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First seismic constraints on the Martian crust – receiver functions for InSight

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NASA's InSight mission arrived on Mars in November 2018 and deployed the first very broad-band seismometer, SEIS, on the planet's surface. SEIS has been collecting data continuously since early February 2019, by now recording more than 400 events of different types. InSight aims at enhancing our understanding of the internal structure and dynamics of Mars, including better constraints on its crustal thickness. Various models based on topography and gravity observed from the orbit currently vary in average crustal thickness from 30 km to more than 100 km, with important implications for Mars' thermal evolution, and the partitioning of silicates and heat-producing elements between different layers of Mars.

We present P-to-S and S-to-P receiver functions, which are available for 4 and 3 marsquakes, respectively, up to now. Out of all of the marsquakes recorded to date, these are the only ones with clear enough P- or S-arrivals not dominated by scattering to make them suitable for the analysis. All of the quakes are located at comparatively small epicentral distances, between 25° and 40°. We observe three consistent phases within the first 10 seconds of the P-to-S receiver functions. The S-to-P receiver functions also show a consistent first phase. Later arrivals are harder to pinpoint, which could be due to the comparatively shallow incidence of the S-waves at the considered distances, which prevents the generation of converted waves. Identification of later multiple phases in the P-to-S receiver functions likewise remains inconclusive. To obtain better

constraints on velocity, we also calculated apparent velocity curves from the P-to-S receiver functions, but these provide meaningful results for only one event so far, implying a large uncertainty. Due to difficulties in clearly identifying multiples, the receiver functions can currently be explained by either two crustal layers and a thin (25-30 km) crust or three crustal layers and a thicker (40-45 km) crust at the landing site. This model range already improves the present constraints by providing a new maximum value of less than 70 km for the average crustal thickness. Information from noise autocorrelations as a complementary method, identification of P-reverberations and S-precursors in the event recordings, and more extensive modeling, ultimately including 3D-effects, are considered to further our understanding of the waveforms and tighten the constraints on the crust.

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