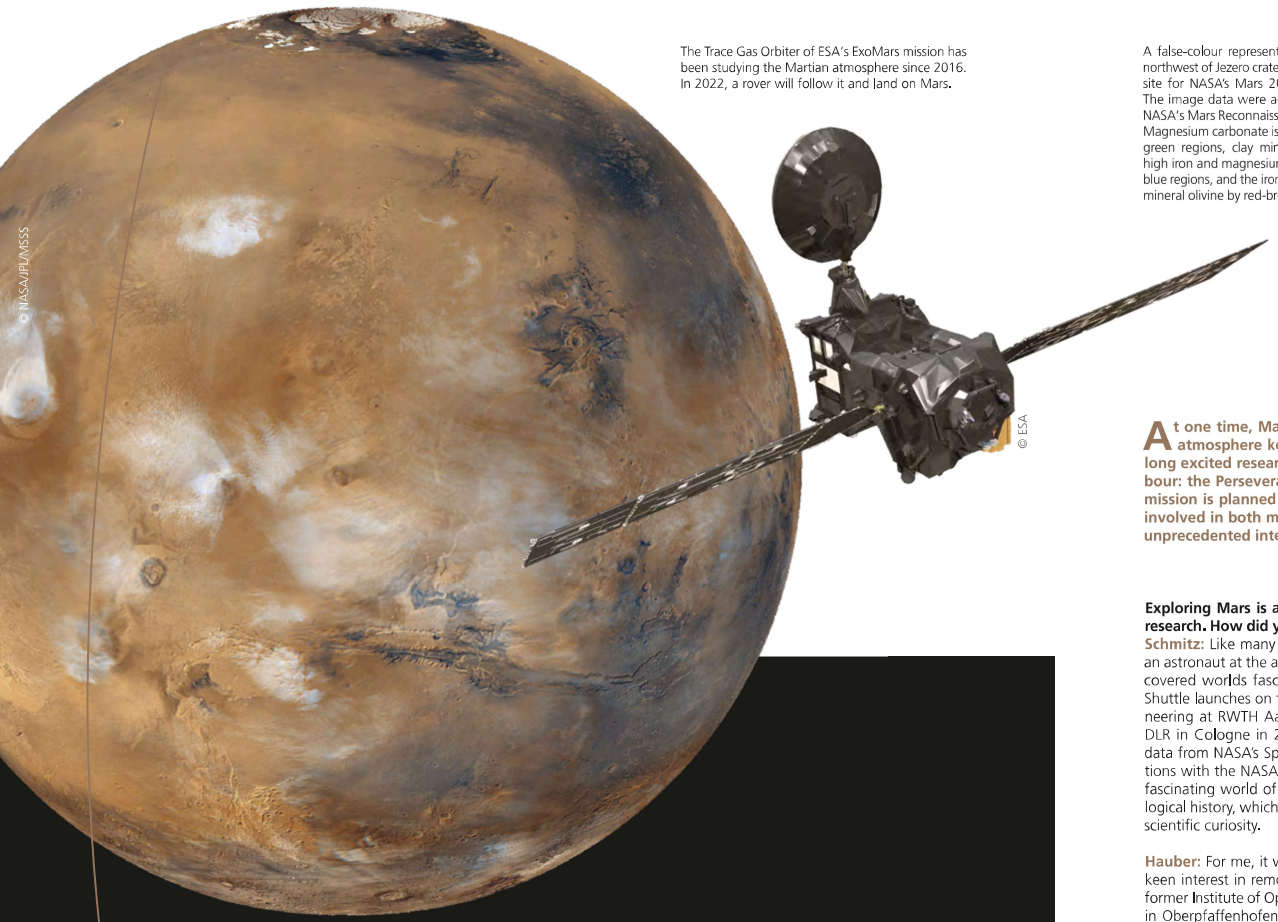

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The Trace Gas Orbiter of ESA's ExoMars mission has been studying the Martian atmosphere since 2016. In 2022, a rover will follow it and land on Mars.

