Retrieval of Near Surface Properties of Martian Regolith Using Under-Sampled Repeating Hammer Source During the 2018 InSight Mission

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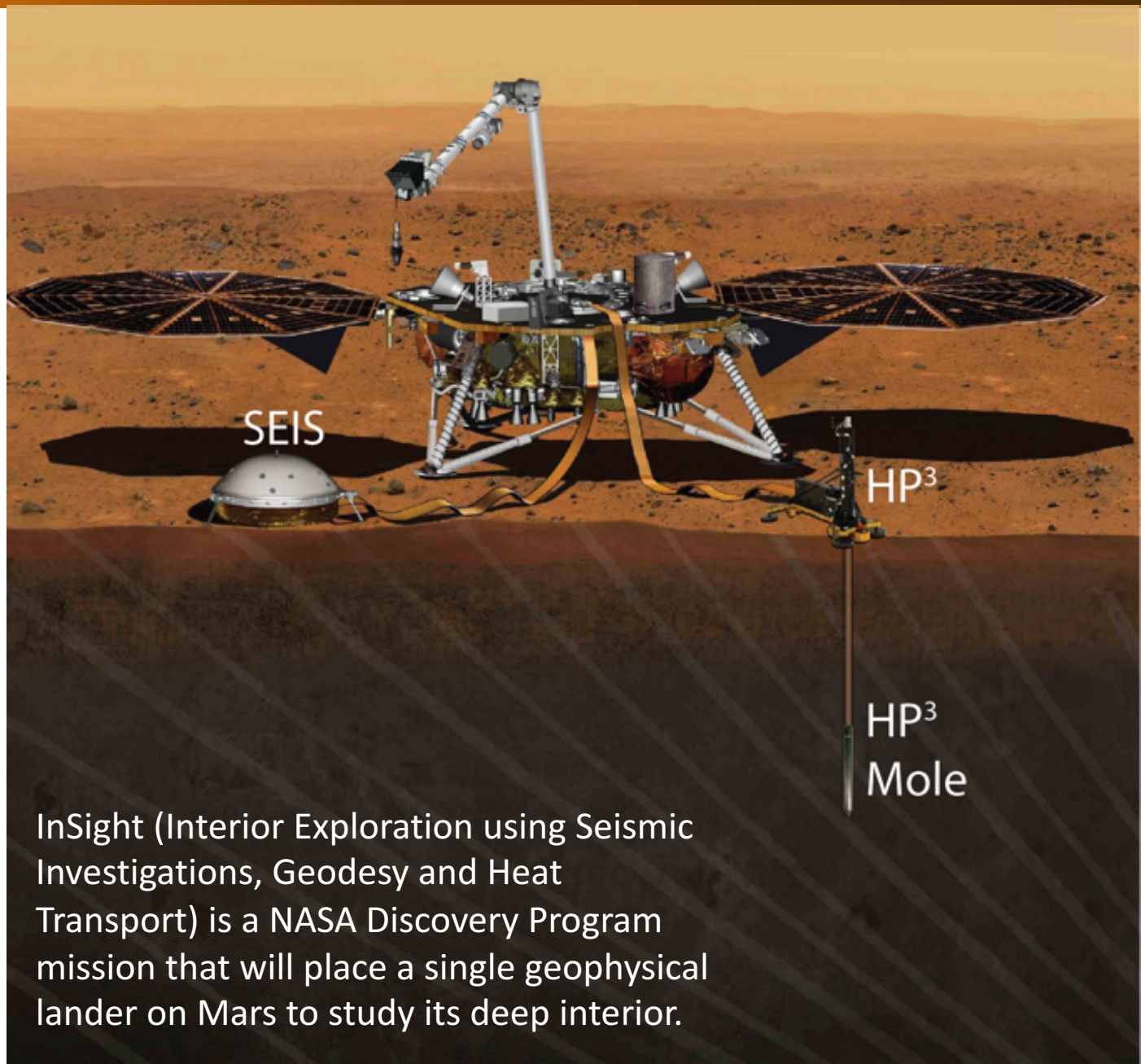
InSight Mission overview

InSight Key Dates

- Launch: May 2016
- Landing: September 2018
- Surface operations: 720 days / 700 sols
- First science return: November 26, 2018
- Instrument deployment: 60 sols (including 20 sols margin)
- End of Mission: September 18, 2018

