

EGU2020-11771

<https://doi.org/10.5194/egusphere-egu2020-11771>

EGU General Assembly 2020

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Magnetic Pulsations and Transients on Martian Surface

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InSight is the first Mars surface mission that includes a magnetometer, and one of the first discoveries made by the InSight FluxGate (IFG) magnetometer is the ultra-low-frequency (ULF) waves, or magnetic pulsations, on the Martian surface. By studying magnetic pulsations and transient signatures in more than six months of IFG data, we find that the morphologies of these two types of perturbations have considerable variations from their counterparts on the Earth, reflecting the fundamental differences between the magnetospheres with and without a global magnetic field. The most noticeable ULF waves are the continuous pulsations (Pc) occurring at around midnight and with wave periods of the order of 100 sec, or in the Pc 4 frequency band when the terminology of terrestrial magnetic pulsations is used. Broadband pulsations at Pc 5 frequencies (i.e., a few mHz) have also been observed. Comparisons with lander activities and InSight's Temperature and Wind for InSight Subsystem (TWINS) data confirm that the observed magnetic pulsations are not caused by tremors of the lander. Simultaneous observations by MAVEN in the solar wind and InSight on Mars indicate that the upstream waves in front of Mars bow shock can hardly reach the dayside surface, leading to a dearth of magnetic pulsations in the daytime. In addition, solar wind discontinuities or transient events can induce noticeable surface magnetic responses only in the nightside, suggesting that the magnetic pileup region and ionosphere can effectively shield external magnetic disturbances. MAVEN observations also help identify sources of magnetic pulsations seen on the Martian surface. While the low-frequency, broad-band Pc 5 pulsations may be excited by the oscillations on the flanks of the induced magnetosphere associated with solar wind variations or the Kelvin-Helmholtz instability, there is a strong indication that the nightside Pc 4 pulsations on the surface originate from the compressional oscillations in the magnetotail. Different from the flow-generated fast mode waves in the terrestrial magnetotail, the fast mode in the Martian magnetotail could travel toward the planet without substantial coupling to the Alfvén mode. The Mars-propagating fast mode experiences little reflection from the ionosphere and can produce surface magnetic pulsations at low latitudes on the nightside. These first findings of magnetic pulsations and transients on the Martian surface not only reveal the origins and propagation of magnetic signals from the outer space but also help determine the source model for the magnetic sounding of Mars' interior.

