Polarization Characteristics of the Mars' InSight Seismic Data Based on the Horizontal to Vertical Spectral Ratio Curve. Wanbo Xiao[1] and Yanbin Wang[1], [1] Department of Geophysics, School of Earth and Space Sciences, Peking University (No. 5 Yiheyuan Road, Haidian District, Beijing, 100871, China. E-mail: wbxiao@pku.edu.cn).

Introduction: The InSight mission has returned high-quality seismic and meteorological data from Mars since the middle of February 2019 [1, 2]. It is the first time that a broadband seismometer was deployed on the surface of Mars and the 100-sps seismic data were obtained from Mars. Previous study has analyzed the polarized ambient noise on Mars' surface below 1.0 Hz and revealed the environmental effects on seismic observation [3]. However, the polarization of the ambient noise in high frequencies remains to be discovered.

In this study, we focus on the polarization characteristics of the ambient noise records on Mars' surface for high frequency ranges. We first adopt the horizontal to vertical spectral ratio (HVSR) method to calculate the H/V curves of several continuous seismic data segments [3, 4]. Then the polarization characteristics of the particle motion are investigated in typical frequency bands of the H/V peaks using a polarization analysis method [5].

Data and Methods: The short period (SP) seismometer is more reliable in high frequencies. The SP data are sampled at an original sampling rate of 100 sps (sampling per second) on Mars while only part of the data can be returned to Earth due to the limitation of the data transferred. We thus choose several continuous 100-sps SP data segments whose observation time lengths exceed 20 hours for analysis.

HVSR method. We adopt the classical single-station HVSR method to obtain the H/V curves of the continuous Mars' seismic data segments. The H/V curve is acquired by the taking ratio of the quadratic mean of the two horizontal spectrums to the vertical spectrum. In this study, Fast Fourier Transform is applied to data of 8192 points and the frequency resolution of the H/V curve is 0.0122 Hz.

Polarization analysis method. The polarization analysis method first conduct eigen-analysis to the covariance matrix of three-component data, and then the planarity, rectilinearity, azimuth and the max/min incidences of particle motion can be extracted from the eigenvalues and eigenvectors. The data have be filtered to the interested frequency band before applying the polarization analysis. In this study, we choose several frequency bands, including the typical peak frequency bands of the H/V curve, for detailed analysis.

HVSR curves: Figure 1 shows the statistical HVSR curves of the SP data in channel EHU/EHV/EHW recorded on sol 98-100, which exhibit multiple peaks both in relatively low frequency band (1-5 Hz) and higher frequency band (5-25 Hz). The H/V curves are generally steady despite a few high ratio values in low frequency (high period) band. The highest H/V peak at around 11.7 Hz is caused by lander vibrations and thus cannot be used for the inversion of subsurface layer [2, 6].

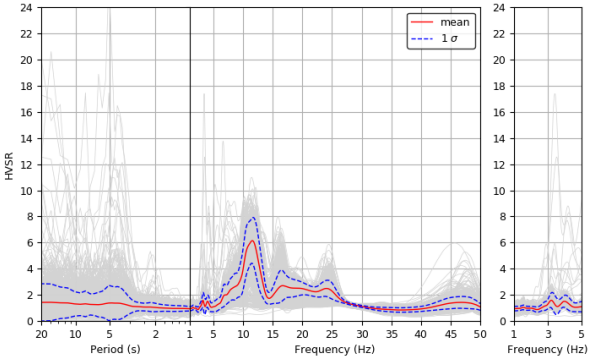

Figure 1. Statistical HVSR curves of the SP data on sol 98-100. Each grey curve represents the H/V curve of a 164-second records. The 1-5 Hz part is enlarged in the right panel.

Meteorological measurements: The meteorological condition on sol 98-100 show obvious daily variation in Figure 2. The change of air temperature and the pressure is more active around local noon and inactive in local nighttime. The same is true for the wind speeds. Environmental effects may greatly influence the ambient noise.

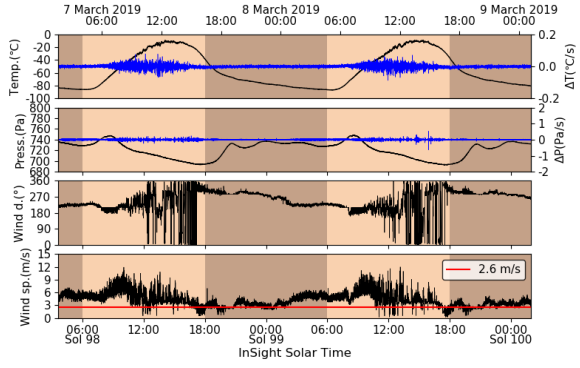

Figure 2. The meteorological measurements on sol 98-100. In the top two panels, the black curves represent the original measurements while the blue curves are the calculated variations of the original measurements.