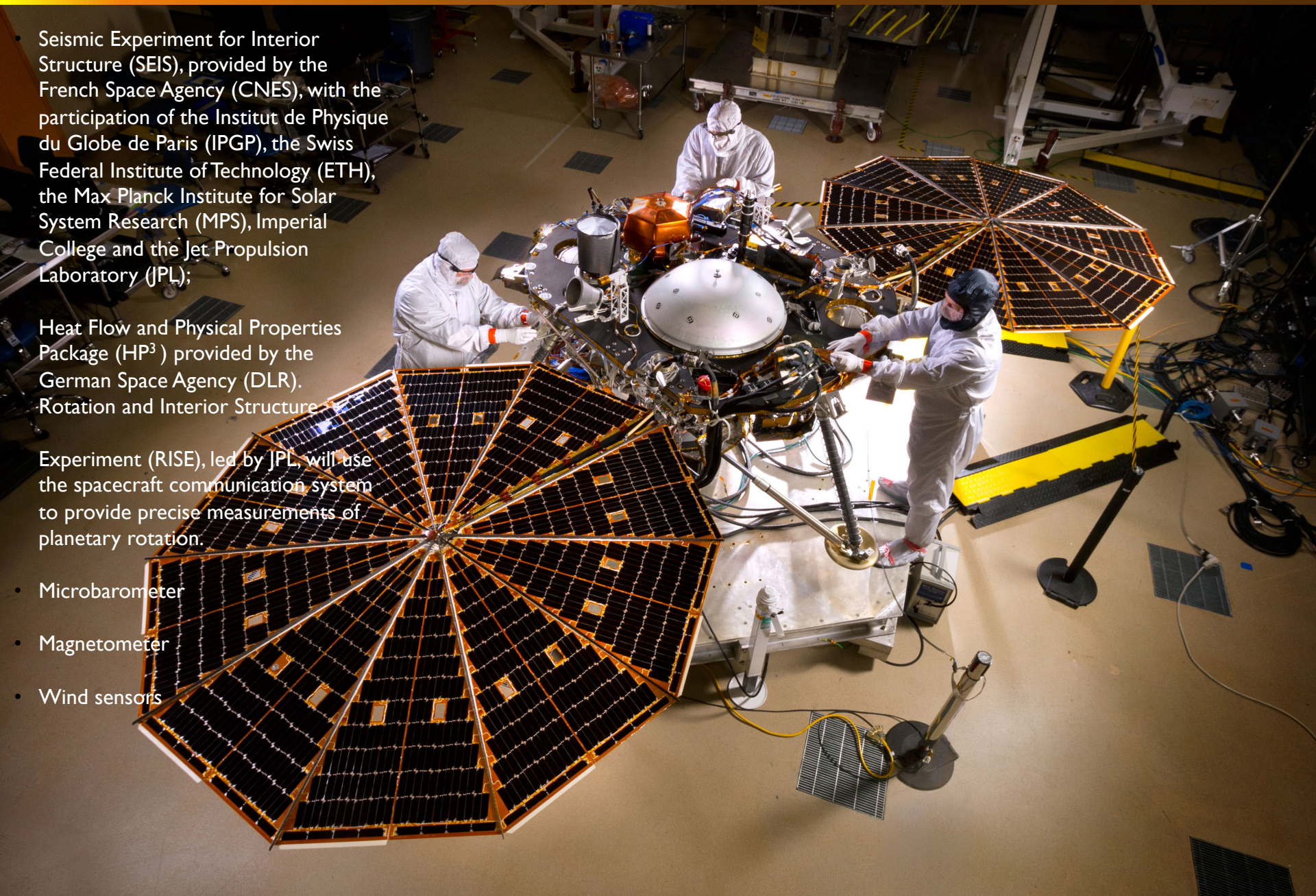
Mission Objectives

- Determine the size, composition, physical state (liquid/solid) of the Martian core
- Determine the thickness and structure of the Martian crust
- Determine the composition and structure of the Martian mantle
- Determine the thermal state of Mars' interior
- Measure the magnitude, rate and geographical distribution of Mars' internal seismic activity
- Measure the rate of meteorite impacts on the surface of Mars



