

Martian art: These weirdly beautiful images of the (not-so-red) planet were made by Nasa's Mars Reconnaissance Orbiter late last year. – AP/ Reuters / Nasa

Two robot rovers on the surface of Mars that were supposed to have stopped functioning half a decade ago have miraculously continued to send data back to Earth. And amidst the gigabytes of information are clues that point to the amazing possibility that the planet might once have supported life.

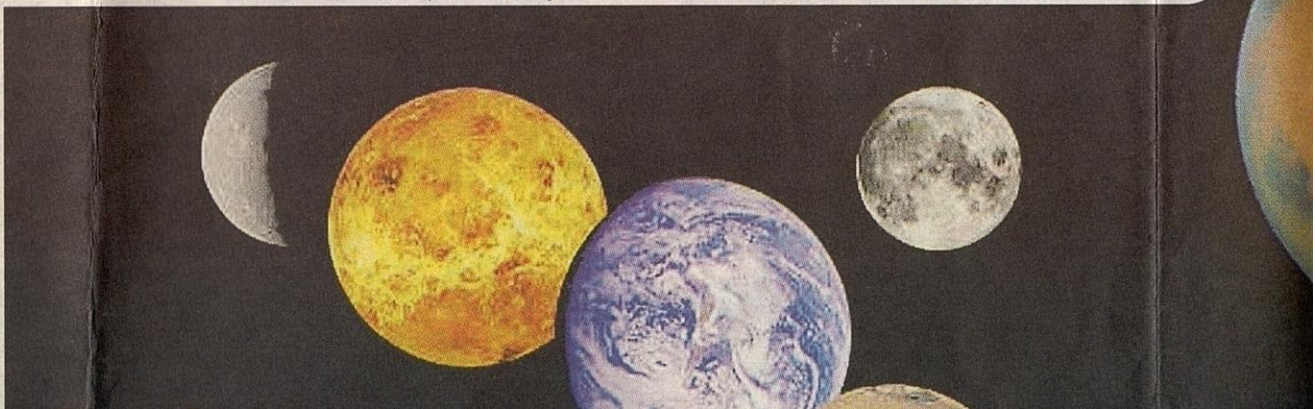
By IAN SAMPLE

HIGH in the sky above Mars, it is snowing right now. Very gently snowing. The snow does not settle on the rubble-strewn land below – not these days, anyway – but instead vaporises into the thin atmosphere long before it reaches the ground.

Ballard. It touched down a short distance from the Columbia Hills in a region named Home Plate, a plateau 80m wide. The rover found the plateau to be surrounded by deposits of opal. As it trundled around, its wheels kicked up soil rich in sulphate. Together, these two pieces of information identify Home Plate as an old volcano.

Life on Mars?

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The first flakes of snow, on a planet that until fairly recently was believed to be waterless, were spotted just a few months ago. A Nasa (US National Aeronautics and Space Administration) lander near the planet's North Pole was scanning the sky with a laser when it noticed the telltale signs of snowfall. The probe, called *Phoenix*, announced the news in a radio signal that was picked up by an overhead orbiter and beamed back to Earth. Nothing like it had ever been seen before.

The news of snow falling is just one piece of an extraordinary wealth of information that has recently been sent back from Mars by orbiters, landers, and rovers. Together, they have mapped the surface in unprecedented detail, cracked open rocks, sniffed the atmosphere, and dug down into the soil. What they have found points to an unimagined Martian history, one where life may have once gained a foothold and may even cling on still in the frigid soils of the permafrost.

Mars is a planet where scale is redefined. It is half the size of Earth, but home to what is probably the largest mountain in the solar system, the 25,000m-high Olympus Mons (our highest peak, Mount Everest, is a mere 8,800m!). Just beneath its Equator is a truly grand canyon that also sets a solar system record: The Valles Marineris is as long as the US is wide, and in places reaches 10km deep.

The dream that refuses to die is that one day humans will climb Olympus Mons, and descend into Marineris.

