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Seismicity of Mars

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NASA's InSight mission deployed the Seismic Experiment for Interior Structure (SEIS) instrument on Mars, with the goal of detecting, discriminating, characterizing and locating the seismicity of Mars and study its internal structure, composition and dynamics. 44 years since the first attempt by the Viking missions, SEIS has revealed that Mars is seismically active. So far, the Marsquake Service (MQS) has identified 365 events that cannot be explained by local atmospheric or lander-induced vibrations, and are interpreted as marsquakes. We identify two families of marsquakes: (i) 35 events of magnitude MW=3-4, dominantly long period in nature, located below the crust and with waves traveling inside the mantle, and (ii) 330 high-frequency events of smaller magnitude and of closer distance, with waves trapped in the crust, exciting an ambient resonance at 2.4Hz. Two long period events with larger SNR and excellent P and S waves occurred on Sol 173 and 235, visible both on the VBB and the SP channels; the location of these events has been determined at distances of 26°-30° towards the East, close to the Cerberus Fossae tectonic system. Over ten additional long period events show consistent body-wave phases interpreted as P and S phases and can be aligned with distance using models of P and S propagation. Marsquakes have spectral characteristics similar to seismicity observed on the Earth and Moon. From the spectral characteristics of the recorded seismicity and the event distance, we constrain attenuation in the crust and mantle, and find indications of a potential low S-wave-velocity layer in the upper mantle. In contrast, the high-frequency events provide important constraints on the elastic and anelastic properties of the crust. The first seismic observations on Mars deliver key new knowledge on the internal structure, composition and dynamics of the red planet, opening a new era for planetary seismology. Here we review the seismicity detected so far on Mars, including location, distance, magnitude, magnitude-frequency distribution, tectonic context and possible seismic sources.