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Crust, mantle and core structure of Mars from InSight seismic data

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With the deployment of a seismometer on the surface of Mars as part of NASA's InSight mission, the Seismic Experiment for Interior Structure (SEIS) has been collecting continuous data since early 2019.
The primary goal of InSight is to improve our understanding of the internal structure and dynamics of Mars, in
particular crust, mantle, and core. Here we describe constraints on the structure of the mantle of Mars based
on inversion of seismic body wave arrivals from a number of low-frequency marsquakes.

We consider 8 of the largest (moment magnitude is estimated to be between 3 and 4) low-frequency events with
dominant energy below 1 Hz for which P- and S-waves are identifiable, enabling epicentral distance estimation.
The 8 events occur in the distance range 25-75 degrees. Body wave arrivals that include the main P- and S-waves,
surface reflections (PP, PPP, SS, SSS), and core reflections (ScS) are picked using a set of complimentary methods
that allows to check for consistency. The resultant set of differential travel times (PP-P, PPP-P, SS-S,...) are
subsequently inverted for radial profiles of seismic P- and S-wave velocity, core size and mean density, and epicentral
location of the events. To determine interior structure, we rely on independent methods as a means of assessing the
robustness of the results.

We present a radial velocity model for the upper mantle of Mars, with implications for the thermo-chemical evolution
of the planet that match a cooling, differentiated body, and a thick lithosphere. Based on the location of the events,
we are able to constrain structure to the core-mantle-boundary, including the size of the core and its mean
density that point to large liquid and relatively light core, implying a significant complement of light alloying
elements. Our estimate of the average crustal thickness as seen by all events is compatible with the local crustal

thickness at the InSight landing determined from observations of converted phases.

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