



From Mars with Love: Postcards from 50 years of Exploring the Red Planet

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Fifty years ago, Nasa's two *Viking* mission were on route to Mars. Each consisted of a sophisticated probe which would go into orbit, providing the first high-resolution maps of the red planet, and a lander which amongst much else would test for the presence of life. The results showed that our neighbour world, far from being a hospitable home for the intelligent Martians dreamt of in science fiction, was an arid, cold, lifeless desert. Relatively little attention was paid to Mars for nearly twenty years, but since the pioneering adventures of *Sojourner*, a tea-tray sized trundling rover, a succession of increasingly sophisticated missions have transformed our view of what now seems to be a planet with a complex past. The data and images they have returned to us have revealed that Mars was once wet, with rivers, lakes and perhaps even long-lived oceans. Though these friendly conditions did not survive the loss of a substantive atmosphere, but even today it is thought possible that life may just have survived. Yet the story of Mars is more than just one of habitability; with the largest volcano in the Solar System, a vast chasm which dwarfs Earth's Grand Canyon, and ice caps which grow and shrink with the seasons, it provides lessons in what planets can do. By far the best studied world other than our own, thinking about Mars is foundational to understanding how planets form and evolve. This lecture presents vignettes from ten missions to Mars, and illustrates the modern view of this fascinating world.

1. Viking

The Viking missions were unprecedented in scale and ambition, with two orbiters and two landers.

Dear Earth

From orbit, Mars looks like a fascinating world. We knew about the ice caps and the high desert from observations made at home, of course, but what's clear up close is that the surface has been shaped by liquid, most likely water. There are what seem to be river valleys hundreds of kilometres long, and whole parts of the planet which seem to have been affected by flash floods of unimaginable scale.

On the surface, the atmosphere seems to change with the seasons, the air pressure rising as carbon dioxide sublimates from the polar ice caps in summer. Regardless, it's always dusty – the sky seems pink with the stuff, and it gets everywhere. I did test for life like you wanted, and the results are...confusing. Best tell everyone that 'there's no conclusive evidence', as I'm sure that will satisfy them.

Yours, Viking.

2. Phoenix

Phoenix landed in the Martian artic in 2008, surviving for 157 sols¹. Its mission was to look for water ice in the Martian soil in this very alien environment.

Dear Earth,

Firstly: it's cold. Very cold indeed, and it's even snowing – dry ice falling from the sky. It's also windy, though the thin Martian air doesn't pack much of a punch. The landscape is peppered with small rocks and the freezing and thawing of the soil has split it into weird looking polygons.

You wanted water? Well, it's here, just as Mars Odyssey suggested from orbit. The soil is full of the stuff, and when I heat it to zero degrees Celsius it boils off. But the acidic soil has another surprise; it's full of perchlorate which is bad news for life, and may explain Viking's odd results all those years ago.

Got to go: winter is coming.

Phoenix.

PS Thanks for the DVD; shame the nearest player is millions of miles away.

3. Opportunity

The Opportunity rover landed on Mars in January 2004. It landed in an impact crater, that provided immediate access to bedrock, which was studied before the rover set off on a journey that lasted more than eight Martian years, and covered more than 45km.

Dear Earth

Hello from Mars!

After a bouncy ride to the surface, I was excited to see rocks. And what rocks they are – rich in blueberries. Not actual blueberries, you understand, but spherical concentrations of hematite which must have formed in water. Not exactly good enough to drink though; to form these things it must have been as acidic as sulphuric acid.

What I don't know is if the water on ancient Mars flowed freely, or if I've landed in what's left of a stagnant pond. Plenty of science to do – time to get some dust under these wheels and explore a little. My arm does feel a little creaky though; hope that's not a problem.

Onwards! Opportunity

¹ A sol is a Martian day, 24.5 hours long.

4. Spirit

The Spirit rover, along with its twin Opportunity, was launched in 2003, landing on Mars in January 2004. It landed in Gusev crater, an apparently dry lake bed. It covered more than 7 kilometers in a mission that lasted more than 2000 sols, into 2010, before getting stuck in a sandbed.

Dear Earth,

Still recovering from all the hard work at Comanche, a small rocky outcrop with a lot to say. It's rich in minerals that must have formed in a warm and watery environment, with no sign of the acidic conditions I (and Oppy) have found elsewhere. These carbonate deposits might be four billion years old, and prove that Mars was a very different place back then.