Polarization results: A total of four peak frequency bands of the H/V curves in Figure 1 is chosen for the polarization analysis, including the

frequency bands 3.0-3.5 (FB 1), 3.6-4.4 (FB 2), 11.0-13.0 (FB 3) and 22.0-26.0 (FB 4) Hz. The polarization results versus time are shown in Figure 3.

In general, the polarization results exhibit diurnal characteristics, possibly related to the daily-varying meteorological conditions in Figure 2. The planarity and rectilinearity vary with time synchronously and both drop to lower value in local nighttime in all four cases. There is slight variation in azimuth either in daytime or nighttime. The maximum and minimum incidence angles are nearly equal for FBs 1 and 2, while the angle differences are almost 90 degrees except the low-wind nighttime for FBs 3 and 4. The change of polarization results is extremely obvious for FB 3, corresponding to the highest H/V peaks in Figure 1, compared with the other FBs. The particle motion in local daytime is horizontally polarized with a fixed azimuth but changes to ellipsoid in low-wind nighttime, which indicates the change of wave type in the ambient noise.

Discussion and Conclusion:

We apply HVSR method to a SP data segments on sol 98-100 and obtain relatively steady H/V curves, from which we choose four peak frequency bands for polarization analysis. The H/V peaks cannot simply be attributed to S-wave resonance or Rayleigh wave ellipticity since previous studies have pointed out that the lander vibrations could dominate the ambient noise on planets with active atmosphere [2, 6].

The polarization results show diurnal variation under the influence of the daily-changing meteorological conditions, especially the wind speeds. The geometric feature of the particle motion in the frequency band of the highest H/V peak changes from horizontal linearity to ellipsoid in low-wind nighttime. This could be an evidence for the change of wave type in the wave-filed as the environmental sources may change. Thus this study may help to reveal the sources of the ambient noise on Mars' surface at the landing site.

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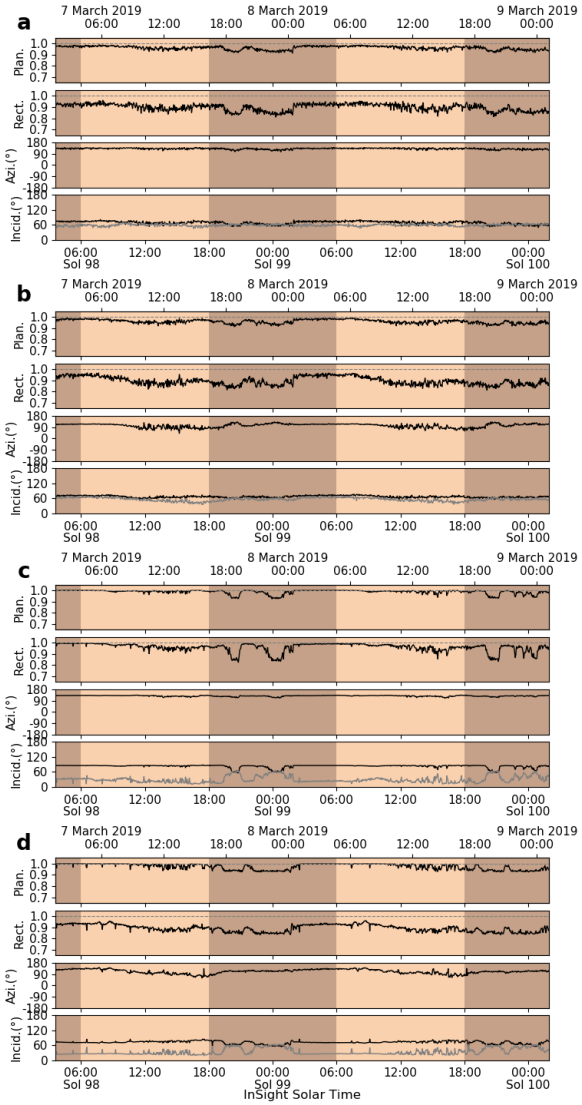

Figure 3. The polarization results versus time on sol 98-100. The subplots (a), (b), (c), (d) are the results for FBs 1-4 respectively. The black and grey curves in the bottom panel of each subplot represent the maximum and minimum incidences respectively. The lightbrown and darkbrown areas denote the periods of relatively active and inactive changes in meteorological conditions, respectively.