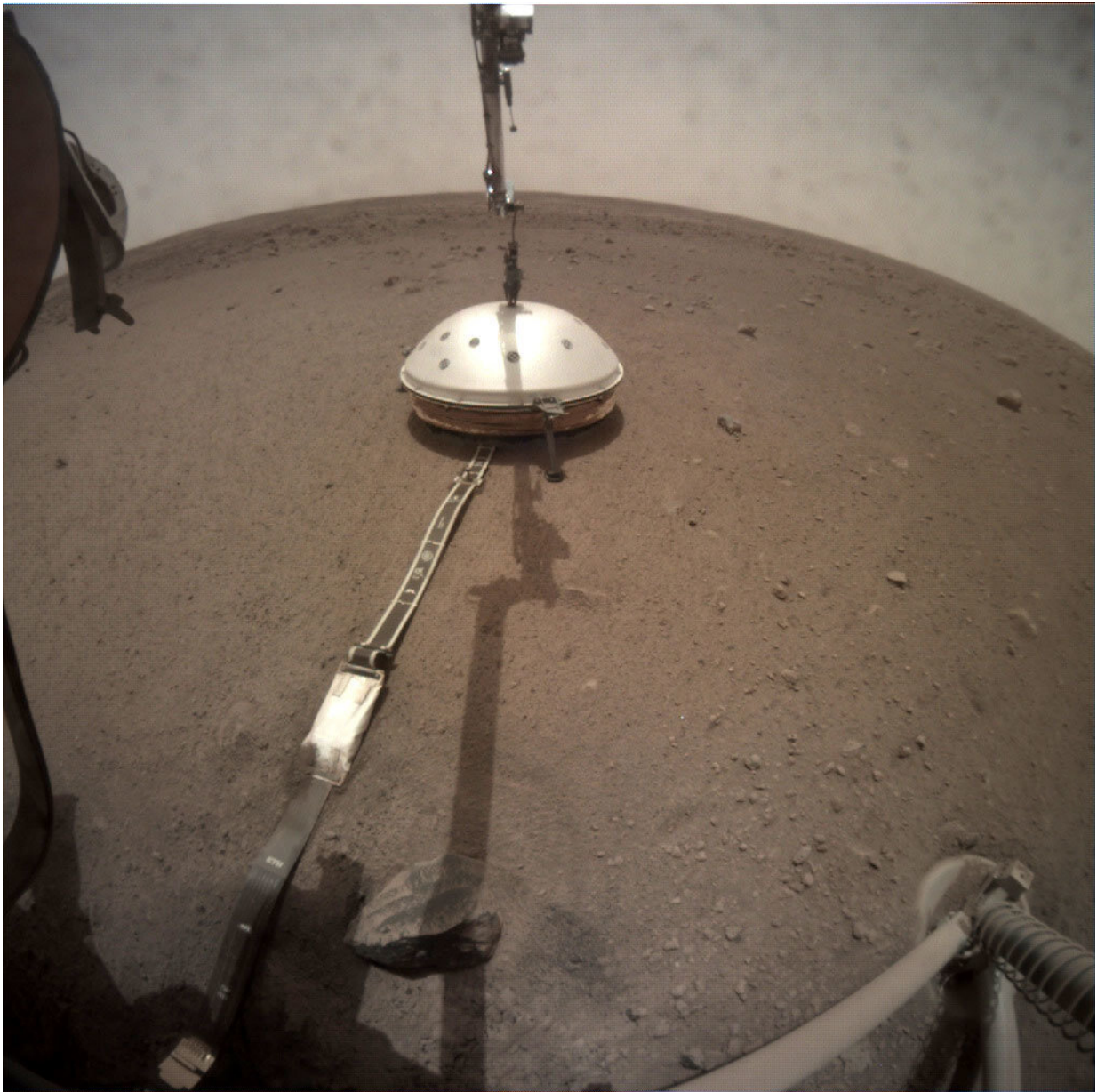


First direct seismic measurements of Mars reveal a geologically active planet

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NASA's InSight lander deployed its seismometer on the Martian surface on Dec. 19, 2018. This image, captured on Feb. 2, 2019 (Martian Sol 66) by the deployment camera on the lander's robotic arm shows the protective wind and thermal shield which covers the seismometer. Credit: NASA/JPL-Caltech

The first reports of seismic activity and ground vibrations on Mars are in. The red planet has a moderate level of seismic activity, intermediate between Earth and the Moon.

An international team that includes University of Maryland geologists released preliminary results from the InSight mission, which landed a probe on Mars on November 26, 2018. Data from the mission's Seismic Experiment for Interior Structure (SEIS) provided the first direct seismic measurements of the Martian subsurface and upper crust—the rocky outermost layer of the planet. The results were published in a special issue of the journal *Nature Geoscience* on February 24, 2020.

