STATISTICAL AND ENERGETIC CHARACTERISTICS OF HIGH FREQUENCY (HF) AND VERY HIGH FREQUENCY (VF) MARTIAN EVENTS. Sabrina Menina[1], Ludovic Margerin[2], Taïchi Kawamura[1], Philippe Lognonné[1], Jules Marti[2], Mélanie Drilleau[3], Marie Calvet[2], Nicholas Schmerr[4], Martin van Driel[5], Foivos Karakostas[4]. [1]Institut de Physique du Globe de Paris (IPGP), Paris, France (menina@ipgp.fr), [2]Institut de Recherche en Astrophysique et Planétologie (IRAP), Toulouse, France, [3]Institut Supérieur de l'Aéronautique et de l'Espace (ISAE-SUPAERO), Toulouse, France, [4]University of Maryland, College Park, [5]Institute of Geophysics, ETH Zurich, Zurich, Switzerland.

Introduction: The InSight (Interior exploration using Seismic Investigations, Geodesy and Heat Transport) seismometer SEIS (Seismic Experiment for Interior Structure) recorded tens of High-Frequency (1.5-5Hz; HF) and Very-High Frequency (1.5-15Hz; VF) Martian events [1, 2]. They are characterized by two temporally separated arrivals with a gradual beginning, a broad maximum and a very long decay lasting up to 16 minutes [3]. These basic observations suggest that HF and VF events are generated by the long-range propagation of seismic P and S waves in a heterogeneous crust [6]. In this work, we propose to explore the properties and structure of the Martian crust using HF and VF events.

Dataset: The data used in this study are ground displacement records from SEIS-VBB sensors with sample rates of 20 samples per second (sps). Based on the Signal-to-noise ratio and the visual inspection only 11 HF and 7 VF events were selected.

Methodology: First, we apply basic multiple-scattering concepts to examine the energetic characteristics of the Martian crust. We carried out statistical analysis of the signal. We measured the delay-time (that we define as the rising time from the direct S-wave onset t_s to the time arrival of the maximum of energy t_{max}) and the coda quality factor (that characterizes the rate of decay of the seismogram envelopes). Furthermore, we examined the energy partitioning on the vertical and horizontal axes. Then, we propose a full envelope modeling based on elastic radiative transport in a half-space. The model parametrization is presented in [3] and the radiative transfer equations, that describe the transport of seismic energy in a heterogeneous / absorbing medium is detailed in [4].

Results: We find that both HF and VF signals are depolarized and verify Gaussian statistics, at the exception of the ballistic primary and secondary arrivals. These properties agree well with a multiple-scattering origin. The energy partitioning ratio V^2 / H^2 between the vertical and horizontal components is strongly frequency dependent for VF events. V^2 / H^2 is maximum at the so-called '2.4Hz resonance' (~2) and decreases rapidly at frequencies higher than 5Hz (~0.1) and remains relatively low up to frequencies of 15Hz at least. HF events do not exhibit a decrease of V^2 / H^2 at high frequencies but further analysis reveals a strong correlation between energy partitioning and signal-to-noise (S/N) ratio for HF events. This observation suggests that a part of the difference between the two groups of events can to some extent be explained by noise contamination. The generally low V^2 / H^2 ratio of VF events is reminiscent of the response of unconsolidated layers, such as observed at Pinyon Flats Observatory on Earth [5]. Contrary to earthquakes and moonquakes observed in the same frequency band, we find that the delay time -measured from onset to peak- of the secondary arrival of HF and VF events is independent of frequency and weakly dependent on hypocentral distance. The weak frequency dependence suggests that the spectrum of heterogeneity of the Martian crust is smooth (poor in small scales). However, the weak hypocentral distance dependence cannot be reconciled with the predictions of multiple-scattering theories in a statistically homogeneous medium. This observation therefore suggests a stratification of heterogeneity in the martian lithosphere. The coda quality factor *Q*c of VF events is generally high and shows a linear increase with frequency (Q_c~500-700*f*). The coda quality factor of HF events is even higher but a noise sensitivity analysis suggests that it may be largely overestimated, as a consequence of the low S/N ratio of HF events. The linear frequency dependence of *Qc* is strongly reminiscent of the leakage effect in a crustal scattering waveguide and suggests that part of the observed coda attenuation may be of structural origin. The full envelope modeling of the S0334a VF event results shows that the estimated value of the diffusivity (≃ 619 km^2/s) is almost 6 times greater than for the S0128a VF event (≃ 90 km^2/s). This observation again suggests a stratification of heterogeneity. In future works, we will perform the full envelope modeling of all the VF selected events at different frequencies to constrain a 1D attenuation and diffusion model of the Martian crust.

References:

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