SEIS: OVERVIEW, DEPLOYMENT AND FIRST SCIENCE ON THE GROUND

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Introduction: The InSight mission landed on Mars on November, 26, 2018. This is the first planetary mission designed to deploy a complete geophysical observatory on Mars, following in the footsteps of the Apollo Lunar Surface Experiments Package (ALSEP) deployed on the Moon in the 1970s [1]. It will thus provide the first ground truth constraints on interior structure of the planet.

The Seismic Experiment for Interior Structure (SEIS) [2] is one of three primary scientific investigations, the others being the Heat Flow and Physical Properties Package (HP^3) [3] and the Rotation and Interior Structure Experiment (RISE) [4]. SEIS is supported by the APSS package, (Auxiliary Payload Sensor Suite, [5]), whose goal is to document environmental sources of seismic noise and signals, as well as an imaging system [6].

After a brief description of the SEIS experiment, we will describe the deployment process, including the evolution of the SEIS noise from the deck (with only SPs) to the ground (with both VBBs and SPs), first without and finally with wind shield. We will then discuss early scientific observations, providing first constrains on the Mars micro-seismic noise, atmospherically-generated seismic signals, and surface and subsurface elastic structure.

Instrument description, Deployment on Mars and first constrain on the Martian micro-seismic noise: As summarized by D.L. Anderson after the Viking mission [7]: "*One firm conclusion is that the natural background noise on Mars is low and that the wind is the prime noise source. It will be possible to reduce this noise by a factor of 10^3 on future missions by removing the seismometer from the lander, operation of an extremely sensitive seismometer thus being possible on the surface*". We demonstrate how well SEIS data confirmed Anderson's predictions and present the noise levels recorded when SEIS was on the deck (*Fig 1*), on the ground before and after the tether release (*Fig. 2*), and finally on the ground after the mechanical decoupling of the tether and the installation of the wind and thermal shield.

We compare these noise levels to those obtained on the Earth and on the Moon [8], to those predicted prior the landing [9,10,11,12], and to the self-noise of both the VBB and SP components of SEIS, as recorded on Earth or predicted by their noise models *(Fig. 2)*. These noise records, together with calibration data including thermal and magnetic field sensitivity, allow us to estimate the fraction of the full sensor noise related to instrument and temperature fluctuation for both the VBBs and SPs, and to provide the first constrain on the micro-seismic noise of Mars and of its diurnal variation. We compare this to estimates of the lander-produced noise [11,13,14] and finally discuss what might remain in term of micro-seismic background, i.e. the incoherent seismic vibrational background.

Figure 1: On-deck configuration with the grapple connected to SEIS. SEIS is in front, with the white Wind and Thermal Shield behind.

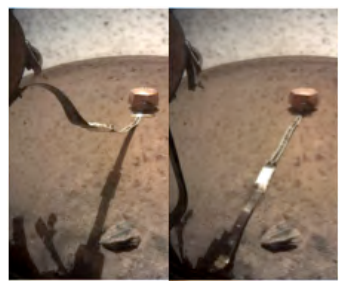

Figure 2: SEIS on the ground before tether release (left) and after tether release (right).

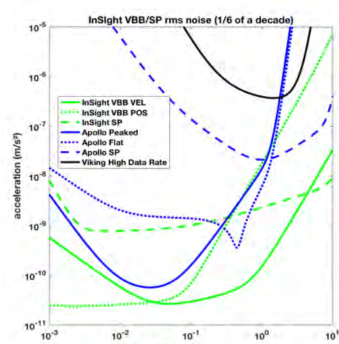

Figure 2: RMS self-noise of the three main outputs of the SEIS instrument (VBB VEL, VBB POS and SP VEL), in acceleration for a 1/6 decade bandwidth, as a function of the central frequency of the bandwidth. This is compared to the Apollo and Viking resolution (Least Significant Bit).

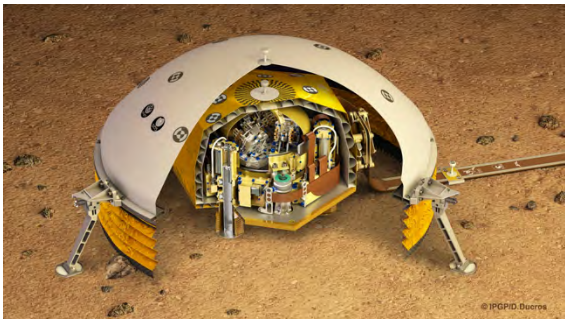

Figure 4: Final configuration of SEIS with the three layers of thermal protection of the VBBs (Evacuated Sphere, Thermal Blanket and Wind Shield). The two last are also shielding the SPs.

Atmospheric signal detection through the ground: As proposed by several pre-landing studies, atmospheric seismic signals at both long period and short period are expected from turbulence in the planetary boundary layer and atmospheric events such as dust devils [15,16,17,18]. We also expect a time variation of the seismic noise as a consequence of the variation of the atmospheric activity [2,19] and as already observed on Earth [20].

We compare these prediction with the data and discuss the possible events identified in both the SEIS and APSS data. For this purpose, models constructed using apriori ground properties [21] will also be presented in order to compare both amplitudes and shapes to those predicted by the models. We will also discuss how much is related to lander noise transmitted to SEIS [22,23], how much can be decorrelated with pressure [17], and finally, how much is related to ground propagation.

Preliminary Subsurface constraints: We expect the SEIS noise to depend on the surface and subsurface elastic structure in several ways, such as lander noise transmission [10,22,23], including lander resonances [24], LVL ground resonances [25], Short-period surface wave dispersion [16, 26], body wave resonances [27]. We will attempt to identify these predicted signals in the data and interpret them in terms of landing site geology [28], laboratory measurements of Mars soil analogs [25] and other pre-landing assumptions [21].

Detection perspectives for quakes and impacts: We conclude by providing a first lower limit of Mars seismic activity from the limited operation time and compare it to those obtained by Viking at mission termination and other published estimates. This is discussed in the frame of the major goals of SEIS, which include quake [30] and impact [31] detection as well as interior structure inversion [32] and long period observations such as normal modes [8,9,33,34] and tides [2,8,35,36].

Conclusions: After successful landing, deployment and commissioning, SEIS is performing the first long-term seismic monitoring of Mars, with a nominal mission of one martian year. SEIS data will be provided to the community through the NASA PDS, the SEIS Mars Data Service and IRIS's DMC. See the SEIS web portal for more information [37].

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