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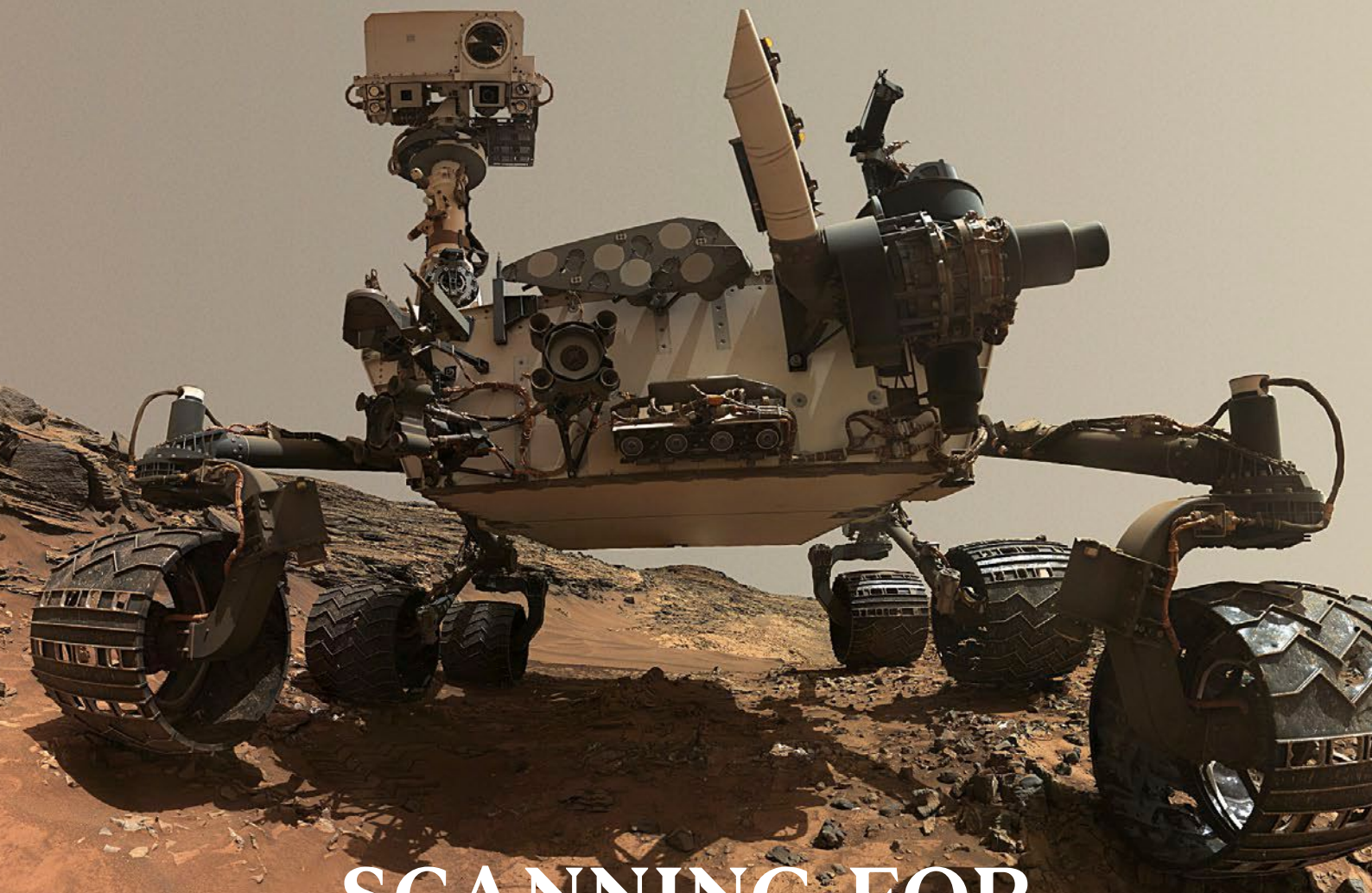

SCANNING FOR LIFE ON MARS 74

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TOOLING UP FOR MARS

Abigail Allwood has designed an instrument that will search for life on Mars. BELINDA SMITH tells how her dream came true.

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TO A YOUNG Abigail Allwood, science was nothing but boring textbooks – but come 2020, the NASA astrobiologist's other office will be the red planet.