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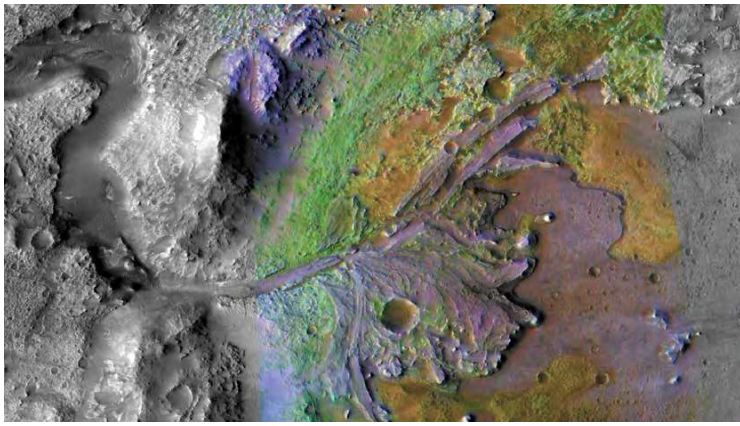
FETCH AND CARRY

New Mars missions and a fascinating plan to bring samples from the Red Planet back to Earth

by Falk Dambowsky



A false-colour representation of the northwest of Jezero crater, the landing site for NASA's Mars 2020 mission. The image data were acquired with NASA's Mars Reconnaissance Orbiter. Magnesium carbonate is indicated by green regions, clay minerals with a high iron and magnesium content by blue regions, and the iron-magnesium mineral olivine by red-brown regions.

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At one time, Mars was in many ways similar to Earth. 3.5 billion years ago, water flowed through its valleys and a denser atmosphere kept its surface warm. The question of whether microbial life could have existed under these conditions has long excited researchers. In the early 2020s, two Mars missions will begin their searches for traces of life on our celestial neighbour: the Perseverance rover of NASA's Mars 2020 mission is already on its way, while the rover component of ESA's ExoMars mission is planned for launch in autumn 2022. Nicole Schmitz and Ernst Hauber of the DLR Institute of Planetary Research are involved in both missions. In an interview with DLRmagazine, they discuss the coming decade of Mars research – including the unprecedented interplanetary feat of bringing Martian rock samples back to Earth.

Exploring Mars is among the most exciting topics in planetary research. How did you become so enthusiastic about it?

Schmitz: Like many other children, I started to dream about being an astronaut at the age of three. The night sky, adventure and undiscovered worlds fascinated me, and I also followed all the Space Shuttle launches on television. So I decided to study aerospace engineering at RWTH Aachen University, which led to an internship at DLR in Cologne in 2004. There, I got the chance to help analyse data from NASA's Spirit and Opportunity rovers. In my daily interactions with the NASA team I gained more and more insight into the fascinating world of our neighbouring planet and its complex geological history, which still offers more than enough riddles to fuel our scientific curiosity.

Hauber: For me, it was a combination of my geology studies and a keen interest in remote sensing. That was what brought me to the former Institute of Optoelectronics, which was located at the DLR site in Oberpfaffenhofen. After only a few projects I was captivated by Mars, with its varied landscape, carved by wind, water and ice. Even after decades of research, Mars still gives us surprises – the latest of which is the possibility of subglacial lakes currently being discussed by researchers.

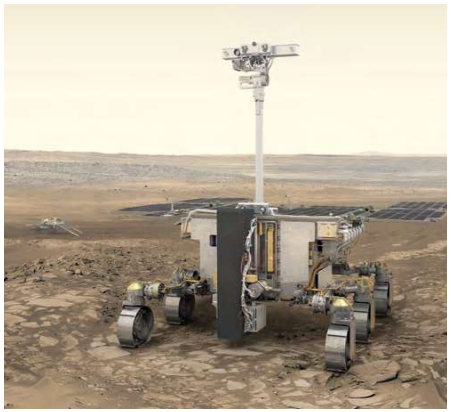
On 18 February 2021, the NASA rover Perseverance will land in Jezero crater. What will it do there?