But in the meantime, a different sort of exploration is going on – less glamorous, but arguably far more revelatory. Last month, Nasa celebrated the anniversary of the landing of two rovers that were sent to opposite ends of the planet exactly five years before, to study its ancient equatorial geology. The rovers, *Spirit* and *Opportunity*, had been designed to survive the harsh environment for just 90 days, but somehow they have survived, and they continue to astound Nasa scientists with the new data they send home.

Warmth + water = life?

Spirit has explored a world as fantastic as any imagined by sci-fi luminary J.G.

"If you were there billions of years ago, it would be exploding, fire-fountaining, with ash coming up, and shallow pools of hot water evaporating into the Martian atmosphere," says Ray Arvidson, deputy principal investigator on the rover mission at the University of Washington in St Louis in America.

Warmth and water rank highly on Nasa's checklist of criteria for the emergence of life, and scientists have been making a credible case for water on Mars since at least the mid-1970s, when pictures sent back from the *Viking* orbiters showed deep channels, canyons and even features that resembled ancient lake shorelines.

In 2006, Nasa had announced the then strongest evidence yet for liquid water on the planet, when its *Mars Global Surveyor* orbiter spotted what appeared to be stains on gully walls caused by gushing water.

On the other side of the planet, *Spirit's* twin, *Opportunity*, has been having its own solar-powered adventures, driving around and analysing rocky features on an expanse called the Meridiani Planum.

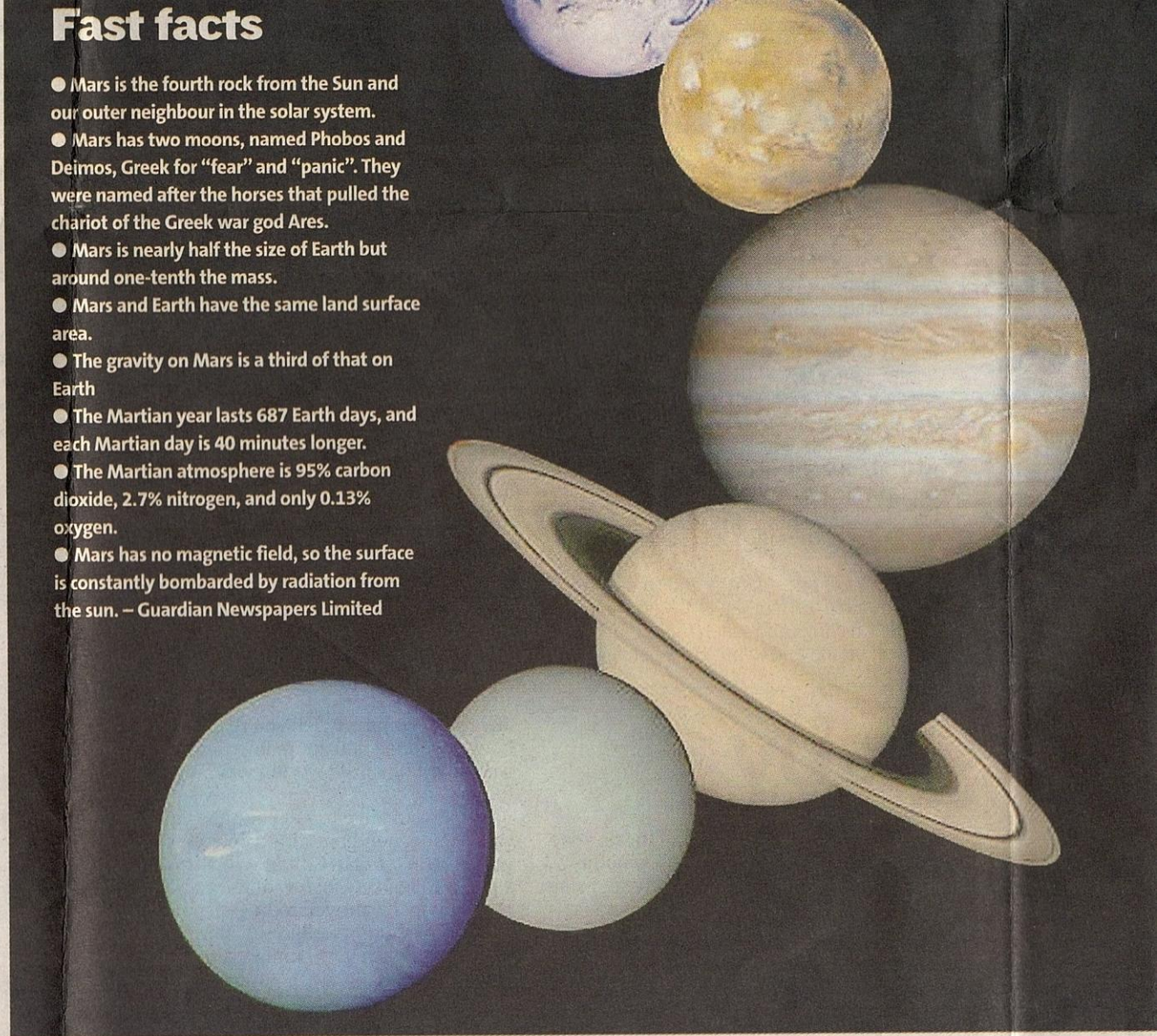
From data sent back to Earth, scientists know that the rover landed on several hundred metres of sedimentary deposits that must have formed in ancient lakes. The soil is inhospitable, similar to that in parts of Rio Tinto in southern Spain, where water bubbles up through iron sulphide deposits, forming sulphuric acid that dries into an acidic mud over the long, dry summer.