ABIGAIL ALLWOOD sat in her stiflingly hot car and screamed with joy. Parked at NASA's Jet Propulsion Laboratory in Pasadena, California, she had just learnt that the instrument she'd designed to search for extraterrestrial life was going to Mars.

ANCIENT SIMILARITIES BETWEEN MARS AND EARTH DRIVES RESEARCHERS TO FOSSICK IN THE PILBARA.

SHE WOULD BE the first woman *and* first Australian scientific leader on a Mars mission. Not bad for someone who handed in her PhD less than 10 years ago.

A year on, in July 2015, I met Allwood on a typically bright blue Brisbane day. She was back in the country to receive the alumnus of the year award from the Queensland University of Technology, amid a flurry of press conferences, presentations, ceremonies and more presentations. But despite her packed schedule, she didn't look exhausted. Her grey-green eyes were alert. Her shoulders, relaxed.

When we spoke, Allwood had just said goodnight to her daughter Sophia, tucked up in bed across the dateline in Los Angeles, the city Allwood, her husband and daughter now call Whome. It's also where Allwood and her team are building the Planetary Instrument for X-Ray Lithochemistry – or PIXL. It will be Mars-bound in less than five years, attached to NASA's Mars 2020 rover.

Life hasn't always been about science for Allwood. On her first day of grade 10 at Somerville House, a girls' school in South Brisbane, the science teacher asked the class: "Who wants to do science when they grow up?" "One person put their hand up," Allwood says, "and it wasn't me." To the 14 year old, science was nothing but boring textbooks.

A couple of years later, Allwood caught a television interview with American planetary scientist Carolyn Porco, then an investigator on the Voyager mission to the Solar System's outer reaches. In August 1980, Porco was the first person to witness close-up images of Saturn. She described sitting alone in her office late at night as the little probe beamed pictures back to Earth. "I thought, 'wow, that is a noble thing to do – and get paid to do it'. And she was a woman!" Allwood recalls. Her next thought was: "So how do you get from Australia to do something like that?"

It was a good question. The obvious route was a degree in astrophysics, but "it was not my cup of tea", she says. While studying, Allwood traded space science for Earth science, graduating with a geology degree with honours in 2002.

Allwood went on to work for Australian oil and gas company Woodside for a couple of months. But the spark had been lit – the lure of space was still strong.

Then two meetings changed her life. And brought space within reach.

"EXTRATERRESTRIAL LIFE FOUND ON MARS!" screamed headlines in 1996. The excitement was triggered by a brown lump of Martian meteorite found in Allan Hills, Antarctica. NASA scientist David McKay reported in *Science* that microscopic beaded chains embedded in the rock appeared to be bacterial fossils. Even Bill Clinton, then US president, weighed into the story, declaring "its implications are as far-reaching and awe-inspiring as can be imagined".

Other scientists soon refuted the findings, saying the beads McKay saw were minerals – not fossilised microbes. McKay's claims remain controversial to this day. But the debate jump-started a new field of research: astrobiology, the study of life on other planets.

The scientific consensus is that Mars might once have supported life. Three and a half billion years ago, Mars and Earth were both wet and warm. But while Earth stayed that way, Mars lost its blanketing atmosphere, which was whisked off into space by the solar wind. Its remaining atmosphere became far too thin to keep surface water from evaporating or freezing. The planet became a cold, uninhabitable desert.

The ancient similarities between Mars and Earth drives astrobiologists such as Malcolm Walter to fossick in the Pilbara – half a million square kilometres of primeval rock in Western Australia. If these rocks, among the oldest on Earth, had once hosted life, then maybe Mars did too? To explore these questions Walter

founded the Australian Centre for Astrobiology at Macquarie University in Sydney in 2001. A year later, he snared Allwood as a PhD student. She recalls him saying: "'You're interested in Mars then? There's a lot we can do about that.' And I said, 'tell me more!'"

Her second life-changing meeting took place on an aeroplane bound for Brisbane. As the plane took off from Sydney, she became aware that a man sitting nearby stank of diesel. His boots and shirt were mottled with holes, and even his beard was crusted with salt. The man, Ian Burch, had just single-handedly sailed a 1954 huon pine racing boat through three storms across Bass Strait from Tasmania to the mainland. "I thought he looked interesting so we got talking," Allwood says coyly. Soon after, they travelled together to the Pilbara to collect rocks.

02

Allwood in Western Australia, showing a fossilised stromatolite she found in the Pilbara. The discovery marked a turning point in her career.

