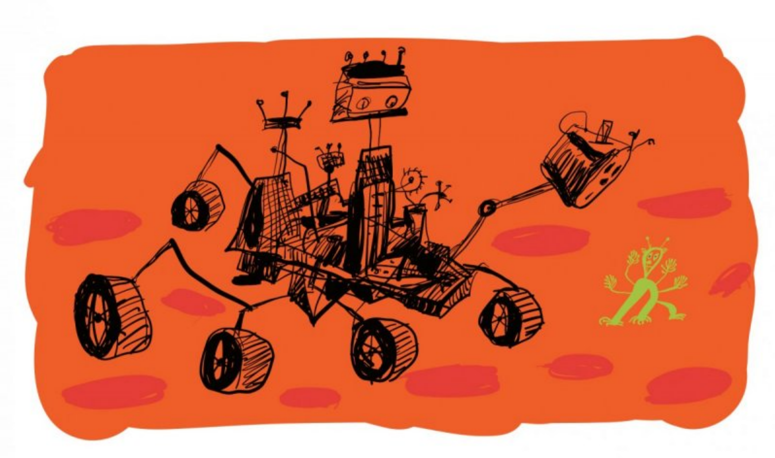
JUNE 2022 THE NATION REVIEWED

Red rover

By Will Higginbotham



The Australian astrobiologist leading NASA's search for life on Mars

When she was six, Abigail Allwood fell in love with space. It was the early 1980s, and the Brisbane girl was dazzled by images from NASA's Voyager probes of Saturn's rings and moons. When her mum took her to the planetarium, she would become so absorbed in the majesty of the planets that she'd walk around the exhibitions in dead silence.

It's fitting that Allwood is now a lead investigator on NASA's Mars 2020 mission – the first Australian and the first woman in such a post. "It's one of those things where the stars aligned; it was perfect timing and luck," Allwood says from the guest-bedroom-cum-study in her California home (even NASA scientists have adapted to working remotely). Her strong Australian accent remains undimmed despite moving to the United States 16 years ago to work as an astrobiologist with NASA's Jet Propulsion Laboratory.

In July 2020, the space agency launched its latest Mars project by sending the Perseverance rover into space. Allwood watched via Zoom – the pandemic having taken hold – an experience she describes as underwhelming: "it was just like any other Zoom meeting – all bobbleheads". The mission landed on Mars in February last year at a carefully chosen spot in the Jezero crater. Perseverance has been there, whizzing about the dusty ochre landscape on its six wheels, for some 450 Martian days (approximately 460 Earth ones).

NASA has had four previous rover missions to the red planet, but this is the first with the stated aim of looking for signs of ancient life.

"A critical aspect of this mission is astrobiology," Allwood says. Astrobiology is an interdisciplinary field studying the origins, evolution and future of life in the universe, and when it comes to Mars the key questions are: Did the planet ever harbour life? What were the planet's past geology and climate like? Could life still exist there?

Perseverance examines rocks that might contain signs of ancient microbial life. Samples deemed interesting are analysed in situ, and others cached for possible further study on Earth. "That's what it has been up to these past months," Allwood says. "Look, a lot has happened and a lot hasn't. It's best if I show you." With a few clicks Allwood shares her screen and sifts through a dozen folders before settling on her selection.

"Ready to go to Mars?" she asks, before presenting a startlingly clear image of the planet surface. The foreground features rocks ranging from small stones to large boulders, and distant cliffs in the background mark the crater rim. "This is an area that's opening up a fascinating window into ancient Mars," Allwood says. "This is the Delta Front area. We are fairly certain it was likely an incredibly wet area eons ago – possibly where a river flowed into a lake bed. It's the sort of place you might expect to find signs of ancient life."

A previously aquatic environment would have transported rocks from all over the nearby region and they would have settled at the river delta, just as they do on Earth. These sedimentary rocks, having sat for billions of years, can now be studied for signs of past Martian organisms. Indeed, NASA has described this area as a geological treasure trove. "If we don't find anything [here] in terms of signs of ancient life, then that's pretty strong evidence against life having previously existed on Mars," Allwood says. "Not conclusive, but strong."

Since Perseverance arrived on Mars, in mid February 2021, Allwood says there have been some "wow" scientific discoveries. For example, scientists were amazed when they found that some rocks in the crater were not sedimentary as they had expected. Instead, some samples turned out to be igneous – rock created by volcanic magma – with crystals inside them. "We've also found within some the presence of minerals like salt, gypsum, and all of that forms when water evaporates in mineral-rich environments." Her voice becomes more excitable. "And guess what – we've also found organics in these salts." Organics refer to the building blocks of life: carbon and hydrogen. Still, NASA isn't declaring the discovery of life just yet, as organics can be produced by both biological and non-biological means. "There's a lot more work to figure out how they formed, but it is compelling science."

Perseverance has been examining rocks using an instrument that Allwood invented. The Planetary Instrument for X-ray Lithochemistry (PIXL) is a lunchbox-sized object attached to the rover's arm. It works to identify the elements and composition of a rock, from which can be determined the context of how it formed. PIXL also works with another instrument to search for specific signatures of life, such as carbon.

Allwood modelled PIXL on a similar tool she used in her groundbreaking work in Australia's Pilbara region. It was the early 2000s, and Allwood, a young PhD student, found evidence of some of the world's most ancient life within the region's sedimentary rocks. What she uncovered were fossilised stromatolites, deposits formed by microorganisms that can provide a record of life on Earth 2 to 3 billion years ago. Her subsequent reputation for finding historical evidence of life in remote places made Allwood the perfect candidate for NASA's Mars program.

"In many ways, working in the Pilbara is almost as close as you get to Mars on Earth," she says. It also meant she knew she would eventually have to leave Australia to pursue her astrobiology interests. "We have a lot of geoscience fieldwork expertise in Australia, when many countries don't. But when an Australian student wants to consider that in a space context, astrobiology is hardly taught, and there are certainly no jobs. It's tremendously sad."

As Perseverance trundles around, it sends data to Earth for Allwood and her team to scrutinise. Should a particular rock be examined further or ignored? Which samples get to be stashed in a titanium tube to be sent back to Earth on a future mission? Allwood's efforts, and those of fellow Australian David Flannery, a former NASA scientist turned academic, meant that NASA commissioned the Queensland University of Technology to create the software capable of crunching this all-important geochemical data. QUT met the challenge but keeping on top of the data is a transcontinental mission: around a dozen of its scientists monitor incoming data when the California team (a few hundred people) log off for the day.

What might conclusive evidence of life on Mars look like? Allwood smiles, as she's been waiting for this question.

"What I can tell you is that there is no smoking gun. People want The Fossil or The Rock, where you analyse the bejesus out of it and there's your answer. But what it really is, is the sum of all observations made. Many are simple geological observations on their own, but pieced together with other observations, with bio and chemical signatures, with the whole environmental context – then that's your evidence of life.

"When we make the call that we have evidence of life on Mars, it'll be because all those pieces started to come together. So far, it's panning out how I would expect if life had once been up there. I'm starting to get excited, but that's just me."

WILL HIGGINBOTHAM

Will Higginbotham is a writer and researcher who has reported for *Guardian Australia*, *Monocle* and *The New York Times*, and for the BBC radio documentary division.

By Will Higginbotham
June 1, 2022