I BET YOU DIDN'T KNOW...

InSight into Mars

Prof. Dudley Shallcross, PSTT CEO, links **cutting-edge research** with the **principles of primary science**

dudley.shallcross@pstt.org.uk

Mars is the fourth planet from the Sun, the 'Red Planet', and can be seen from Earth with a telescope at various times in the year. The red colour comes from iron in the soil, in a similar way to soils found on Earth. It is smaller than Earth and further away from the Sun (about 1.5 times further away). A day on Mars is very similar in length to a day on Earth and the planet takes 687 days to orbit the Sun. Mars has two moons, Phobos and Deimos. There have been a number of spacecraft launched with the intention of orbiting Mars (the earliest successful one was in 1965 as part of the Mariner programme) and some have been designed to land on the planet. The successful missions have provided a lot of information about Mars.

Discussion: Why do you think more information is obtained about the planet by landing on it and analysing it *in situ*?

Mars rovers, Spirit and Opportunity, landed in January 2004 and explored the surface of Mars long after their expected 90 day expeditions, and their signals were still being received up until 2018 (see https://mars.nasa.gov/mer/ for the latest news). These probes have provided much important information. Curiosity Rover landed in 2012 and began to explore the surface of Mars and it is still working (see https://mars.nasa.gov/msl/home/ for the latest news). In recent papers published in 2020, scientists describe the 'Initial results from the InSight mission to Mars'. NASA's InSight (**In**terior exploration using **S**eismic **I**nvestigations, **G**eodesy and **H**eat **T**ransport) craft landed on the *Elysium Planitia* (a broad plane that straddles the equator of Mars) on Mars on the 26th November 2018 (Figure 1). Its aim was to provide data to allow researchers to determine the structure of the interior of Mars, its *seismicity* and its impact cratering rate.

Discussion: Why couldn't orbiters provide the same data? What do we know about the seismicity on Earth? What is *impact cratering rate* and why would we want to know this?

So, what has InSight found out in the first year of its mission? (live updates can be found from https://mars.nasa.gov/insight/).

174 marsquakes (note the name) had been detected in the first six months, with 150 small magnitude events that are from the crustal surface, and 24 sub-crustal events

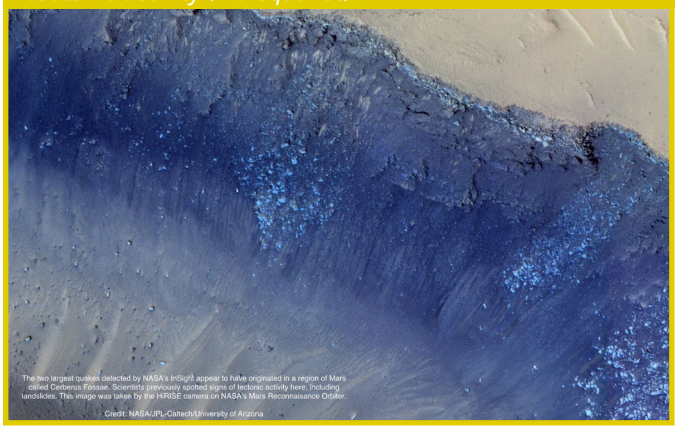
Figure 1. a). NASA InSight's first 'selfie' and b). InSight's scoop pushes on top of the 'mole', Insight's Heat Flow and Physical Properties Package,a self-hammering heat probe that measures the heat flowing from the planet.

(from deeper into the surface of Mars) that are higher in magnitude (equivalent to 3-4 on the Richter scale used to measure earthquakes). Figure 2 demonstrates how marsquakes may move through the planet. Two of the largest marsquakes were located near the *Cerberus Fossae* fracture system. On Earth, earthquakes occur along the boundaries between different *tectonic plates*. Mars does not have tectonic plates like Earth but does have volcanoes and marsquakes seem to occur at the boundary between different rock systems along the fault lines generated, it is assumed, by the volcanic activity in the past (Figure 3). *Seismic activity* is very low during the martian night but increases in the day and scientists are analysing data to understand why this occurs.

Do you know that moonquakes have also been detected on the Earth's moon?

Figure 2. An artist's concept of seismic waves through Mars' interior (GIF format - click on the image to view an animation showing seismic waves through Mars' interior).

Figure 3. Landslide on the Mars surface indicating tectonic activity (marsquakes).



The magnetic field detected by InSight is around ten times stronger than that inferred from orbiter measurements (a reason why surface measurements are so important) and preliminary studies suggest that there are magnetised rocks beneath the surface of Mars that are 3.9 billion years old. Mars did have a magnetic field like Earth a long time ago but does not now, but rocks have become magnetised and persist today.