The Pilbara is tough, isolated and inhospitable. Some questioned Allwood's wisdom in travelling there with Burch. Allwood recalls their objections: "You've just met this guy, and you're going into this stressful situation in the middle of nowhere."

But it worked. Burch had a military background and a keen interest in geology. He helped Allwood survive in areas that would otherwise have been inaccessible to her. Today they're married.

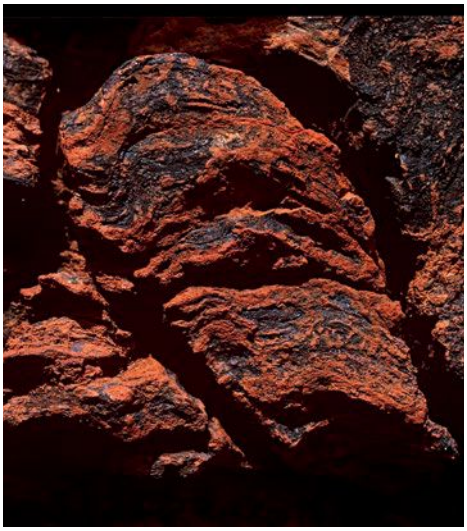
WHILE EXPLORING the Pilbara, Allwood was also entering dangerous academic territory. The controversy over the Allan Hills meteorite and its supposed traces of Martian life had dropped to a simmer, but a fresh dispute was bubbling up around microfossils – purportedly early Earthly life forms – described in 3.5 billion year old Pilbara rocks, and discovered in the early 1980s. Two decades later, the controversy over the Pilbara "microfossils" refused to go away.

"So I naively step into this mire to do my research project," Allwood laughs. But rather than take sides in the "microfossil versus mineral" debate, she decided to break new ground.

Surely, if life had existed 3.5 billion years ago, she would find it in the Pilbara. When the Pilbara rocks formed they were at the bottom of a sea. Allwood decided to search for fossil stromatolites. Built by ancient communities of microbes, stromatolite fossils are found all over the world. In a few places – including Western Australia's Shark Bay – they're still growing. Mucous oozing from the top of the microbial mat glues sediments to the stack, resulting in distinctive growth layers resembling tree rings.

For three years Allwood, Burch and Malcolm Walter roamed a 180 kilometre wide swathe of the east Pilbara searching for fossilised stromatolites, which are roughly the size and shape of a small tombstone. Allwood and Burch lived in a battered white truck for the cooler months of each field season. Walter joined them for a couple of weeks at a time.