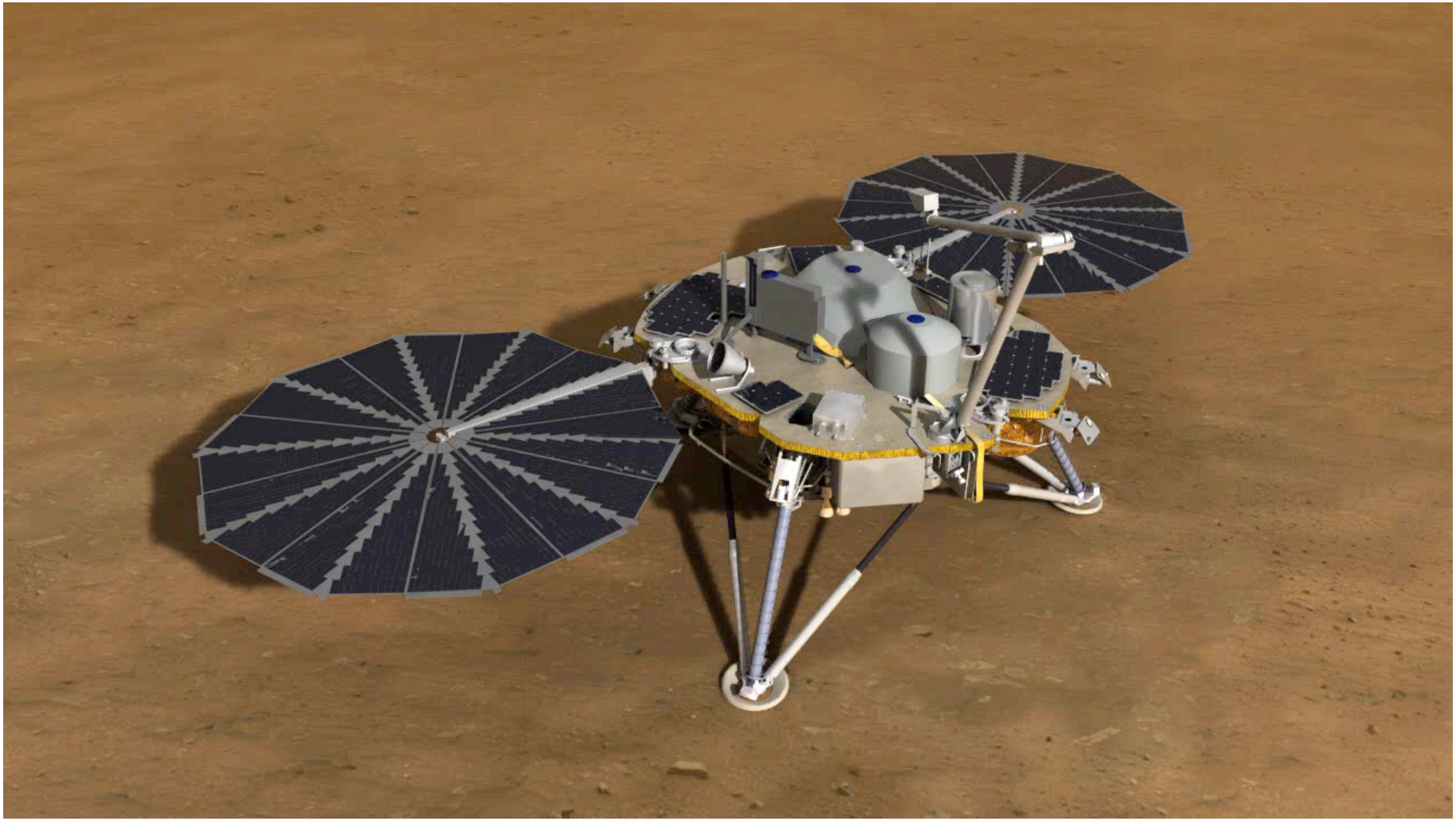
InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) is a NASA Discovery Program mission that will place a single geophysical lander on Mars to study its deep interior.

