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Energetic characteristics of High Frequency (HF) and Very High Frequency (VF) Martian events

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The InSight seismometer SEIS recorded tens of high-frequency (1.5-5Hz; HF) and Very-high frequency (1.5-15Hz, VF) Martian events. They are characterized by two temporally separated arrivals with a gradual beginning, a broad maximum and a very long decay. This observation is consistent with a long-range propagation of seismic P and S waves in a heterogeneous crust (Van Driel et al., accepted). To examine this hypothesis, first, we employ basic multiple-scattering concepts on the two groups of events. Then, we propose a full envelope modeling based on elastic radiative transport in a half-space. The model parametrization and the radiative transfer equations are presented in (Lognonné, P., et al. (2020) and Margerin, L., (2017)). 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 with a multiple-scattering origin. For VF events, the energy partitioning ratio V^2/H^2 between horizontal and vertical components is frequency dependent. We observe that V^2/H^2 is maximum at the so-called '2.4Hz resonance' (~2) and decreases rapidly at frequencies higher than 5Hz (~0.1) then i 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 however 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 HF and VF 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, as observed at Pinyon Flats Observatory on Earth (Margerin, L., et al. (2009)). Unlike earthquakes and moonquakes observed in the same frequency band, the delay time measured from onset to peak of the secondary arrival of HF and VF events is frequency-independent. This suggests that the spectrum of heterogeneity of the Martian crust is smooth. We observe that, for HF and VF events, the delay time is weakly dependent on hypocentral distance. This observation cannot be reconciled with the predictions of multiple-scattering theories in a statistically homogeneous medium however it suggests a stratification of heterogeneity in the Martian lithosphere. The coda quality factor Q_c of VF events is high and shows a linear increase with frequency. Q_c of HF events is higher but it may be overestimated due to the noise contamination. The linear frequency

dependence of Q_c 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.