03

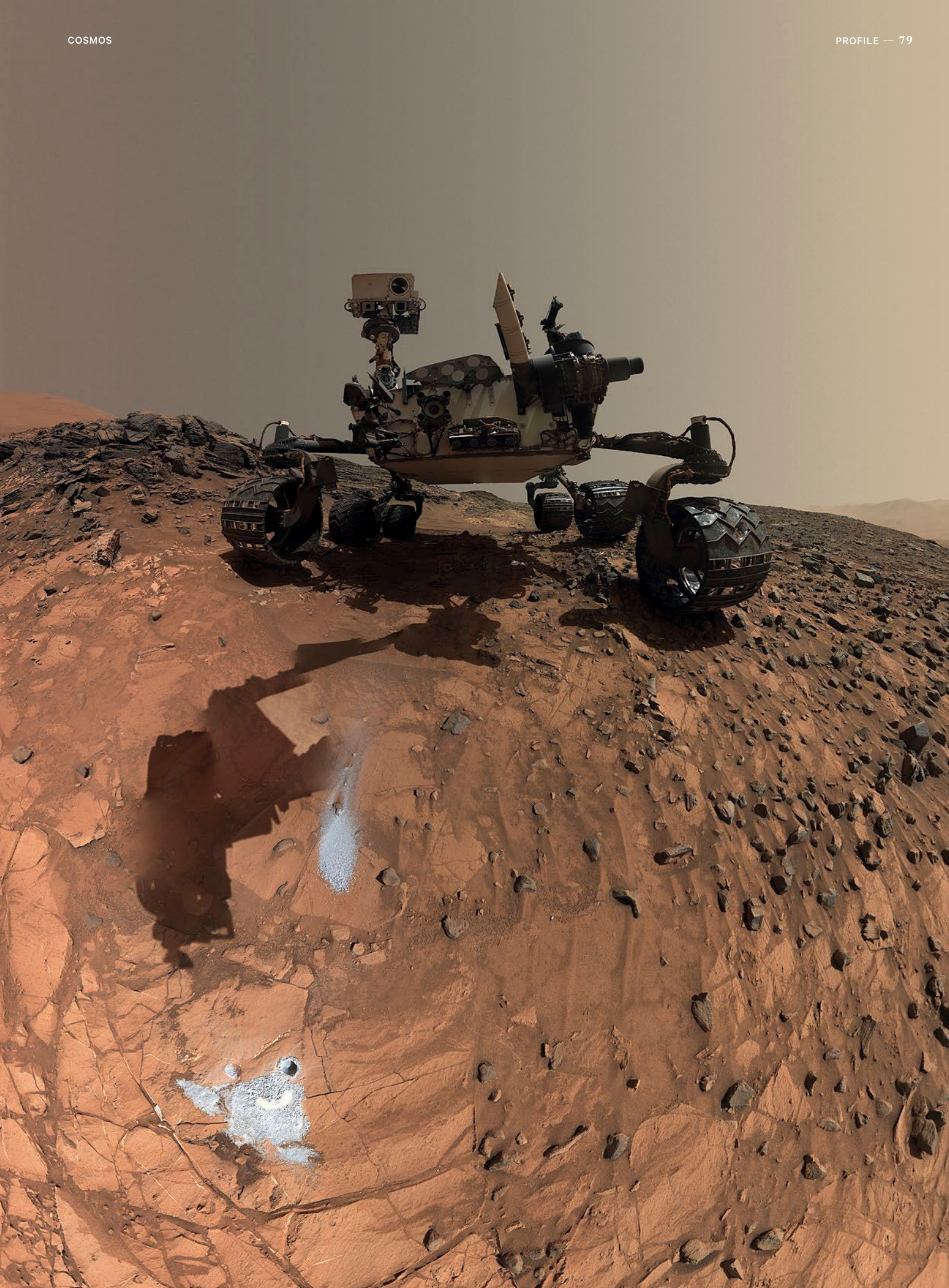


Pilbara stromatolites – one of the oldest widely accepted examples of life on Earth.

The long search paid off. In a 10-kilometre stretch of rocky Pilbara, Allwood identified seven different-shaped stromatolites. She dated them as 3.43 billion years old.

Walter remembers the moment the pieces of the puzzle fell into place. The three were sitting around the fire in the evening, on the bank of a big dry river, discussing what they'd found that day. Allwood picked up a stick and began drawing in the sand. She realised she was the first person to have discovered an ancient, shallow reef in the Pilbara. Finding a single ancient stromatolite

04
NASA's Curiosity Mars rover drills and collects rock samples. Allwood has designed an instrument that can scan rock samples for signs of life. It will be sent to Mars in 2020.



fossil might not have convinced sceptics, but a whole community of them, all the same age, put the discovery beyond doubt.

The work graced the cover of *Nature* in 2006. In contrast to the microfossil claims, her reef has held firm since – it is one of the oldest widely accepted examples of life on Earth.

ALLWOOD'S GROUNDBREAKING WORK won her a position at the California Institute of Technology in Pasadena, California. Caltech boasted 33 Nobel laureates and was also home to geologist John Grotzinger.

His name may be familiar to those following the discoveries made by the Mars Curiosity rover in 2014. The rover made headlines by detecting the calling cards of life: complex mixtures of organic molecules in the sandstones of the Gale crater, and occasional whiffs of methane. Grotzinger was the lead scientist behind those discoveries.

THE ROVER WAS STILL ON THE DRAWING BOARD AND THERE WAS NO GUARANTEE NASA WOULD FUND THE MARS MISSION.

When Allwood secured her job in 2006, Grotzinger had recently become chief of Curiosity's on-board science lab. At that time Allwood was continuing her stromatolite work in Grotzinger's lab.

Then in 2009, when Curiosity was almost complete, NASA announced its next multi-billion-dollar space mission. The mission would search for life, and would be launched around 2020. The destination had been narrowed to two choices: the red planet or Jupiter's icy moon Europa.

In 2010, Allwood began living her dream. NASA funded her to develop an instrument that scans rocks for chemical signatures of life – the PIXL. She'd used a similar instrument to analyse the Pilbara rocks, but it was almost a metre wide and weighed around 120 kilograms. Allwood needed to shrink the instrument down to a two-kilogram, 12-centimetre box, so that it could fit on the Mars rover.