InSight Payload

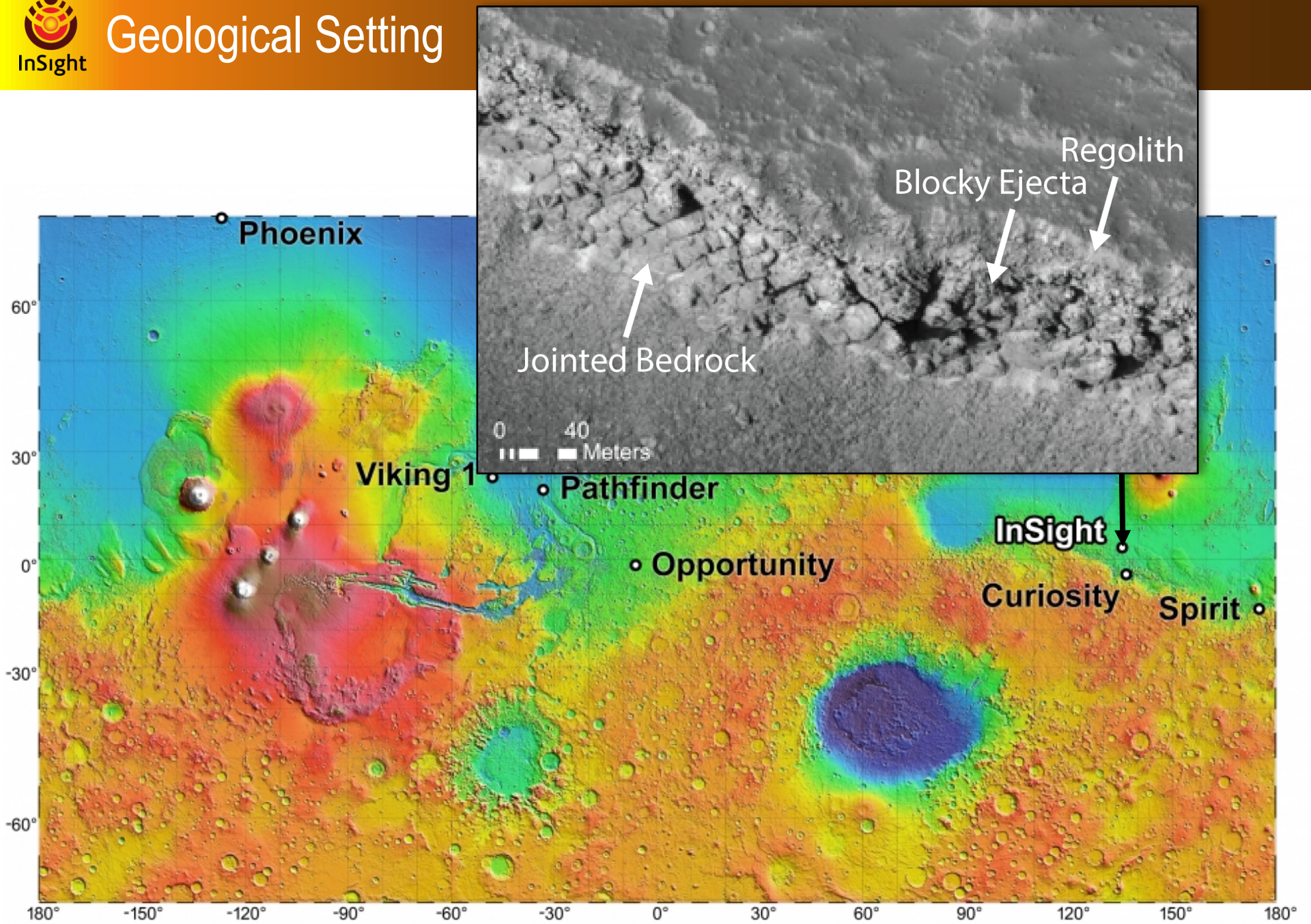


- Seismic Experiment for Interior Structure (SEIS), provided by the French Space Agency (CNES), with the participation of the Institut de Physique du Globe de Paris (IPGP), the Swiss Federal Institute of Technology (ETH), the Max Planck Institute for Solar System Research (MPS), Imperial College and the Jet Propulsion Laboratory (JPL);
- Heat Flow and Physical Properties Package (HP^3) provided by the German Space Agency (DLR).
- Rotation and Interior Structure Experiment (RISE), led by JPL, will use the spacecraft communication system to provide precise measurements of planetary rotation.
- Microbarometer
- Magnetometer
- Wind sensors

