Extraterrestrial Seismology: The Perspective After Nearly 1 Year of InSight on Mars

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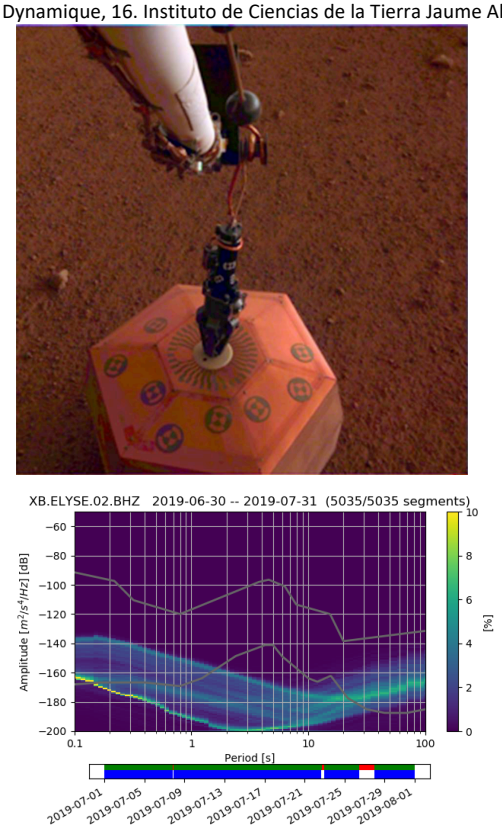

Figure 1: a) SEIS deployed on the surface of Mars as captured by Instrument Deployment Camera (IDC). b) Probabilistic Power Spectral Density estimation for the vertical component of the VBB instrument over the month of July, 2019.

InSight is the first planetary mission with a broadband seismometer package, SEIS, since the Apollo Lunar Surface Experiments Package recorded data on Earth's moon through 1977, although narrower band intruments were also landed in the Viking mission, as well as on Venus and comet 67P/Churyumov-Gerasimenko. After landing in late 2018, SEIS was deployed in a multi-month process (Figure 1a). Multiple missions including seismic instruments are likely in the coming decades, including the recently selected Dragonfly rotorcraft which would go to Saturn's moon Titan [1], and the proposed Europa Lander [2], while future missions returning seismometers to the moon are also in progress.

On Mars, more than 50 events have been detected through July 2019, including 3 significantly above the SEIS instrument noise requirement (which has been exceeded). Two have clear arrivals of P and S, enabling location, diffusion and attenuation characterization, and receiver function analysis. The event's magnitudes are likely near M_W=3 to 3.5 or less and neither clear surface waves nor deep interior phases have been identified.

Most detections are made possible due to the low noise achieved by the instrument installation strategy and the low VBB self-noise (Figure 1b). Most of the signals have amplitudes spectral densities in the 0.03-5Hz frequency bandwidth ranging from 10^{-10} m/s^2 $Hz^{1/2}$ to 5 x 10^{-9} m/s^2 $Hz^{1/2}$. The smallest noise level is found during the early night, with displacements below 100 picometers.

InSight's primary mission is planned to continue collecting data until early 2021, and so many more events may be recorded, and so our understanding of both the seismicity and internal structure of Mars should continue to improve over the duration of the mission.

References and Acknowledgments: [1] Turtle, E. et al., Abstract #1641, Lunar & Planetary Science Conference, 2018. [2] Hand, K. et al., Report JPL D-97667, NASA, 2017. Work supported by the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.