THE FOCAL MECHANISM SOLUTION OF MARSQUAKES BY INVERSION OF P- AND S- WAVES

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Seismic data recorded by the SEIS experiment [1] onboard the InSight mission [2] have shown that Mars is seismically active with more than 1300 events detected and catalogued by the InSight Marsquake Service (MQS) [3]. The seismometer on board NASA's Mars InSight mission has discovered a seismically active planet. We focus on a few events that were recorded by the very wide-range sensors and the associated ELYSE channel, located 37.2° from InSight. We use a method based on the point source approach for elastic horizontal-layered media to obtain source parameters for seismic events on Mars. In this case, the seismic moment tensor inversion of high-frequency seismogram data is calculated using a matrix method for direct waves. The process involves generating offset records using a frequency-wavenumber integration technique. A method for inverting the moment tensor of direct P- and S-waves, which are less sensitive to path effects than reflected and transformed waves, is presented, which significantly improves the accuracy and reliability of the method [4,5].

We propose to invert only the direct waves instead of the full field. An advantage of inverting only the direct *P*- and *S*- waves is that, compared to reflected and converted waves, they are less sensitive to the structural model used in the inversion. For example, waveforms of converted and reflected waves depend strongly on velocity contrasts below the source and receiver, and thus imprecise knowledge of subsurface structure will lead to inaccurate modelling. Waveforms of direct phases are less sensitive to subsurface layering, scattering and may carry a less distorted imprint of the source. The advantage of choosing a matrix method for calculating synthetic seismograms is its ability to analytically isolate direct waves from the full wave field. In the earlier version of our method, as well as in most other MT inversions, waveforms at several seismic stations are simultaneously inverted [4,5]. Although much more information on the source should be contained in the waveforms from several stations, we show nevertheless in our study that all the components of seismic moment tensor contribute to the waveforms at only one station and, at least theoretically, can be retrieved from them, a possibility explored in a current version of the inversion. We use a point-source approximation, assuming the location and origin time proposed by [6]. We first present the focal mechanism of the S0235b event on Mars (July 26, 2019), located 25° from the epicenter [6]. We compare two methods: in the first we propose to invert only direct waves [7], and in the second we consider direct inversion for the full moment tensor [8]. We tried three different source depths: 17 km, 32 km and 56 km. The TAYAK velocity model was used [7,8]. The durations of direct *P*- and *S*- waves at the station are estimated visually from the records and delays of the reflection-conversion phases at the respective epicentral distance and source depth are considered. The focal mechanisms for the source depth of 32 km shown in Figure 2 look very similar to each other.

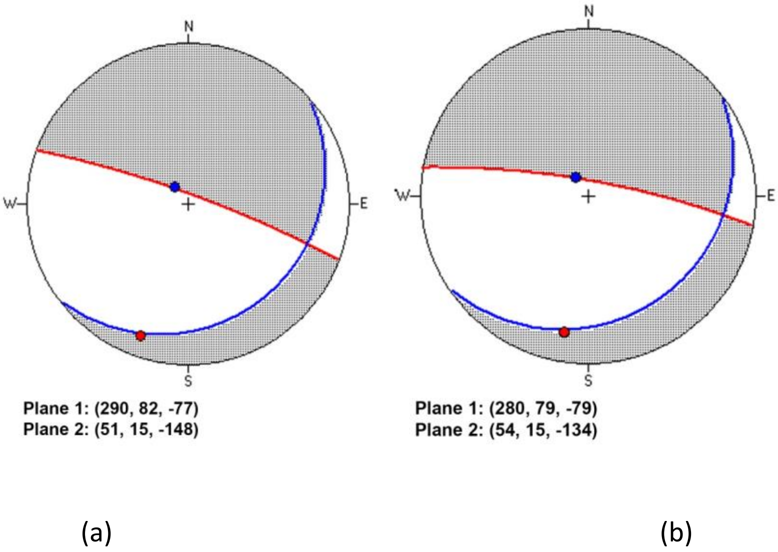

Fig. 1. Focal mechanisms of the S0235b event obtained by inversion of only direct waves [7] (a) and by direct inversion for the full moment tensor [8] (b) for a source depth of 32 km

We also present the inversion results for the S1222a event on Mars (2022-05-04, *P*-arrival 23:27:45, 3:54 LMST, M_w 4.7, back azimuth 109°) which is located on Aeolis Southeast at 37.2° distance from InSight [6]. The component of moment tensor resulting from the inversion of the direct *P*- and *S*- waves forms at only the station ELYSE. The corresponding focal mechanism are shown in Figure 2.

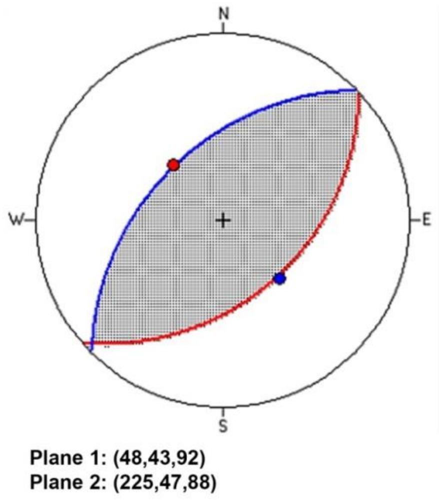

Fig. 2. Version of the focal mechanism solution for the S1222a event on Mars (2022-05-04, M_w 4.7, back azimuth 109°) [7]

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