The rovers are guided across the Martian landscape by a team of 14 drivers based at the Jet Propulsion Laboratory in Pasadena, California. They arrange their working day to coincide with the Martian night, so they can work out the details for the next day's excursions while the rovers are asleep. The Martian day is 40 minutes longer than on Earth, so the team is constantly shifting the hours it works.

Before shutting down each night, the rovers send pictures and other data of their positions to an orbiter called *Mars Odyssey*, which relays them back to mission control. There, the drivers confirm the rovers' locations and decide where to send them next. When the rovers wake up, they receive a day's worth of – telling

Fast facts

- Mars is the fourth rock from the Sun and our outer neighbour in the solar system.
- Mars has two moons, named Phobos and Deimos, Greek for "fear" and "panic". They were named after the horses that pulled the chariot of the Greek war god Ares.
- Mars is nearly half the size of Earth but around one-tenth the mass.
- Mars and Earth have the same land surface area.
- The gravity on Mars is a third of that on Earth
- The Martian year lasts 687 Earth days, and each Martian day is 40 minutes longer.
- The Martian atmosphere is 95% carbon dioxide, 2.7% nitrogen, and only 0.13% oxygen.
- Mars has no magnetic field, so the surface is constantly bombarded by radiation from the sun. – Guardian Newspapers Limited



A montage of planetary images taken by spacecraft: (from top) Mercury, Venus, Earth (and Moon), Mars, Jupiter, Saturn, Uranus and Neptune. – AFP / Nasa

them what direction to drive in and for how long. All of the moves are run through a simulator on Earth to ensure the rovers won't crash into any boulders or drive off the edge of a cliff.

The process is arduous but it is the only way to drive a golf cart-sized buggy around a planet 161 million kilometres away. Because the driving instructions

are relayed via *Mars Odyssey*, they can take between one-and-a-half hours and a day to reach the rovers. Once the instructions arrive, though, they are handily carried out – remarkably, though long out of warranty, *Spirit* and *Opportunity* are carrying only a few mechanical injuries.

