scientific conundrum that future Mars exploration needs to address. The orbiters and rovers that were sent to Mars up to now have been extremely successful and have fully rewritten our view of the past and present of Mars in basically every aspect. In other words, Mars science has become mature and most of the low-hanging fruit has been plucked by now. This makes it progressively more difficult for each mission to find its space and profile. This does not mean, of course, that most outstanding scientific questions have been clearly answered — far from it. As an example, consider the Perspective written by Le Wang and Jun Huang on the hypothesis that ancient Mars had a large ocean occupying the entire northern plains. This crucial piece of information for Mars's evolution and its potential for life is still hotly debated, with various pieces of evidence brought forward in favour or against it, the last being the contribution of the Chinese Zhurong rover discussed in the article (supporting the hypothesis). However, more and more sophisticated, and thus costly, instruments are needed to give a more definitive answer to these open questions, and with their shifting priorities, space agencies are possibly more reluctant to dedicate those resources. One way to escape this loop could be to employ fresher points of view as guidelines for future Mars exploration.

This issue of *Nature Astronomy* proposes two pieces that go in that direction, concerning in particular the biggest question of all: how to look for life on Mars (and other planets). For a long time, NASA's and other space agencies' mantra has been to 'follow the water', and that has informed the planning of many missions. With our improved understanding of both the planet and what to look for in terms of life, more complex and holistic signatures can be (and have been) proposed. In a Perspective, JianXun Shen and colleagues suggest to "follow the serpentine", as this mineral encompasses various conditions leading to habitability: not just the presence of water, but also of life-supporting minerals and elements, and energetic and chemical processes. On the other hand, a Comment by Dirk Schulze-Makuch suggests the provocative idea that the notoriously inconclusive life experiments onboard the Viking landers were not wrong per se, but just conceived with the wrong assumptions in mind, lacking the knowledge of the planet that we have now. In the presently cold and hyper-arid environment, any adapted or dormant life form would have reacted with shock and died from the sudden influx of moisture and heat introduced by the Viking experiments. Schulze-Makuch thus points at 'following the salt' as an example of a hygroscopic compound where microbial life could have left traces on Mars. Both these approaches can be applied more generally in the search for life in the Solar System.

These are just two examples, and there have been other proposals in the same vein, but they can still serve as inspiration for targeted Mars exploration that does not involve sample return, and as with 'follow the water' they can indicate for example the landing sites of future Mars missions, and the kind of payload conceived to probe these specific environments.

Far from being dead or boring, Mars exploration still has many questions to tackle: a fresh perspective can help to look at an old problem from a different point of view and motivate the planning of exciting missions for the upcoming launch windows.

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