Instrument Deployment



Geological Setting



HP^3 Hammer Mechanism

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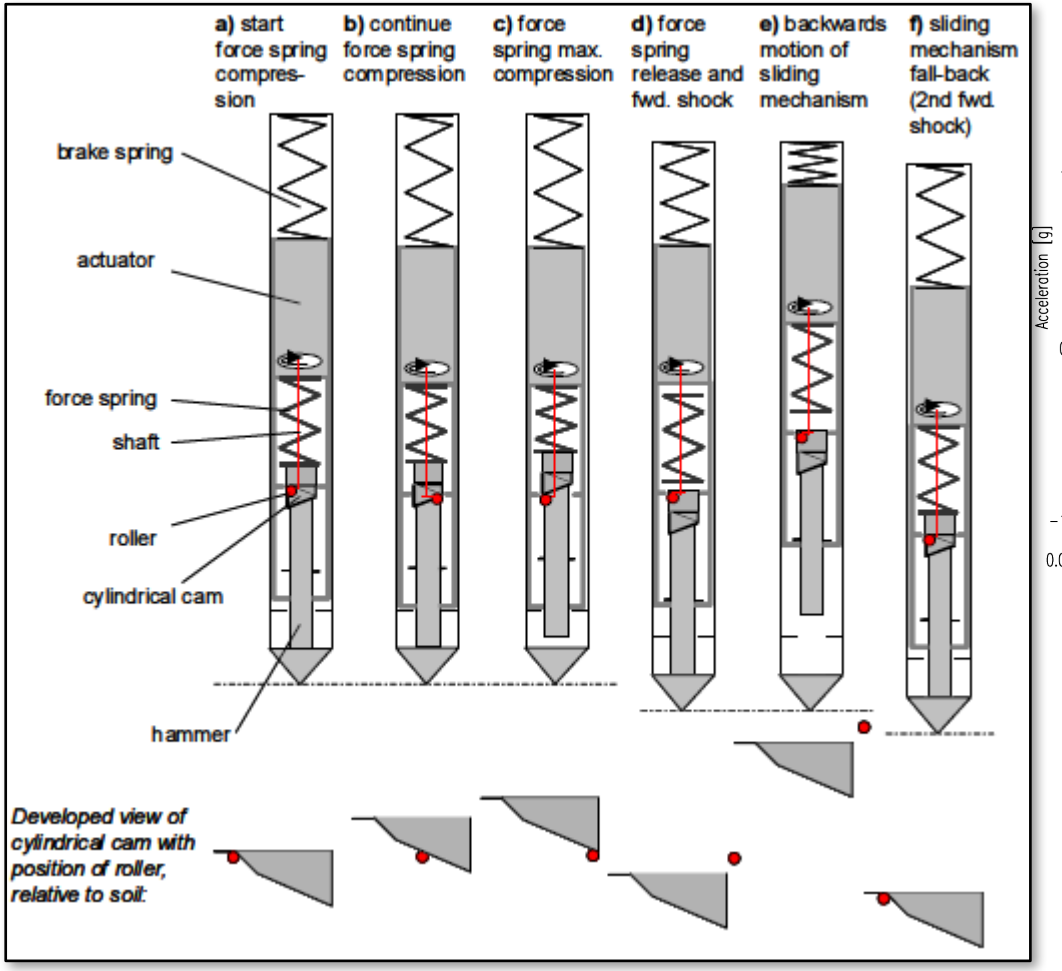