"This is the first mission focused on taking direct geophysical measurements of any planet besides Earth, and it's given us our first real understanding of Mars' interior structure and [geological processes](#)," said Nicholas Schmerr, an assistant professor of geology at UMD and a co-author of the study. "These data are helping us understand how the planet works, its rate of seismicity, how active it is and where it's active."

The seismic data acquired over 235 Martian days showed 174 seismic events, or marsquakes. Of those, 150 were high-frequency events that produce ground shaking similar to that recorded on the Moon by the Apollo program. Their waveforms show that seismic waves bounce around as they travel through the heterogeneous and fractured Martian crust. The other 24 quakes observed by SEIS were predominantly low-

frequency events. Three showed two distinct wave patterns similar to quakes on Earth caused by the movement of tectonic plates.

"These low-frequency events were really exciting, because we know how to analyze them and extract information about subsurface structure," said Vedran Lekic, an associate professor of geology at UMD and a co-author of the study. "Based on how the different waves propagate through the crust, we can identify geologic layers within the planet and determine the distance and location to the source of the quakes."

The researchers identified the source location and magnitude of three of the low-frequency marsquakes, and believe that 10 more are strong enough to reveal their source and magnitude once they are analyzed.

"Understanding these processes is part of a bigger question about the planet itself," Schmerr said. "Can it support life, or did it ever? Life exists at the edge, where the equilibrium is off. Think of areas on Earth such as the thermal vents at the deep ocean ridges where chemistry provides the energy for life rather than the sun. If it turns out there is liquid magma on Mars, and if we can pinpoint where the planet is most geologically active, it might guide future missions searching for the potential for life."

Detecting signs of life was the primary mission of the earlier Mars probes, Viking 1 and Viking 2. Each carried seismometers, but they were mounted directly on the landers and provided no useful data. The Viking 1 instrument did not unlock properly, and Viking 2 only picked up noise from wind buffeting the lander but no convincing marsquake signals.

The InSight mission is dedicated specifically to geophysical exploration, so engineers worked to solve previous noise problems. A [robotic arm](#) on the lander placed the SEIS seismometer directly on the Martian ground

some distance away to isolate it from the lander. The instrument is also housed in a vacuum chamber and covered by the aptly named Wind and Thermal Shield. The SEIS seismometer is sensitive enough to discern very faint ground vibrations, which on Mars are 500 times quieter than ground vibrations found in quietest locations on Earth.

In addition, the seismometer provided important information about Martian weather. Low-pressure systems and swirling columns of wind and dust called dust devils lift the ground enough for the seismometer to register a tilt in the substrate. High winds flowing across the surface of the ground also create a distinct seismic signature. Combined with data from meteorological instruments, SEIS data help paint a picture of the daily cycles of surface activity near the InSight lander.

The researchers found that the winds pick up from about midnight through early morning, as cooler air rolls down from highlands in the Southern Hemisphere onto the Elysium Planitia plains in the Northern Hemisphere where the lander is located. During the day, heating from the sun causes convective winds to build. Winds reach their peak in late afternoon when atmospheric pressure drops and dust devil activity occurs. By evening, the winds die down, and conditions around the lander become quiet. From late evening until about midnight, atmospheric conditions are so quiet, the seismometer is able to detect the rumblings from deeper inside the planet.

All of the marsquakes have been detected during these quiet periods at night, but the geologic activity likely persists throughout the day.

"What is so spectacular about this data is that it gives us this beautifully poetic picture of what a day is actually like on another planet," Lekic said.

The InSight mission is scheduled to continue collecting data through

2020.

The research papers, "Constraints on the shallow elastic and anelastic structure of Mars from InSight [seismic data](#)," P. Lognonné et al., and "Initial results from the InSight mission on Mars" by W. Banerdt et al., were published as part of a special issue of the journal *Nature Geoscience* released on February 24, 2020.

More information: Initial results from the InSight mission on Mars, *Nature Geoscience* (2020). [DOI: 10.1038/s41561-020-0544-y](https://doi.org/10.1038/s41561-020-0544-y) , [nature.com/articles/s41561-020-0544-y](https://www.nature.com/articles/s41561-020-0544-y)

Constraints on the shallow elastic and anelastic structure of Mars from InSight seismic data, *Nature Geoscience* (2020). [DOI: 10.1038/s41561-020-0537-x](https://doi.org/10.1038/s41561-020-0537-x) , [nature.com/articles/s41561-020-0536-y](https://www.nature.com/articles/s41561-020-0536-y)

Provided by University of Maryland

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