InSight also provides weather data for Mars and it is now possible to obtain a daily weather report from the NASA website. A *sol* is a Mars day. It is slightly longer than an Earth day at 24 hours, 39 minutes and 35 seconds. As an example of data obtained, we have selected Sol 19. On this day, the wind speed varied between 7.5 and 17.5 metres per second (27-63 km/h), The temperature was about 180 K (-93.15 °C) just before Martian dawn and peaking at about 250 K (-23.15 °C) around Martian midday. The surface pressure varied between 720 and 760 *Pascals* (Pa) – this is over 100 times lower than Earth (on Earth, the surface pressure would be around 101,000 Pa). These are typical variations seen each day, while dust storms have been regularly detected.

In other words, it is windy, dusty and very cold on the surface of Mars. The Martian atmosphere contains mainly carbon dioxide (CO_2) and so you could not breathe on Mars without a space suit and a life support system.

The Teacher Guide that accompanies this series of *I bet you didn't know...* articles on planets includes activities that enable children to learn more about the Earth and space, the processes of science research and to develop their own enquiry skills.

Activities that are relevant to this article include:

- Researching all the missions to Mars: which succeeded, and which failed, which countries led them and their objectives
- Finding out about some of the scientists/engineers who worked on the InSight program
- Investigating the formation of 'craters' by dropping meteors into sand
- Magnetising metals
- Analysis of Mars weather data – plotting graphs

GLOSSARY

in situ
in the original place

Pascal
a unit of pressure (equivalent to one Newton per square metre)

seismic activity
the types, frequency and size of earthquakes over a period of time in a given region

sol
a solar day on Mars (24 hours, 39minutes, 35 seconds)

tectonic plates
massive pieces of land that connect together on the earth's outer shell. These pieces bump together and move, just a few centimetres each year

The papers that inspired this work are:

The seismicity of Mars .

By D. Giardini,[1] P. Logonne,[2,3] W.B. Banerdt,[4] W.T. Pike,[5] U. Christensen,[6] S. Ceylan,1 J.F. Clinton,[7] M. van Driel,[1] S.C. Staehler,[1] M. Bose,[1,7] R.F. Garcia,[8] A. Khan,[1,9] M. Panning,[4] C. Perrin,[2] D. Banfield,[10] E. Beucler,[11] C. Charalambous,[5] F. Euchner,[1] A. Horleston,[12] A. Jacob,2 T. Kawamura,[2] S. Kedar,[4] G. Mainsant,[8] J-R. Scholz,[6] S.E. Smrekar,[4] A. Spiga,[3,13] C. Agard,[14] D. Antonangeli,[15] S. Barkaoui,[2] E. Barrett,[4] P. Combes,[14] V. Conejero,[2] I. Daubar,[16] M. Drilleau,[2] C. Ferrier,[14] T. Gabsi,[2] T. Gudkova,[17] K. Hurst,[4] F. Karakostas,[18] S. King,[19] M. Knapmeyer-Endrun,[20] R. Llorca-Cejudo,[14] A. Lucas,[2] L. Luno,[14] L. Margerin,[22] J.B. McClean,[5] D. Mimoun,[8] N. Murdoch,[8] F. Nimmo,[23] M. Nonon,[14] C. Pardo,[2] A. Rivoldini,[24] J.A.R. Manfredi,[25] H. Samuel,[2] M. Schimmel,[26] A.E. Stott,[5] E. Stutzmann,[2] N. Teanby,[12] T. Warren,[27] R.C. Weber,[28] M. Wieczorek,[29] C. Yana,[14] .