Other than that, I've been enjoying the spring winds blowing dust off my solar panels (it is very dusty here) which has meant that this extended trip has lasted much longer than the ninety days I originally planned. My right front wheel is busted, which is a drag, but in the trenches it produces as I trundle along we get a glimpse of what's under this endless sand.

Still, it would be nice to be repaired.

Spirit

5. Pathfinder and Sojourner

In the 1990s, Nasa was pursuing a policy of lower cost missions – ‘faster, cheaper, better’ was the slogan, in defiance of the engineering nostrum that states one can only have two of those three things. Pathfinder was an early success for the program, touching down on Mars nearly twenty years after the Viking landings, and demonstrating with Sojourner the potential of a rover.

Dear Earth

We've very glad to be here – the Great Galactic Ghoul spared us. It may have been a budget holiday, but the ride was fine, and the view from Sagan Memorial Station is great.

There's dust sticking to all but one of my magnets, and in communicating with you we've been able to find out that Mars has a solid iron core which might explain the lack of magnetic fields.

The weather's a bit of a worry – we've seen dust devils, and surprising swings in temperature. Bigger solar panels next time please.

Pathfinder & Sojourner

6. InSight

The InSight lander touched down in what its team of geophysicists lovingly called ‘the most boring place on Mars’ in 2018. Its seismometer successfully recorded Marsquakes, and used them to study the planet's interior, but the other main instrument, a mole intended to burrow into the ground, failed to deploy.

Dear Earth

No wonder none of your fancy rovers wanted this job. This place sucks. Nothing to see for as far as the camera can reach, just the empty plains and me.

Dig, you say? Well, you try digging in this stuff – the marvellous and expensive mole you've provided just keeps slipping out again. I have at least deployed the seismometer and so can spend sol after sol listening to the faint rumble of Marsquakes and, more likely, the wind as another dust devil rumbles past.

I guess I'll just hang around. Might dribble some sand on my solar panels for fun. They're not making a movie of this mission, that's for sure.

InSight.

5. Mars Reconnaissance Orbiter

Of all the orbiters that have visited Mars, MRO is special. It's HiRISE camera, capable of picking out features as small as rover tracks, has produced shots of breathtaking beauty, and a remote sensing dataset of unprecedented quality.

Dear Earth

Wow! I love Mars. It has majestic dunes, craters, valleys and old lava flows, and even the odd avalanche. I could stare at it all day. In fact, I usually do (unless there's a passing comet, of course).

I try not to have favourite places, but I do like the dark streaks on the northern planes. Could they be caused by flowing water? Or dust?

Speaking of dust, let's hope the weather stays clear. We don't need another global storm, thank you very much.

MRO

6. Curiosity

The Curiosity rover is on a different scale from its predecessors, and it needed a new way of getting to the surface. It was lowered to the surface from a rocket powered hovering platform in 2012, landing in Gale Crater. Since then it has been slowly climbing up the crater's central peak, Mount Sharp, reading Martian history as it goes.

Dear Earth,

Been busy doing chemistry since arriving here – that's what I'm built for, after all. Everything you need for life is here – SChNOps (Sulphur, Carbon, Hydrogen, Nitrogen, Oxygen and Phosphorus) in all sorts of combinations. So this was not only a wet place, once, but also somewhere where life could have got started.

I sang myself happy birthday one Earth year after getting here. Maybe a Martian year would have been more appropriate.

Curiosity

PS I keep looking for that methane you are so interested in. It's odd – sometimes I taste it, sometimes I don't. What's going on?

7. ExoMars Trace Gas Orbiter

Though this story has focused on the Nasa Mars program, ESA have been active at Mars too. Mars Express continues to monitor the planet's weather, while TGO arrived in 2016. Though its experimental Schiaparelli lander failed, TGO has been important in revealing the chemistry of the Martian atmosphere.

Dear Earth

Firstly, I feel my name is a bit of a mouthful. The American rovers have positive sounding names, and at least MRO has a forward-looking feel. ExoMars Trace Gas Orbiter feels like a name decided by committee, and I think TGO is a system for reviewing no balls in cricket.

That aside, I have been observing trace gases in the Martian atmosphere. Oxygen doesn't really count, but I've caught it glowing, and spent some time thinking about hydrogen chloride, and the destruction of carbon dioxide. What I can't see is any methane – none, zip, nada. And if Curiosity is right it should be there. Curiouser and curioser.

