Mars as Seen by InSight SEIS after 1100 Sols of Seismic Monitoring

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The successful landing of the NASA InSight lander on November 26, 2018 has opened a new frontier in Mars science and planetary seismology. The Seismic Experiment for Interior Structure (SEIS) has been monitoring the martian seismicity for more than 1000 sols almost continuously. SEIS has detected more than 1000 seismic events which were then deeply investigated to uncover the internal structure of Mars. We would like to review the latest achievements made with SEIS observation and the new view of Mars as seen by InSight SEIS.

One of the first discoveries made by SEIS was that Mars has a rich seismicity with a variety of different types of seismic events distributed differently on Mars. The detected events are now classified by their frequency content and are called Low Frequency (<2.4 Hz) and High Frequency (> 2.4 Hz) family. Events from the Low Frequency family resemble those of Earth with clear P and S signals identified. We found that most of the Low Frequency family events are coming from the Cerberus Fossae region, which is about 1500 km East of the InSight landing site. This area was confirmed to be seismically very active and we succeeded in obtaining the source mechanisms for some high magnitude events which provide us with the first seismo-tectonic constraints on Mars. The High Frequency family shows more scattered features similar to moonquake signals. This makes the seismic difficult, and the source locations for these events are yet to be confirmed.

With such events in hand, the first internal structure model was obtained. We found that Mars consists of principally 4 different layers which can be described as follows.
- A 10 km low velocity zone with a significant seismic anisotropy, likely related to a highly porous zone of the planet, possibly related to cracks associated to impact cratering history and in which alteration occurred in the past. This zone is however today relatively dry, and is characterized by highly scattered waves and low intrinsic attenuation
- A martian crust/mantle discontinuity either at 20±5 km or 38±8 km, the first model being characterized by a larger porosity and smaller densities (<2700 kg/m3) than the second one (< 3100 kg/m3)
- A martian mantle, with a thick thermal lithosphere of 500±100 km generating a low shear velocity zone at the base of that lithosphere but relatively constant P velocities.
- A relatively large liquid core of 1830±40 km, making the phase transition from spinel to dominantly bridgmanite impossible in the mantle. Due to its size and geodetic constraints this core is furthermore

associated with low densities, confirming a volatile-rich accretion scenario.

In addition to seismic events, InSight also searches for seismic signatures generated by impacts. InSight is also equipped with atmospheric sensors such as a pressure sensor. Impacts will not only generate seismic signals but also infrasound signals. Thus, we have investigated how we can identify impact signals using both seismic and infrasound signals and locate them. These methods are confirmed with synthetic datasets, and we are now searching through the SEIS dataset to find impacts within the seismic events detected so far.

After 1100 sols of observations, InSight succeeded in achieving most of the mission objectives. The power situation of InSight is degrading, but SEIS observations are maintained and it continues to provide continuous data from Mars. With such a rich dataset, investigation continues to further constrain the internal structure of Mars and better understand the martian seismicity.

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