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1. *Swiss Federal Institute of Technology, Institute of Geophysics, Department of Earth Science, Zurich, Switzerland.*
2. *Université de Paris, CNRS, Institut de Physique du Globe de Paris, France.*
3. *Institut de Université de France, Paris, France.*
4. *Jet Propulsion Lab., California Institute of Technology, Pasadena, California, USA.*
5. *Department of Electrical and Electrical Engineering, Imperial College, London, England.*
6. *Max Planck Institute for Solar System Research, Gottingen, Germany.*
7. *Swiss Federal Institute of Technology, Swiss Seismology Service SED, Zurich, Switzerland.*
8. *Institut supérieur de l'aéronautique et de l'espace (ISAE-SUPAERO), Toulouse, France.*
9. *University of Zurich, Institute of Theoretical Physics, Zurich, Switzerland.*
10. *Cornell University, Cornell Centre for Astrophysics and Planetary Science, Ithaca, New York, USA.*
11. *University of Nantes, CNRS, Laboratory of Planetology and Geodynamics, Nantes, France.*
12. *University of Bristol, Department of Earth Science, Bristol, England.*
13. *Sorbonne University, Laboratory of Meteorology and Dynamics, Paris, France.*
14. *Centre National Etude Spatiales, Toulouse, France.*
15. *Sorbonne University, Museum of Natural History, Institut de minéralogie, de physique des matériaux et de cosmochimie, Paris, France.*
16. *Brown University, Department of Earth, Environment and Planetary Science, Providence, RI 02912, USA.*
17. *Russian Academy of Science, Schmidt Institute of Physical Earth, Moscow, Russia.*
18. *University of Maryland, Department of Geology, College Park, Maryland 20742, USA.*
19. *Virginia Polytechnical Institute and State University, Department of Geoscience, Blacksburg, VA, USA.*
20. *DLR Institute of Planetary Research, Berlin, Germany.*
21. *University of Cologne, Bensberg Observatory, Bergisch Gladbach, Germany.*
22. *University of Toulouse, 111 Paul Sabatier, CNRS, CNES, Institute of Research in Astrophysics and Planetology, Toulouse, France.*
23. *University of California at Santa Cruz, Department of Earth and Planetary Science, Santa Cruz, CA 95064, USA.*
24. *Royal Observatory, Belgium, Brussels, Belgium.*
25. *Institute of National Technology in Aerospace, Centre for Astrobiology, Madrid, Spain.*
26. *CSIC, Spanish Research Council, ICTJA, Institute of Earth Science Jaume Almera, Barcelona, Spain.*
27. *University of Oxford, Department of Physics, Oxford, England.*
28. *Marshall National Space Flight Centre, Huntsville, USA.*
29. *Universite de Cote Azur, Observatory Cote Azur, Lagrange Laboratory, CNRS, Nice, France.*

Crustal and time-varying magnetic fields at the InSight landing site on Mars .

By C.L. Johnson,[1,2] A. Mittleholz,[1] B. Langlais,[3] C.T. Russell,[4] V. Ansan,[3] D. Banfield,[5] P.T.J. Chi,[4] P.O. Ellinghim,[6] F. Forget,[7] H.F. Haviland,[8] M. Golombek,[9] S. Joy,[4] P. Logonne,[10] X.P. Liu,[4] C. Michaut,[11] L. Pan,[12] C. Quantin-Nataf,[11] A. Spiga,[7,13] S. Stanley,[14,15] S.N. Thorne,[11] M.A. Wieczorek,[16] Y.N. Yu,[4] S.E. Smrekar,[9] W.B. Banerdt.[9].

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1. *University of British Columbia, Department of Earth, Ocean and Atmospheric Science, Vancouver, British Columbia, Canada.*
2. *Planetary Science Institute, Tucson, AZ 85719, USA.*
3. *University of Nantes, CNRS, Laboratory of Planetology and Geodynamics, UMR 6112, Nantes, France.*
4. *University of California, Los Angeles, Earth, Planetary and Space Science, Los Angeles, CA, USA.*
5. *Cornell Centre, Astrophysics and Planetary Science, Ithaca, New York, USA.*
6. *University of California Berkeley, Space Science Laboratory, Berkeley, CA 94720, USA.*
7. *Sorbonne University, Ecole Polytechnic, CNRS, LMD IPSI ENS, Pierre and Marie Curie BC99, Paris, France.*
8. *Marshall Space Flight Centre, Huntsville, Alabama, USA.*
9. *California Institute of Technology, Jet Propulsion Lab., Pasadena, CA, USA.*
10. *University of Paris Diderot, Institute of Physics, Sorbonne Paris, France.*
11. *UCBL, Ecole Normale Super Lyon, University of Lyon, CNRS, Laboratory of Geology, Lyon, France.*
12. *University Claude Bernard, Lyon ENS, CNRS UMB 5276, Lyon, France.*
13. *IUF, Paris, France.*
14. *Johns Hopkins University, Department of Earth and Planetary Science, Baltimore, MD 21218, USA.*

15. *Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, USA.*

16. *University Cote Azur, Observatory Cote Azur, CNRS, Lagrange Laboratory, Nice, France.*

The atmosphere of Mars as observed by InSight.

