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The seismicity of Mars

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The InSight (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport) mission landed in Elysium Planitia on Mars on 26 November 2018 and fully deployed its seismometer by the end of February 2019. The mission aims to detect, characterize and locate seismic activity on Mars, and to further constrain the internal structure, composition and dynamics of the planet. Here, we present seismometer data recorded until 30 September 2019, which reveal that Mars is seismically active. We identify 174 marsquakes, comprising two distinct populations: 150 small-magnitude, high-frequency events with waves propagating at crustal depths and 24 low-frequency, subcrustal events of magnitude M_w 3–4 with waves propagating at various depths in the mantle. These marsquakes have spectral characteristics similar to the seismicity observed on the Earth and Moon. We determine that two of the largest detected marsquakes were located near the Cerberus Fossae fracture system. From the recorded seismicity, we constrain attenuation in the crust and mantle, and find indications of a potential low-S-wave-velocity layer in the upper mantle.

Sol 185 was a typical sol on Mars (a Mars sol is 24 h 39.5 min long, and we number sols starting from landing). The ground acceleration spectrogram recorded by the very broadband (VBB) instrument of SEIS[1–3] (Seismic Experiment for Interior Structure; Fig. 1a) is dominated by the noise produced by the weakly turbulent night-time winds and by the powerful, thermally driven convective turbulence during the day[4]. Around 17:00 local mean solar time (LMST), the wind fluctuations die out quite suddenly and the planet remains very quiet into the early night hours. Several distinctive features can be seen every sol on Mars. Lander vibrations activated by the wind appear as horizontal thin lines with frequency varying daily as a result of temperature variations of the lander; almost invisible during quiet hours, they are not excited by seismic events (for example, the lander mode at 4 Hz in Fig. 1a). We also observe a pronounced ambient resonance at 2.4 Hz, strongest on the vertical component, with no clear link to wind strength but excited by all the seismic vibrations at that frequency. The relative excitations of the 2.4 Hz and 4 Hz modes serve as discriminants for the origin of ground vibrations recorded by SEIS, allowing us to distinguish between local vibrations induced by atmospheric or lander activity and more distant sources of ground vibrations. On Sol 185, two weak events can also be spotted in the quiet hours of the early evening, one with a broadband frequency content and a second 80 min later, centred on the 2.4 Hz resonance band (Fig. 1a).

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