How did she manage the jump from geologist to instrument designer? "I have a very talented team of engineers," she says. "Without them, PIXL wouldn't exist." Allwood's intimate knowledge of the beads-in-the-Pilbara-rocks battle also served her well. She knew what it would take to make a robust case for life in Martian rocks.

PIXL scans the surface of the rock with X-rays. In contrast to methods such as mass spectrometry, PIXL doesn't require a rock to be ground into dust in order to analyse it. When a rock is zapped by the PIXL beam various atoms, including sodium and iron, reflect a characteristic set of X-rays back. PIXL can then map the distribution of these elements on to high-resolution photographs of the rock.

This combination of visual and chemical data is vital, Allwood says. Any traces of life will almost certainly be microbes fossilised in sedimentary rock. If PIXL turned up the possible chemical signature of ancient life, she would be able to analyse it in context. Does it appear blobby, like you would expect ancient cyanobacteria (blue-green algae) to look? Is it in fine-grained sedimentary rock, such as that deposited at the bottom of a lake? This contextual information would lend weight – or not – to the chemistry maps, just as it did with her Pilbara stromatolites in the ancient reef.

At the beginning of 2012, NASA confirmed its 2020 mission would be heading back to Mars, sending a rover laden with instruments developed in partnership with the European Space Agency.

But, as Allwood learnt, space science can be an emotional roller coaster.

Weeks after the announcement, the global financial crisis killed the collaboration. NASA funding was also crippled: $300 million was cut from planetary science with the Mars program suffering a massive 40% hit.

Allwood recalls thinking, "that's it".

Then in December 2012, after some financial shuffling, NASA announced a billion dollars to resuscitate the 2020 Mars mission. To cut development costs, the new rover would reuse the chassis design of the Curiosity rover already trundling around Mars – and would be fitted with a new set of instruments. "All of a sudden we had our dreams back," Allwood says.

Laboratories were given a year to justify why their instruments should be included on the mission. Room on board the one-tonne rover was at a premium.

Allwood and her team outlined PIXL's case at the end of 2013. The NASA panels were expected to announce the payload the following April. But April came and went. No word. May, June passed. "We were left hanging," Allwood says.

Then came that sweltering July 2014 day. Allwood had finished work at the Jet Propulsion Laboratory for the day and was heading for the car when her mobile phone rang. Jim Green, head of the Planetary Science Division, was on the line: PIXL was one of seven instruments going to Mars. She wheezed a reply, hung up, bundled herself in her car and screamed.