Schmitz: Jezero is located on the inner edge of one of the largest and oldest impact basins on Mars. It is a fascinating spot that has been shaped by a variety of geological processes. More than 3.5 billion years ago, there was water flowing into Jezero crater, and a river delta formed near the western rim. For the first time in the history of Mars research, Perseverance has sample collection containers on board, which will hold rock and soil samples taken from a depth of several centimetres. The rover is about the size of a small car and has a mass of around 1000 kilograms. It has room for seven scientific zinstruments that will allow it to analyse the geology of the landing site and to search for traces of past microbial life in rocks and sediment. The most promising of these will be transported back to Earth for detailed analysis in the future.

Hauber: And then comes the really exciting part! For decades now, scientists have been discussing how to get samples from Mars to Earth, and now it has become a top priority for both NASA and ESA. Things have finally got moving, and Perseverance marks the beginning!

What is different about ESA's ExoMars rover, which is planned for launch in 2022?

Hauber: The main difference is the drilling depth. ESA's ExoMars rover, named Rosalind Franklin, will be the first to be able to drill down as far as two metres into the Martian surface. It will then also be able to immediately analyse the extracted material – via gas chromatography and mass spectrometry, for example – with its various instruments. There is a chance that cosmic rays have not penetrated that far beneath the surface. This increases the possibility that we will be able to detect traces of past microbial life there.



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The Rosalind Franklin rover of ESA's ExoMars mission

Rosalind Franklin will not prepare any samples for later transportation to Earth. What are the advantages of laboratory analysis compared with examinations carried out on board rovers on Mars?

Schmitz: The possibilities for analysis on board rovers are limited in size and complexity. So it is helpful to have access to the more extensive arsenal of analytical equipment available on Earth. Unfortunately, some of the equipment from these laboratories cannot yet be reduced in size enough to make them suitable for space travel. It is also very advantageous to collect samples today that can then be examined on Earth in decades time using more advanced future technologies.

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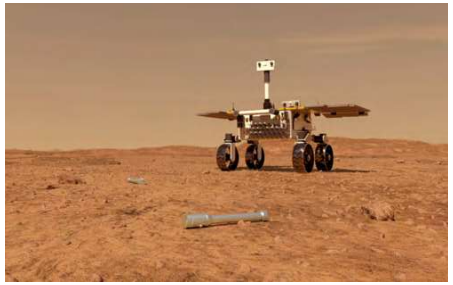
The Mars 2020 rover Perseverance takes drill samples of Martian rocks with its arm, seals them and places them on the ground.



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The Sample Fetch Rover, which could launch in 2026, will collect the samples and transport them to the Mars Ascent Vehicle (MAV).

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The MAV delivers the sample capsules into orbit around Mars, where they are collected by a spacecraft and brought to Earth.

What exactly are the traces of life that we are looking for?

Schmitz: At its landing site, Perseverance will search for what are known as 'biosignatures'. These are objects, substances or structures that can only have been left by living organisms, such as patterns in the rock or chemical isotopes. Unlike previous Mars rovers, Perseverance has the tools required to detect these 'fingerprints' of life, to map the signatures and to understand their formation and origins. These fingerprints come in many different forms. In order to confirm any findings, we would have to find several independent signs, and to be certain, we would then bring samples of these potential biosignatures to Earth to be analysed in highly-specialised laboratories.

Hauber: Even on Earth, identifying billion-year-old biosignatures in rocks is anything but simple. Biosignatures can be morphological, physical or chemical in nature. Like Perseverance, Rosalind Franklin can also perform analyses that are able to identify these fingerprints. However, because the ExoMars mission won't be sending examples back to Earth, it's particularly important to find several independent biosignatures to be really certain.

How will the samples from Mars actually get to Earth?

Schmitz: First, Perseverance will leave capsules (caches) containing rock and sediment samples at the places they were collected. A planned second component to the mission will pick these samples up in the future. This Sample Fetch Rover is expected to be provided by ESA. The next step will be the launch vehicle, the Mars Ascent Vehicle (MAV) supplied by NASA. The samples will be packed into the MAV and launched on a small spacecraft into orbit around Mars. The Sample Fetch Rover and the MAV could be launched together in 2026.

