Stratification of attenuation properties in the crust of Mars from full seismogram envelope modeling of near impacts detected by InSight. S. Menina[1], L. Margerin[2], T. Kawamura[1], M. Drilleau[3], R. Garcia[2,3], P. Lognonné[1], M. Calvet[2], Z. Xu[1], A. Stott[3]. [1]Institut de Physique du Globe de Paris, Université Paris Cité, CNRS F-75005 Paris, France, [2]Institut de Recherche en Astrophysique et Planétologie, Université Toulouse III Paul Sabatier, CNRS, CNES, 31400 Toulouse, France,[3]Institut Supérieur de l'Aéronautique et de l'Espace SUPAERO, 10 Avenue Edouard Belin, 31400 Toulouse, France

Introduction: Impact detection and identification was a priority objective for InSight mission. During the last year of the mission, SEIS detected a few seismic events which were later confirmed to be impacts through orbital imaging [1]. In fact, meteorite impacts are excellent candidates for the investigation of the crust. As these events occur on the surface, the seismic signals recorded will be very sensitive to the upper layers of the internal structure. On the Moon, seismic records of meteorite impacts, combined to other seismic events, were used to investigate the megaregolith thickness. It has been estimated between 10 and 80 km thickness based on different methods and algorithms [2,3,4]. Based on the signal-to-noise (SNR) ratio, we selected four near-impacts (NI) to investigate the attenuation properties of the Martian megaregolith.

Dataset: Seismic data used for this study are ground displacement records of four near-impacts event recorded from SEIS-VBB sensors with sample rates of 20 samples per second (sps). They were collected as part of the NASA InSight [5] Mission to Mars using SEIS (Seismic Experiment for Interior Structure) seismometer [6] They can be downloaded from the IRIS Data Management Center website (https://www.iris.edu/hq/sis/insight) [7].

Methodology: To characterize the depth extent and attenuation characteristics of heterogeneities in the crust, we propose to use elastic radiative transfer theory to model the full seismogram envelopes of impact records. We consider a stratified medium in both velocity and absorption properties, which furthermore exhibits a highly scattering upper crust superposed on a weakly scattering lower crust and upper mantle. To retrieve the properties of each layer, we use a hybrid inversion method which combines a local optimization algorithm with a grid search. The latter is used to explore a variety of heterogeneity models for the lower crust and mantle and various thicknesses for the megaregolith.

Results: We find that models exhibiting a strongly scattering upper crust provide excellent match to envelope records of impacts. In fact, depending on the event, 15 or 20 km diffusive layer thickness is sufficient to explain the shape of the seismogram envelopes of near impacts.

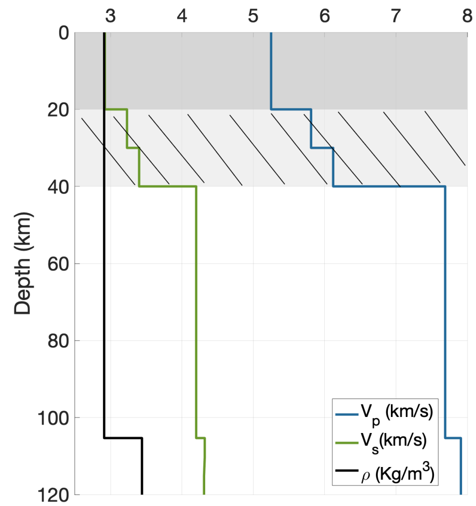

Fig 1: Velocity and density profile used to model near impacts. The shaded area indicates a layer of strong scattering.

At 7.5 Hz central frequency, which corresponds to the highest SNR ratio for our observations, our inversion results using a 15 km- or 20 km-thick diffusive layer showed similar scattering (Q_{sc}) and absorption (Q_μ) quality factors values (Q_{sc} = 50∓15 and Q_μ = 2500∓200; with 15 km diffusive layer, and Q_{sc} = 40∓12 and Q_μ = 2800∓200; with 20 km diffusive layer) .

The reported values are intermediate between Earth and Moon [4]. With a seismic albedo of the order of 0.95, the present study confirms that the crust near InSight is mostly dry. However, the inversion results for the impact nearest to the landing site (50 km epicentral distance) exhibits lower scattering and absorption quality factor, which may be related to a shallow layer with stronger scattering and absorption than the rest of the upper crust. This suggests the existence of a stratification of attenuation properties that could be related to the presence of the megaregolith.

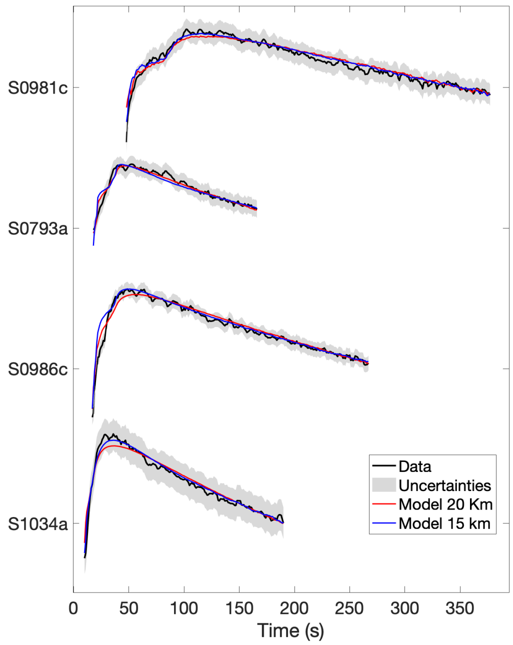

Fig.2: Radiative transfer modeling of the energy envelope of near impacts. The black lines shpw the energy envelope of the horizontal components filtered at 7.5 Hz and the gray area the associated uncertainties. Blue and red curves correspond to the best-fitting radiative transfer models using a 15 km- or 20 km-thick diffusive. t = 0 s corresponds to the origin time.The different events are modeled separately.

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