By D. Banfield,[1] A. Spiga,[2,3] C. Newman,[4] F. Forget,[2] M. Lemmon,[5] R. Lorenz,[6] N. Murdoch,[7] D. Vludez-Moreiras,[8] J. Pla-Garcias,[5,8] R.F. Garcia,[7] P. Lognonne,[3,9] O. Karatekin,[10] C. Perrin,[9] L. Martire,[7] N. Teanby,[11] B. Van Hove,[10] J.N. Maki,[12] B. Kenda,[9] N.T. Mueller,[13] S. Rodriguez,[3,9] T. Kawamura,[9] J.B. McLean,[14] A.E. Stott,[14] C. Charalambous,[14] F. Millour,[2] C.L. Johnson,[15,16] A. Mittleholz,[15] A. Maattanen,[17] S.R. Lewis,[18] J. Clinton,[19] S.C. Staehler,[20] S. Ceylan,[20] D. Giardini,[20] T. Warren,[21] W.T. Pike,[14] I. Daubar,[22] M. Golombek,[12] L. Rolland,[23] R. Widmer-Schnidrig,[24] D. Mimoun,[7] E. Beucler,[25] A. Jacob,[9] A. Lucas,[9] M. Baker,[26,27] V. Ansan,[25] K. Hurst,[12] L. Mora-Sotomayor,[18] S. Navarro,[8] J. Torres,[8] A. Lepinette,[8] A. Molina,[8] M. Marin-Jimenez,[8] J. Gomez-Elvira,[8] V. Peinado,[8] J-A. Rodriguez-Manfredi,[8] B.T. Carcich,[1] S. Sackett,[1] C.T. Russell,[28] T. Spohn,[13] S.E. Smrekar,[12] W.B. Banerdt.[12].

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1. *Cornell Centre, Astrophysics and Planetary Science, Ithaca, New York, 14853, USA.*
2. *Laboratoire de Meteorologie Dynamique / Institut Pierre Simon Laplace (LMD/IPSL), Sorbonne Universite´, Centre Institute Université of France, Paris, France.*
3. *Institute Université France, Paris, France.*
4. *Aeolis Research, 333 N Dobson Road, Unit 5, Chandler AZ 85224-4412, USA.*
5. *Space Science Institute, Boulder, CO USA.*
6. *Johns Hopkins University, Applied Physics Laboratory, Laurel, MD, USA.*
7. *Institut supérieur de l'aéronautique et de l'espace (ISAE-SUPAERO), Toulouse, France.*
8. *CSIC, Spanish Research Council, ICTJA, Institute of Earth Science Jaume Almera, Barcelona, Spain.*
9. *Universite Paris, CNRS, Institute Physics, Paris, France.*
10. *Royal Observatory Belgium, Brussels, Belgium.*
11. *University of Bristol, School of Earth Science, Bristol, England.*
12. *California Institute of Technology, JPL, Pasadena, CA, USA.*
13. *German Aerospace Centre DLR, Institute of Planetary Research, Germany.*
14. *Imperial College London, Department of Electrical and Electronic Engineering, London, England.*
15. *University of British Columbia, Department of Earth, Ocean and Atmospheric Science, Vancouver, BC, Canada.*
16. *Planetary Space Institute, Tucson, AZ, USA.*
17. *Laboratoire ATmosphe`re Milieux Observations Spatiales / Institut Pierre-Simon Laplace (LATMOS/IPSL), Sorbonne, Universite´, Universite´ Paris-Saclay, Universite´ de Versailles Saint-Quentin-en-Yvelines, Centre National de la Recherche Scientifique, 78280 Guyancourt, France.*
18. *Open University, School of Physical Science, Milton Keynes, England.*
19. *Swiss Federal Institute of Technology, Swiss Seismology Service SED, Zurich, Switzerland.*
20. *Swiss Federal Institute of Technology, Institute of Geophysics, Zurich, Switzerland.*
21. *University of Oxford, Department of Physics, Oxford, England.*
22. *Brown University, Department of Earth, Environment and Planetary Science, RI 02912, USA.*
23. *Universite Cote Azur, Observatory Cote Azur, CNRS, Valbonne, France.*
24. *Stuttgart University, Black Forest Observatory, Wolfach, Germany.*
25. *Universite Nantes, Laboratory of Planetology and Geodynamics, UMR6112, Nantes, France.*
26. *Johns Hopkins University, Morton K Blaustein Department of Earth and Planetary Science, Baltimore, MD, USA.*
27. *Smithsonian Institute, Centre for Earth and Planetary Studies, National Air and Space Museum, Washington DC, 20560, USA.*
28. *UCLA, Department of Earth, Planetary and Space Science, Los Angeles, CA, USA.*