Despite intense radiation (unlike Earth,

Mars has no magnetic field to deflect particles spraying out of the Sun) and temperatures that dip below -95°C, the rovers keep going. So far, they have sent back a quarter of a million pictures from Mars and 36 gigabytes of scientific data.

Phoenix rising

While *Spirit* and *Opportunity* poked

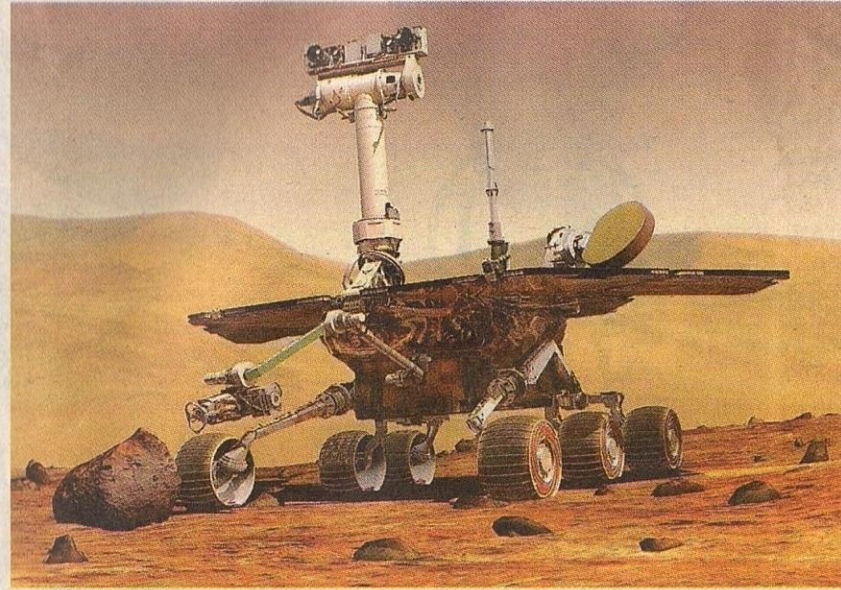
Rovers and orbiters and landers, oh my!

MARS exploration is not for the faint-hearted. Of 39 robotic missions launched since 1960, 22 have been outright failures. Some exploded on the launch pad, many were lost in space, and others simply crash-landed on arrival. The rocket journey from Earth to Mars can take 10 months and cover more than 600 million kilometres.

Robotic exploration is done using orbiters, landers, and rovers. Today, there are three orbiters circling the planet. The oldest, *Mars Odyssey*, arrived in 2001 and is creating maps of the planet's surface that reveal its mineral and chemical make-up.

The orbiter has played a vital role in relaying information from Mars rovers to Earth via its UHF antenna. Another orbiter, the European Space Agency's *Mars Express*, arrived in 2003 to look for signs of sub-surface water. In 2006, NASA's *Mars Reconnaissance Orbiter* arrived, carrying the most powerful camera ever taken to another planet. The orbiter is also being used to set up an interplanetary Internet link to Earth.

There are several defunct landers on Mars. *Viking 1* and *2*, which arrived in the mid-1970s, were the first US missions to land safely and return pictures from the red planet. Since then, there has been only one successful lander, the *Phoenix* probe, which touched

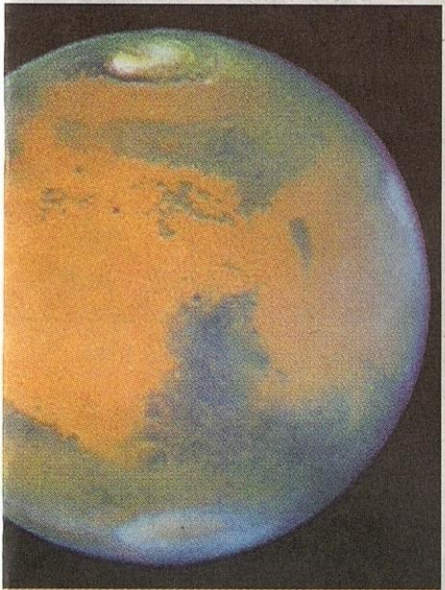
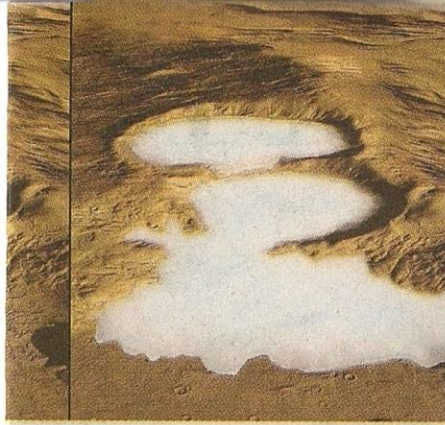