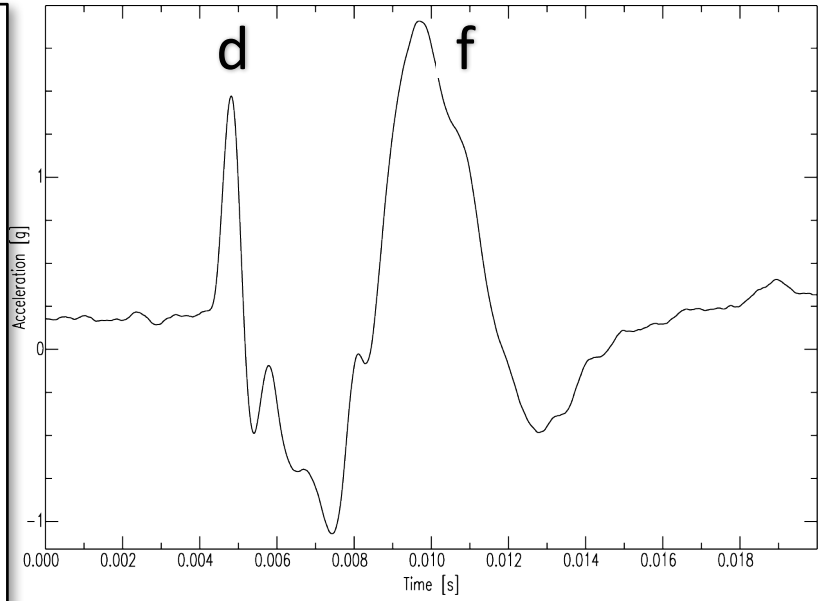
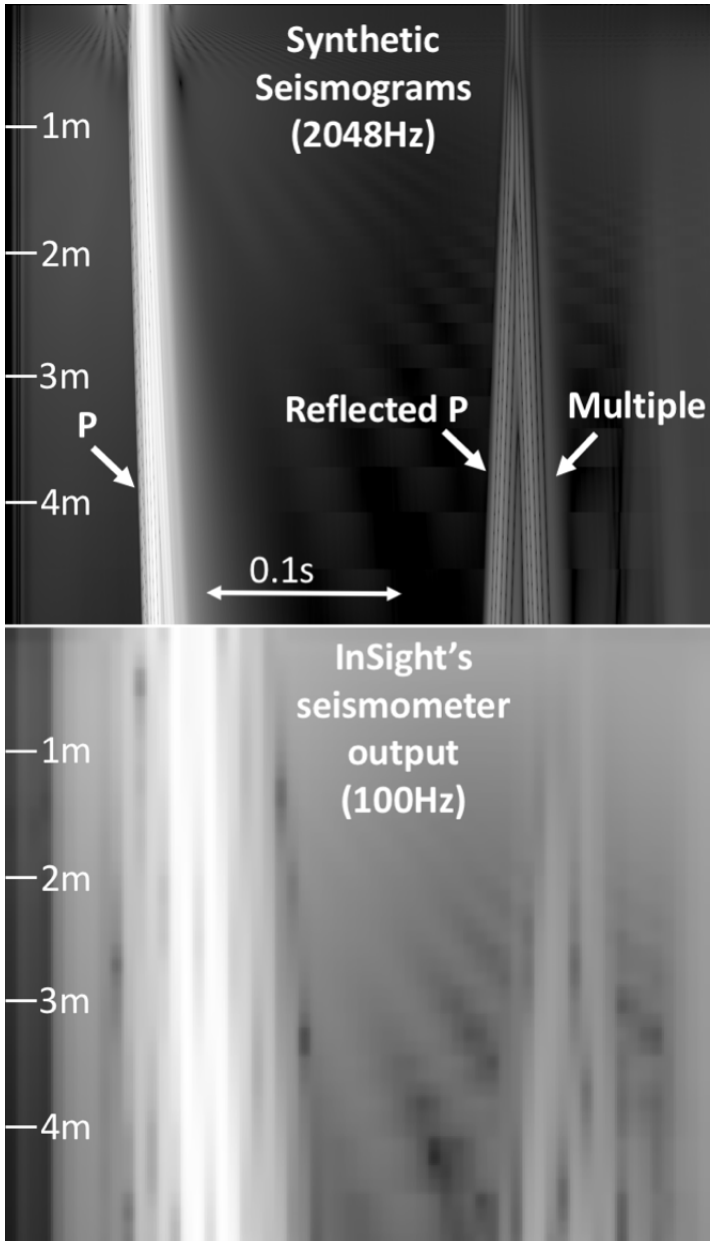
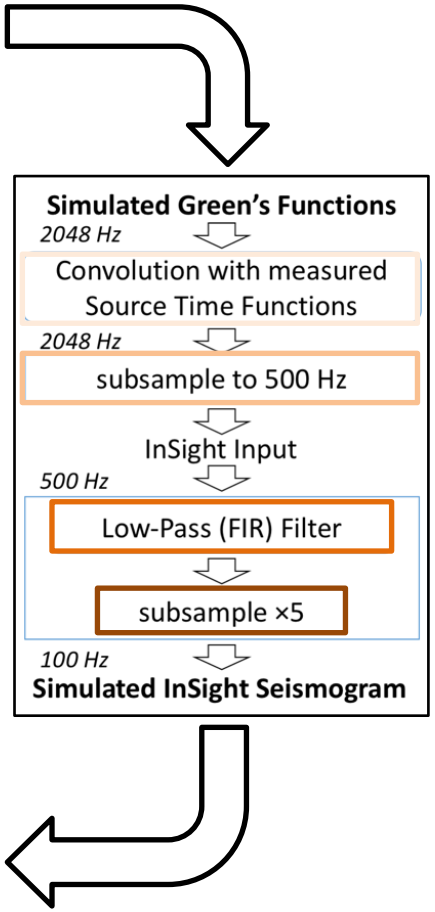