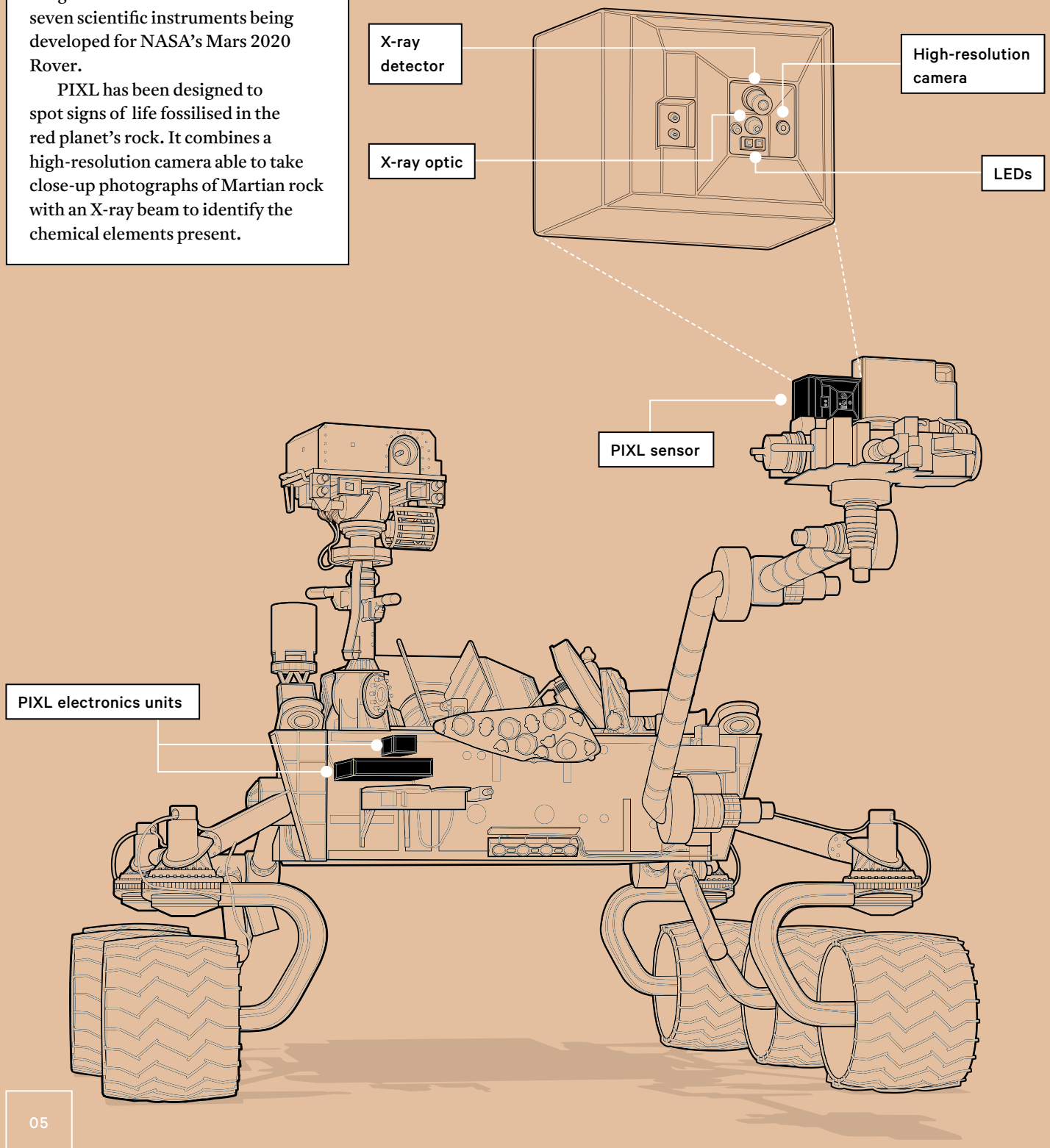
SINCE THE ANNOUNCEMENT it's been all systems go. Allwood's team now has a PIXL prototype that works in simulated Mars conditions: low atmosphere and pressure and wild temperature

A CLOSER LOOK

MARS 2020 ROVER: PIXL INSTRUMENT

Abigail Allwood's PIXL is one of seven scientific instruments being developed for NASA's Mars 2020 Rover.

PIXL has been designed to spot signs of life fossilised in the red planet's rock. It combines a high-resolution camera able to take close-up photographs of Martian rock with an X-ray beam to identify the chemical elements present.



06

Queensland University of Technology's 2015 outstanding alumnus of the year, Abigail Allwood, at a QUT press conference.

"SHE CERTAINLY HAS STRONG PASSION ... TO BUILD A CAREER THAT ULTIMATELY RELATES TO SPACE."

fluctuations from minus 140°C to 40°C.

The next prototype, Allwood says, will be the last, the same as the flight model. It will be put through its paces to make sure it can survive the vibrations and shocks of space travel.

At the same time, Allwood has been involved in another important part of the 2020 rover mission. It's the first of what she calls the "three major miracles" of planetary science: to collect rock samples on Mars, lift them off the surface and ferry them to Earth for more analysis. The 2020 Mars mission is only aiming for the first miracle: collecting and packaging rocks.

How big should these samples be? She and others at NASA decided only 10 or 20 grams, collected in metal tubes about the size of a finger. They will be dropped off around the planet for collection by another rover down the track.

ALLWOOD'S RISE IN ASTROBIOLOGY has been breathtaking. Was it because she was in the right place at the right time, so that her path crossed with Walter and then Grotzinger at pivotal moments? No, says Walter. "She certainly has strong passion; it's how she came to work with me," he says warmly. "She came with a huge amount of determination to build a career that ultimately relates to space exploration." That dedication, he adds, will stand her in good stead down the track.

When she sat under the stars in flickering firelight in the Pilbara, it was beyond Allwood's wildest dreams to think that one day she might build an instrument, put it on a launch pad and send it to Mars. "Not to mention see it scanning its little X-ray beam across rocks to help us answer some of mankind's most fundamental questions," she adds.

The girl from Brisbane is about to have her dreams come true. She is only 42 – the best is yet to come.

BELINDA SMITH is deputy editor of *Cosmos*.

IMAGES
01 Sonja de Sterke
02 Abigail Allwood
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05 Anthony Calvert
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