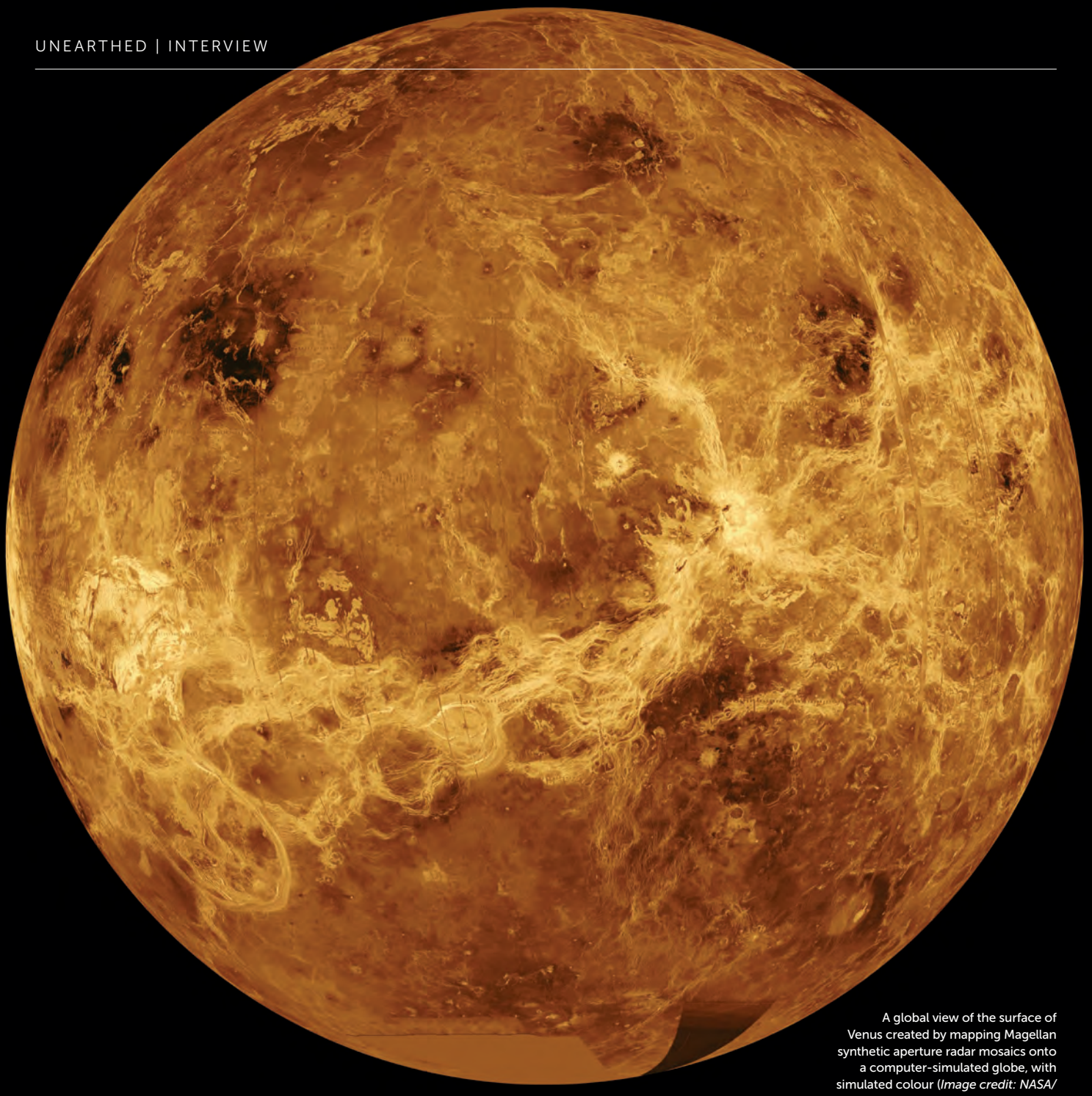

A global view of the surface of Venus created by mapping Magellan synthetic aperture radar mosaics onto a computer-simulated globe, with simulated colour (*Image credit: NASA/ Jet Propulsion Laboratory-Caltech*)

Planetary frontiers

Ground-breaking missions to Mars have captured imaginations and headlines around the world. However, as Peter Grindrod discusses, Venus will soon move back into the spotlight

MARS AND EARTH were probably quite similar before going down different evolutionary paths. Peter Grindrod, from the Natural History Museum, London, notes that the divergence probably happened just before or at the same time as early life seems

to have begun on Earth, around 4 to 3.5 billion years ago, making this a key period in Martian history for investigation.