Yours,

ExoMars TGO

PS Where's my lander got to?

PPS mille-feuille. Really? One can be too European.

8. Perseverance

The Perseverance rover is the most advanced yet, landing on the red planet in an adapted version of Curiosity's skycrane system in 2021. While exploring Jezero Crater, its main goal is to collect samples for later return to Earth, though the future of any mission to do that is currently very uncertain. A recent announcement – perhaps conveniently timed for budget discussions in the US – suggested that the rover had found chemistry consistent with the presence of past life.

Dear Earth

Jezero Crater is fascinating; it appears a flood sculpted much of the landscape here in the distant past. I've had fun trundling around – pet rock on board for some of the time – and I know the geologists on the team seem excited.

The recent pictures of 'leopard spots' were exciting; is it possible that we're seeing here the signs of life on Mars altering its environment, just as it does on Earth? Who knows. I certainly can't do much more here than tell you what I see; a proper analysis will require getting samples back to you.

I've got several good samples on board, and have left others for you nicely stored and scattered around the landscape. When are you coming to get them? I'm a little concerned I haven't heard from you.

I'll keep going in the meantime. Clue's in the name,

Perseverance.

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Reading List

General books:

- *Mapping Mars*, Oliver Morton, 2002, Picador

Viking

- Nasa's archive: <https://science.nasa.gov/mission/viking/>

Phoenix

- NASA: <https://science.nasa.gov/mission/mars-phoenix/>
- Perchlorate: Hecht et al, 2009, *Science*, 325, 5936
<https://ui.adsabs.harvard.edu/abs/2009Sci...325...64H/abstract>
- Ice: Mellon et al., 2009, *JGR*, 114, 53, E00E07
<https://ui.adsabs.harvard.edu/abs/2009JGRE..114.0E07M/abstract>

Spirit and Opportunity

- The Planetary Society have an excellent bibliography here:
<https://www.planetary.org/space-missions/mars-exploration-rovers>
- NASA: <https://science.nasa.gov/mission/mars-exploration-rovers-spirit-and-opportunity/science-highlights/>
- Roving Mars: Spirit, Opportunity, and the Exploration of the Red Planet, 2006, Squyres, Hachette
- Spirit: Nice Scientific American article here:
<https://www.scientificamerican.com/article/water-mars-carbonate/>
- Spirit at Comanche: Morris et al., 2010, 329, 5990, 421
<https://www.science.org/doi/10.1126/science.1189667>
- The film 'Good Night Oppy' tells the story of the two Mars rovers. It is currently available on Amazon Prime in the UK.

Pathfinder

- Golombek, M. et al. 1997. "Overview of the Mars Pathfinder Mission and Assessment of Landing Site Predictions". *Science*. *Science*: 278. pp. 1743–1748
- There's an overview of the results in a special edition of the *Journal of Geophysical Research*: [https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/\(ISSN\)2169-9100.RESPATH1](https://agupubs.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)2169-9100.RESPATH1)

Insight

- There's an overview of the mission here, <https://www.jpl.nasa.gov/news/a-year-of-surprising-science-from-nasas-insight-mars-mission/>, with links to the main papers from the first year.

Curiosity

There are two excellent books about the rover itself:

- Mars Rover Curiosity: An Inside Account from Curiosity's Chief Engineer, Manning and Simon, 2014, Bravo

- The Design and Engineering of Curiosity: How the Mars Rover Performs Its Job, Lakdawalla, 2018, Praxis

MRO

- I strongly recommend losing yourself in the images at the HiRISE website: <https://hirise.lpl.arizona.edu>

TGO

- ESA website: https://www.esa.int/Science_Exploration/Human_and_Robotic_Exploration/Exploration/ExoMars
- Methane results are Korablev et al., Nature, 2019: https://oro.open.ac.uk/60547/2/2019%20Korablev%20TGO%20methane%20Nature_accepted.pdf
- Mille-feuille atmospheric structure is reported in Thomas et al, Science Advances, 2025, 11, 38, <https://www.science.org/doi/10.1126/sciadv.adu0859>

Perseverance

- Possible detections of signs of life: <https://www.jpl.nasa.gov/news/nasas-perseverance-rover-scientists-find-intriguing-mars-rock/>