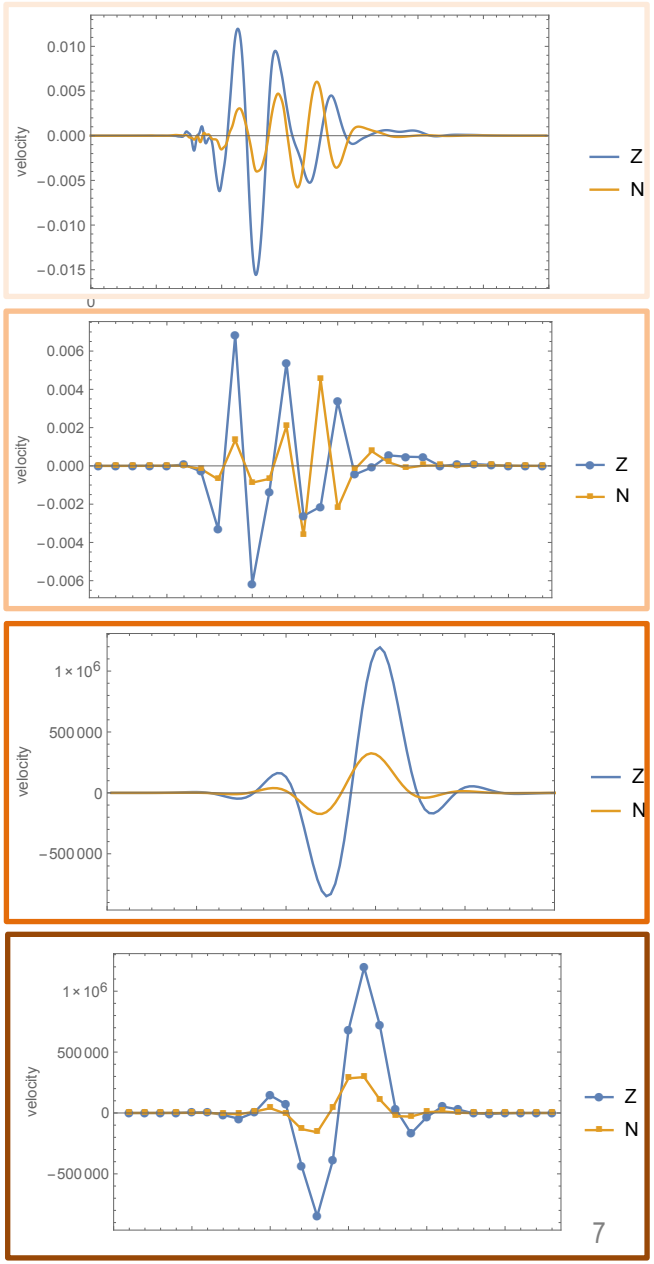


Vertical seismic signature of the HP^3 mole mechanism recorded 0.3m away.

Challenge: Under-sampled Data

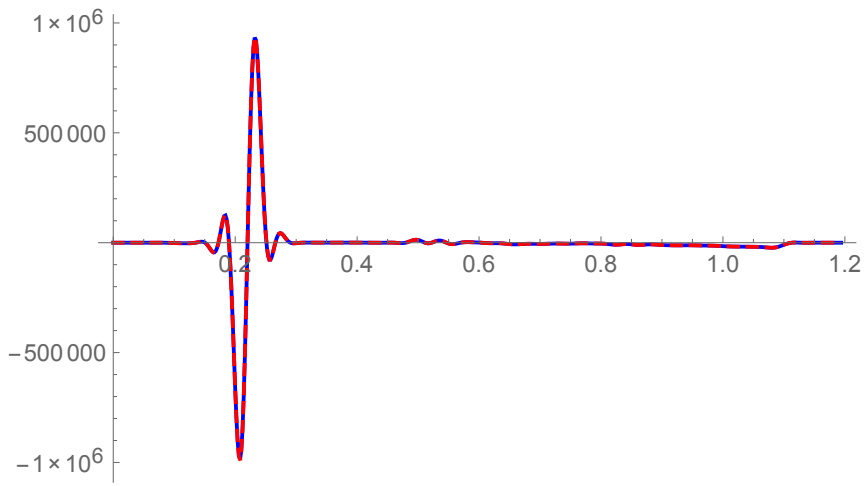




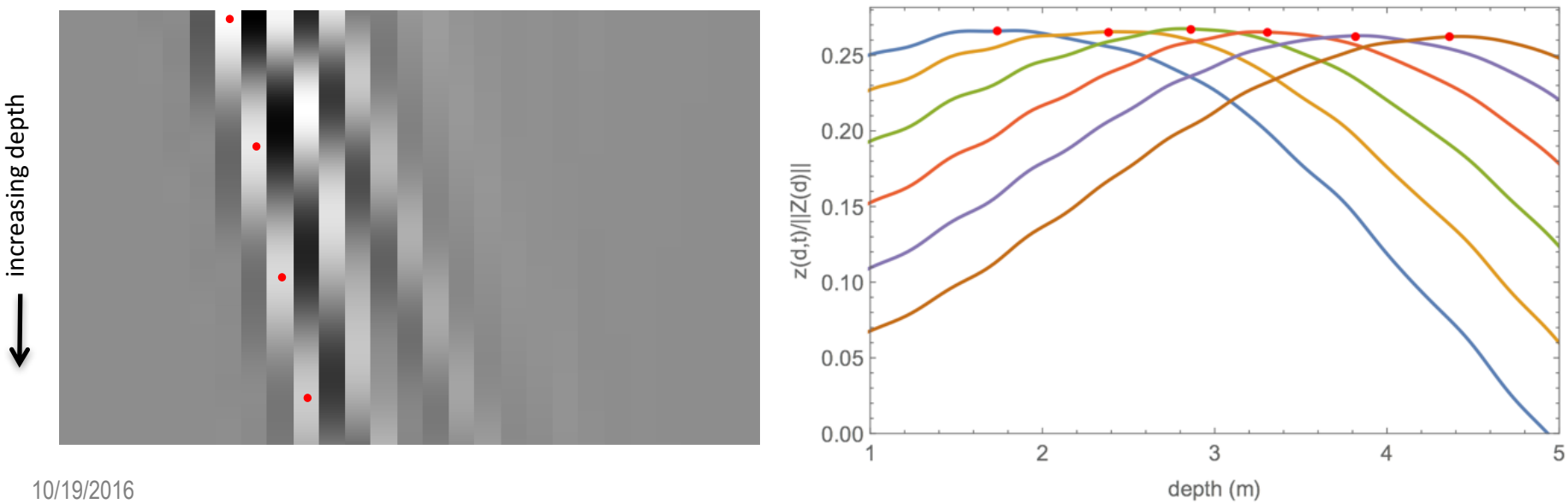


Recovery of seismic velocities and regolith thickness from the under-sampled data