The Mars Exploration Rover looks like something you might build from a pile of junk – but it has been performing sturdily for five years, way beyond its expected 90-day lifespan. – Nasa photo

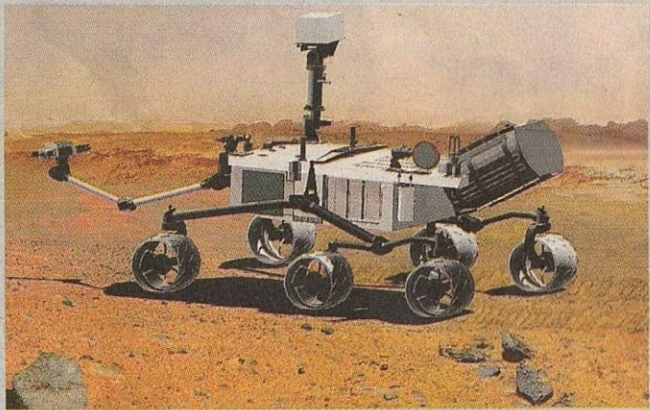
down in 2007 to investigate whether Martian soil could ever have been hospitable to life. Scientists lost contact with *Phoenix* in November last year.

Britain's ill-fated *Beagle 2* lander was flung at the red planet on Christmas Day 2003, after hitching a ride aboard *Mars Express*. It hasn't been seen since.

The first rover to land on Mars was NASA's *Pathfinder*, a technology demonstrator that touched down in 1997. The twin Mars "Exploration Rovers", *Spirit* and *Opportunity*, which arrived in 2004, are the only ones since, and they continue to send data back from the planet. – Guardian Newspapers Limited



The red planet as seen through the Hubble Space Telescope. – Reuters



Artist's concept of the next stage in the exploration of Mars: the Mars Science Laboratory, designed to investigate the planet's past or present ability to sustain microbial life. – AFP

What next?

The missions the heading to Mars in the future include:

- 2009 – Phobos-Grunt, a Russian mission to the Martian moon, Phobos, to bring back soil samples.
 - 2011 – *Mars Science Laboratory*, a Nasa rover twice the size of the *Spirit* and *Opportunity* probes. It will collect and analyse rocks and soil. Chief among its objectives is to find organic compounds and to check for environmental conditions that could have supported microbial life now or in the past.
 - 2013 – *Maven*, a Nasa orbiter designed to look at gases being given off from the Martian atmosphere.
 - 2016 – *ExoMars*, a European Space Agency mission to send an orbiter and rover to look for Martian life and possible surface hazards for future manned missions.
- Guardian Newspapers Limited

and prodded rocks dating back billions of years, the *Mars Phoenix* lander was sent to explore more recent conditions on the planet. The probe touched down after a flawless descent in the Martian Arctic last year, in an area known as Vastitas Borealis, or “Northern Waste”.

On arrival, *Phoenix's* lead scientist, Peter Smith, of the University of Arizona in the United States, expected the lander to find precisely what *Spirit* and *Opportunity* had already seen: a landscape smothered in acidic, salty soils that could hardly be considered hospitable.