"Somewhat paradoxically, Mars has a longer and cleaner stratigraphic record than Earth. The absence of plate tectonics means that the history of the planet has been better preserved, although it is much more difficult to explore, of course.

"The rover missions are essentially robot field geologists, and they are producing results that are staggering in their detail. From the 3D structure of lithified dunes, to fluvial sedimentary deposits, we are able to explore Mars (at least in small areas) in a similar way to how we do on Earth."

Defining moment

NASA's Perseverance Rover is currently exploring Jezero Crater. This landing site was chosen because rocks in this crater probably record a range of geological processes at a crucial point in the geological history of Mars. In September 2021, the rover successfully collected its first sample of Martian rock from Jezero Crater.

"The plan is for Perseverance to keep on exploring the Jezero Crater region, collecting samples along the way. These samples will be picked up by a future Sample Fetch Rover and returned to Earth within the next decade for study in laboratories around the world. It is no understatement to say that these Mars rocks will be among the most important samples ever studied in planetary science, and will be examined for decades to come – the results could be a defining moment in our exploration of the solar system."

2022 will see the launch of the joint ESA and Roscosmos ExoMars Rosalind Franklin Rover. The rover will land in a part of Mars named Oxia Planum, a 200-km-wide clay-bearing plain, in 2023.

"This area has an abundance of rocks that are thought to be rich in phyllosilicate minerals, suggesting the importance of water around the time of their formation about 4 billion years ago. The goal is for the rover to take a deep drill core on Mars, from two metres, beyond the influence of radiation at the surface, to search for life. There is evidence to show that this part of Mars appears to have been habitable, but was there ever life on Mars? Hopefully ExoMars can answer this question in just a few years."

> **"The results could be a defining moment in our exploration of the solar system"**

Catching up

Over the past few decades, the large number of missions to Mars has resulted in an explosion of interest, which is reflected in the high number of discoveries published in research papers. While there have been more successful soft landings on Venus than on Mars, publications on Venus have not kept pace.

"Nothing has touched down on Venus since the early 1980s, with the last of the Soviet Union's Venera landers. Because of the harsh conditions at the surface, and the earlier technology, only basic information was returned. However, this information is vital because it is all we have, and shows that the surface at the landing sites appears to be basaltic. Radar images from NASA's Magellan orbiter, which launched in 1989 and orbited Venus during the early 1990s, show an essentially volcanic planet.

"But interest in Venus has never gone away. Studies mined the Magellan data, applying new techniques that helped generate an increased awareness in the importance of understanding Venus. In 2005, ESA launched their Venus Express orbiter which, although designed to study the atmosphere, provided tantalising evidence that Venus is still volcanically active."

There has been a recent resurgence of interest in Venus with reports of phosphine in Venus's atmosphere.

"This is one of the most exciting, and controversial, recent results involving Venus. Using telescopes on Earth, Greaves and colleagues (Nat. Astron. 5, 655-664, 2021) claimed to have found phosphine – a gas often associated with life on Earth, and that shouldn't be present at Venus – in the planet's atmosphere. So, the implications are huge. Other studies refuted the claim, but recent repeat analyses support the original findings. Right now, this an open, but exciting, question."

Both NASA and ESA have recently announced new missions to Venus.

"NASA's DAVINCI+ mission will involve a probe that will enter Venus's atmosphere and study its chemistry, as well as imaging possibly ancient, tectonic regions on the planet's surface, while VERITAS will use synthetic aperture radar (SAR) to study the surface in greater detail than ever before. Both of these missions will launch towards the end of the decade. ESA's EnVision mission is a complementary SAR mission, launching in the early 2030s. The data from these missions should lead to a new understanding of Venus, and the evolution of planetary systems.

"Venus has had a very different evolution compared to Earth, despite being similar in size, composition, and distance from the Sun. Because of the relatively young surface, we are missing about four-fifths of the history of Venus. Yet, we see a planet with a rich geological story that we are a long way from fully understanding. Why does Venus (apparently) lack plate tectonics? What happened to the water (if it was there)? There are many fundamental questions still to be answered, which are important not just for understanding our solar system, but also the planets that we now know exist in large numbers around other stars."

PETER GRINDROD

Dr Peter Grindrod is a Research Leader in Meteoritics and Planetary Science in the Department of Earth Sciences at the Natural History Museum, London