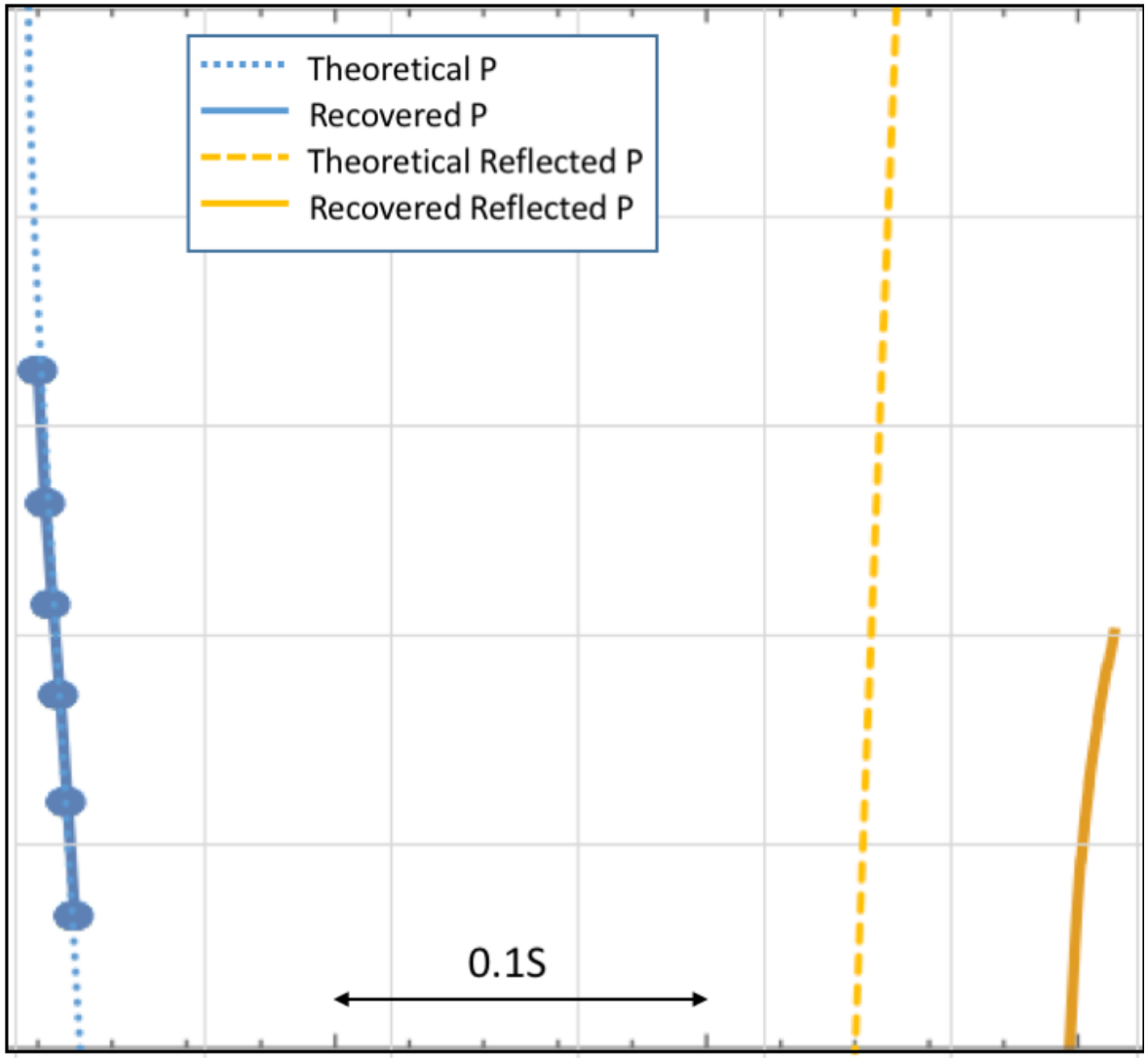
Step 1: Approximation to the 500 Hz input signal via sinc-function interpolation



Step 2: Estimation of the movement of the combined S+P waves and the reflected P-wave



Detecting direct and reflected seismic phases



Conclusions

- Although not included in the InSight mission's level 1 science objectives, the self-hammering mole of the HP^3 heat probe provides a unique opportunity to conduct the first ever seismic geotechnical study of the Martian soil.
- Simulation of a soft layer over half-space incorporating InSight's seismic data sampling chain shows that the under-sampled signal will be blurred.
- Nevertheless, analysis combining sinc-function interpolation and tracking maximum amplitudes in consecutive time bins demonstrated here shows that the key information regarding the shallow Martian subsurface (P-wave velocity, and regolith thickness) can be recovered.