Hauber: Then comes the most difficult part of the mission, unprecedented in its complexity. Another spacecraft, that ESA is also expected to provide, will arrive in Mars orbit towards the end of the decade and collect the sample container while in orbit. From there, it will return to Earth in the early 2030s with the samples on board. Due to the great distance between Earth and Mars, remote steering of the spacecraft will not always be possible, therefore a high degree of automation will be required. The top priority throughout all stages of the mission will be to protect the samples.

How are scientists preparing for the arrival of the samples from Mars?

Hauber: The landing capsule with the samples inside is planned to land at a military site in Utah, USA. From there, it will be recovered by a specialist team and taken to a high-security laboratory for preliminary analysis. Preparing this laboratory will be a complex operation, as there will be numerous safety and security requirements to consider and all of the necessary equipment will have to be prepared well in advance.

Schmitz: One question that is particularly relevant is how the initial analysis laboratory and subsequent laboratories can be designed to ensure maximum biological safety. Until now, we have designed our secure laboratories to prevent anything from unintentionally getting out. For samples from other planets, we will have to design the research environment in such a way that they cannot be contaminated from outside, to preserve their integrity.

How are you involved in this very logistically, technically and scientifically complex process?

Hauber: The ideas and proposals behind these missions are developed by many international research groups. Since summer 2020, I have been a part of the joint NASA-ESA Mars Sample Return Science Planning Group 2, where approximately 20 experts from the USA and Europe across various fields of expertise meet regularly. Together, we are drawing up a plan for the examination of future Martian samples. We discuss things such as how large the first sample laboratory should be and what equipment it should have. Distribution is another key consideration. Where and how should the Martian samples be stored? How will they be distributed among scientists around the world and according to which criteria? Then there is the question of whether and how any of the samples should be sterilised for non-biological investigations.

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The sample capsules of the Perseverance rover

Schmitz: We are also directly involved in the first mission of the Mars Sample Return programme. I am a Co-Investigator for the Perseverance rover's Mastcam-Z camera instrument. In the international mission team, we are already planning what type of rock and soil samples we would like to collect with Perseverance, based on various scientific criteria. This means that during the mission, we will be involved in the day-to-day decision making regarding where the rover should take samples. I was also previously on international committees dealing with the scientific, technical and software aspects of the Mars Sample Return programme.

What new findings from Mars do you hope to see from ExoMars and Mars 2020 by the end of the decade?

Schmitz: We are hoping to get closer to answering one of the most exciting questions in Mars exploration: was it once home to simple life? For this, we need even better data to help us understand how geological, physical and chemical processes have impacted the planet's habitability – its viability for life – over time. We are very hopeful for the examination of the samples collected by Perseverance and for the analyses carried out by the ExoMars mission.

Hauber: We also hope that improved data will allow us to more precisely model the internal evolution of Mars, to better understand its formation and geological history in comparison with the other Earth-like planets in the Solar System.

The interview was conducted by **Falk Dambowsky**, editor at DLR Media Relations.

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Ernst Hauber is a geologist and a member of the team that chose the landing site of the ExoMars rover. The team relied on data from the ESA Mars Express probe's High Resolution Stereo Camera, whose image recording Hauber has coordinated since 2005. He's also acting project research manager of the ExoMars rover's PanCam instrument, preparing mission operations. And, Hauber is a member of the ESA Working Group on Planetary Protection, which works to prevent space probes from contaminating the Earth and other planets, and to help coordinate international regulation in this regard.

Nicole Schmitz is a research associate and engineer in planetary geology at the DLR Institute of Planetary Research. She has been involved with DLR since her student days, when she helped to evaluate data from NASA's Spirit and Opportunity Mars rovers. As co-project leader of PanCam instruments on the ESA ExoMars rover and co-investigator on the Mastcam-Z team on NASA's Perseverance rover, Schmitz is involved in technical and research activities on the next two Mars rover missions. She has also been a member of the international ESA and NASA teams working on the research, technical and programming preparation of the Mars Sample Return programme.

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