There was good reason to think as much: the planet is frequently hit by giant dust storms that can measure thousands of kilometres wide. When they

strike, they whip up the soil and scatter it around on a global scale. The soil in one place, scientists thought, would be similar to that in another.

But built into *Phoenix* was a robotic arm that allowed it to reach down and gather clods of Martian soil to test with its onboard chemistry lab. And as *Phoenix's* arm scraped away at the frozen surface, it revealed clear patches of ice that quickly evaporated, making it the first probe to touch water on another planet.

On closer inspection, it became clear that the soil at *Phoenix's* feet, in the planet's Arctic circle, was very different to that found by *Spirit* and *Opportunity* at the Equator. It was slightly alkaline, like sea water, and contained calcium car-

bonate, which usually forms in the presence of water.

“It told us that Mars is not the same everywhere, as people were suggesting,” says Smith. “If the soil was acidic and salty everywhere, you would have trouble imagining life even getting started in a place like that, but we found conditions much like those you see in the Earth's oceans, and for those of us looking for habitable zones on Mars, that's good news.”

Scientists poring over data coming back from *Phoenix* are using it to work out what may have happened in the planet's past. Their best guess links the soil conditions to wild swings in the planet's orientation.

As the Earth orbits the Sun, it leans over on its axis at an almost constant 23.5°, and in doing so underpins the regularity of our seasons. Today, Mars is leaning over at around 25°, but five million years ago, that could have been 40° or even 50°. By showing more of its polar caps to the sun, the Martian ice will have warmed up and vaporised. The atmosphere would have become thick with ice clouds that later released snow, which fell to the ground and made the ground damp. That, at least, is the leading theory.

Further tests by the *Phoenix* lander found traces of a substance called perchlorate in the Martian soil. On Earth, some microbes use perchlorate as a source of energy, Smith says. The picture that emerges from *Phoenix* is that millions of years ago, when Mars was tilted more toward the sun, the planet may have been hospitable to life. Whether it remained so for long enough for primitive life to get started is another matter.

“We have nutrients in the soil, energy sources, and if there was liquid water five millions years ago, we're getting close to an environment where life could live,” says Smith. “If you tossed some Earthly life up there that hadn't evolved for the climate, then it probably couldn't survive. But you have to wonder if, over a long period of time – say a billion years – if Mars slowly transformed itself from a more benign place to what we see today, whether little creatures could have

evolved and maybe learned to survive.

“Life does amazing things on Earth. You can unfreeze the permafrost in Siberia and bring things back to life that have been encased in ice for a million years, so who knows?”

Last month, the evidence for life on Mars received another boost, when Nasa scientists reported enormous plumes of methane emanating from the planet's north during the summer months. Methane is not proof of life – it can just as well be released by geological processes – but the prospect that life might be responsible is tantalising none the less.

A smoking gun?

Nasa lost contact with the *Phoenix* lander on Nov 2 last year, after it had sent back 25,000 images from the planet. The probe died, or perhaps went into hibernation, when a dust storm darkened the sky and blocked light from reaching the lander's solar panels. The probe's batteries are now drained, and there is only a minute chance that it will power up when the sun is high in the sky again later this year.

In Arizona, Smith's team is turning its attention to an unsolved puzzle in the *Phoenix* data. Ironically, the presence of perchlorate in Martian soil ruined the probe's chances of detecting organic molecules, which would surely be there if life is present. By testing Martian soils concocted in the lab, and comparing the results with those from *Phoenix*, Smith believes he may answer the question yet.

Arvidson, who was on the *Phoenix* team and continues to work on the Nasa rovers, says the evidence from the latest missions points to a Mars that at least in the past could well have supported life.

“We've been to three locations and each has its own story of water interacting with the surface and beneath,” he says. “The question now is, was it habitable for long enough for life to synthesise and establish an ecosystem? We're paving the way to answer that question, for the future missions that will really dig in and look for the smoking gun.”

A trip to Mars, anyone? – Guardian Newspapers Limited