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editorial

Mars gets geophysical

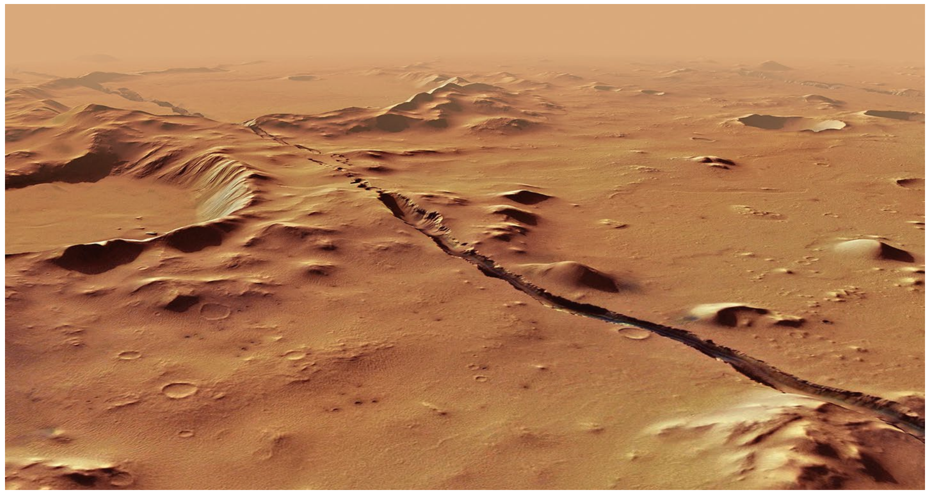
The first marsquakes detected by NASA's InSight mission mark just the start of seismology on Mars. Both Earth and planetary scientists alike should embrace this new frontier of geophysics.

On 17 April 1889, a distant earthquake in Tokyo was detected from the perturbation of a horizontal pendulum in Potsdam, Germany (https://go.nature.com/2ViZq4E). Eighty years after this turning point in the development of modern seismology, the Apollo missions deployed several seismometers on the Moon. The next decade saw a functioning seismometer on Mars with the Viking 2 lander and, in 1982, Soviet Venera landers brought seismometers to Venus. The lunar seismometers were shut off in 1977 after a successful campaign, but the Viking seismometer detected mostly wind in the year or so that it operated, and the Venera seismometers survived only hours under the harsh Venusian conditions. Planetary seismology then went silent for almost 40 years. In late 2018, NASA's InSight lander touched down on Mars and — 130 years since the first recorded teleseismic event on Earth — its seismometer recorded the first unambiguous marsquakes. This issue features the initial results from the InSight mission. Planetary seismology is at the frontier of geophysics and *Nature Geoscience* is along for the ride.

Seismic data can be used to decipher a planet's interior structure and composition. Terrestrial seismology has long since moved beyond the detection of seismic waves with single simple pendulums: today, seismology on Earth is conducted using networks of sophisticated seismometers that can measure the seismic wave arrivals from a single event at multiple locations to better characterize the event and pinpoint its location.

The Apollo missions also established a network — albeit a small one of four stations — on the lunar nearside. A variety of moonquakes with both deep and shallow sources were detected, providing tantalizing clues about the structure and seismic activity of the Moon.

InSight, however, was only able to deploy a single seismometer. So, in some ways, seismology on Mars is beginning similarly to that first teleseismic recording 130 years ago (https://go.nature.com/38URz1h). But that single InSight seismometer has benefited from the advances in instrumentation that have followed the lessons learned from early attempts at planetary seismology. InSight's seismometer is designed to block out the weather, complemented by a suite of other instruments that can characterize the background noise, and tuned to detect even faint marsquake signals.



A fracture running through the Cerberus Fossae region on Mars where NASA's InSight mission has detected marsquakes, as seen by ESA's Mars Express orbiter. Credit: ESA/DLR/FU Berlin, CC BY-SA 3.0 IGO

Over its first 10 months of operation, InSight detected 174 seismic events on Mars. Strikingly, two seismic events of over magnitude 3 have been traced to the Cerberus Fossae region, which shows evidence of recent faulting and volcanism. These detections point towards a tectonically active planet. Analysis of the seismic events also constrains the structure of the Martian crust, and suggests that Martian seismicity is similar to terrestrial intraplate seismic activity for small events, although relatively fewer large quakes have been detected.

Meanwhile, InSight's other instruments primarily intended to characterize the ambient noise around the seismometer have yielded their own surprising scientific discoveries. Weather measurements have revealed a range of turbulent processes in a dynamic atmosphere and the magnetometer measurements support an unexpectedly strong crustal magnetic field, at least locally.

The publication of this package of initial results from InSight also represents a new frontier for *Nature Geoscience*: this is the first time we have led such a package from a planetary mission. We are publishing these papers partly because of the inherent novelty of the results — including the first unambiguous detections of marsquakes and the first magnetic field measurements on the Martian surface — but mostly because the science questions that InSight seeks to answer about the interior structure and evolution of Mars are just the sort of questions that *Nature Geoscience* has long been asking in its pages, for both Earth and its planetary neighbours.

The InSight mission is only intended to operate for a couple of Earth years, but when geophysical data are carefully stored and made available to future generations of scientists, they have a long scientific shelf life, as demonstrated by the legacy of the Apollo missions. It has been more than 40 years since the Apollo seismometers were mothballed and we still occasionally receive submissions with new analyses of these lunar seismic data (for example, https://go.nature.com/2HQzuFI).

The initial InSight results reported in this issue of *Nature Geoscience* are only the beginning of the science that will come out of this mission. Insights from InSight will continue far beyond the mission's limited lifetime and will not be limited to marsquakes: planetary geophysics missions offer glimpses into the workings of terrestrial planets, including our own. ❐

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