Using Data from InSight to Explain and Locate Marsquakes

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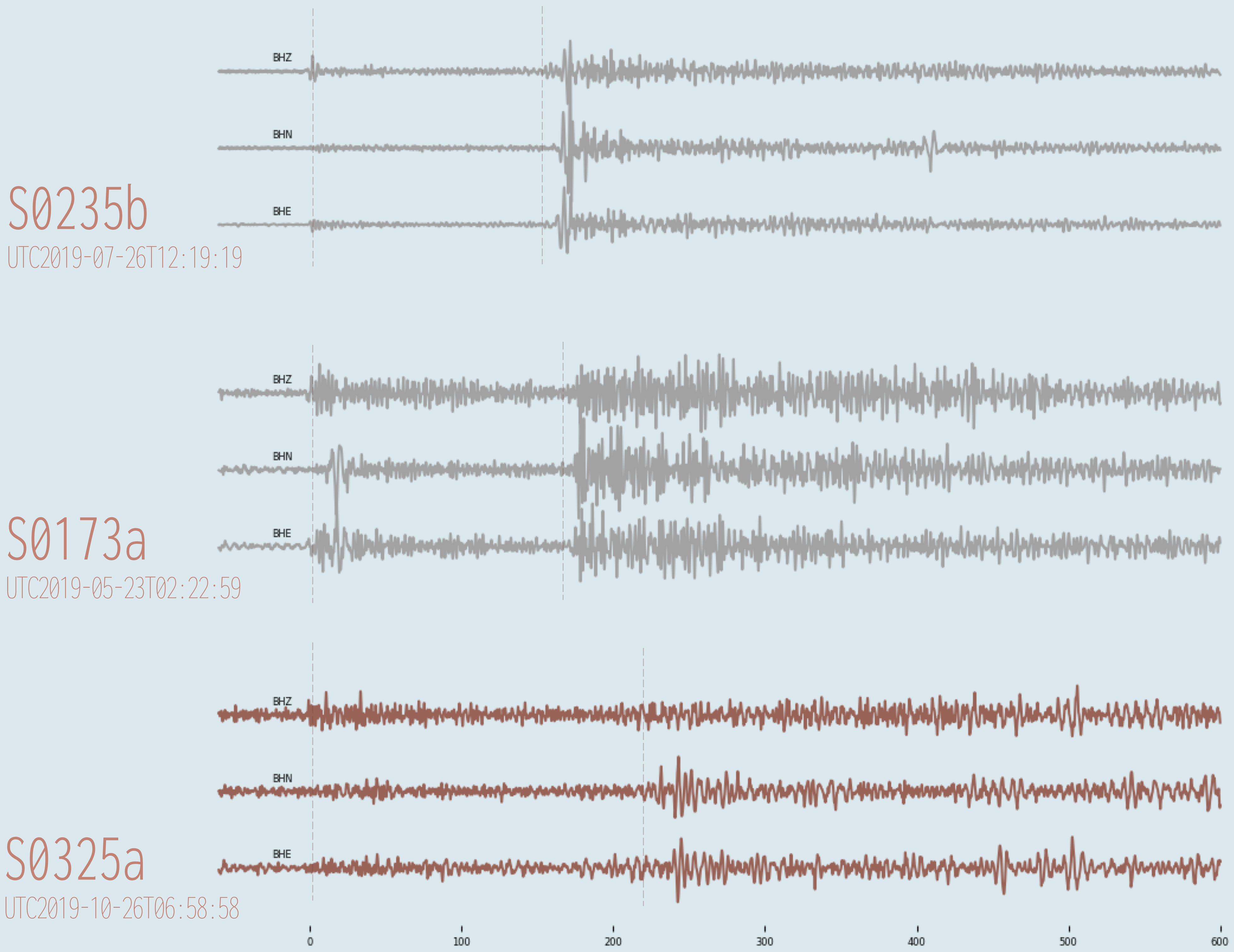
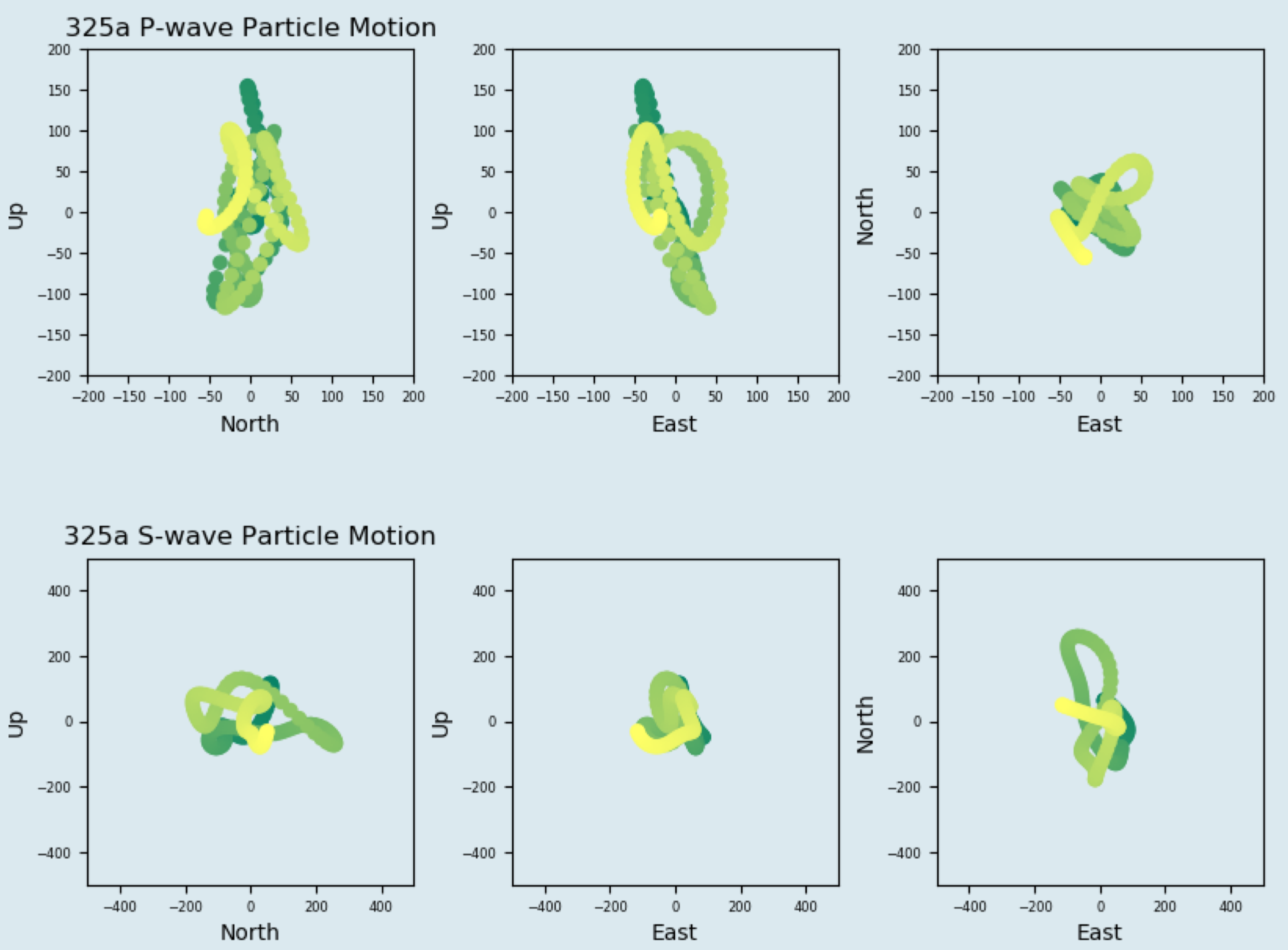
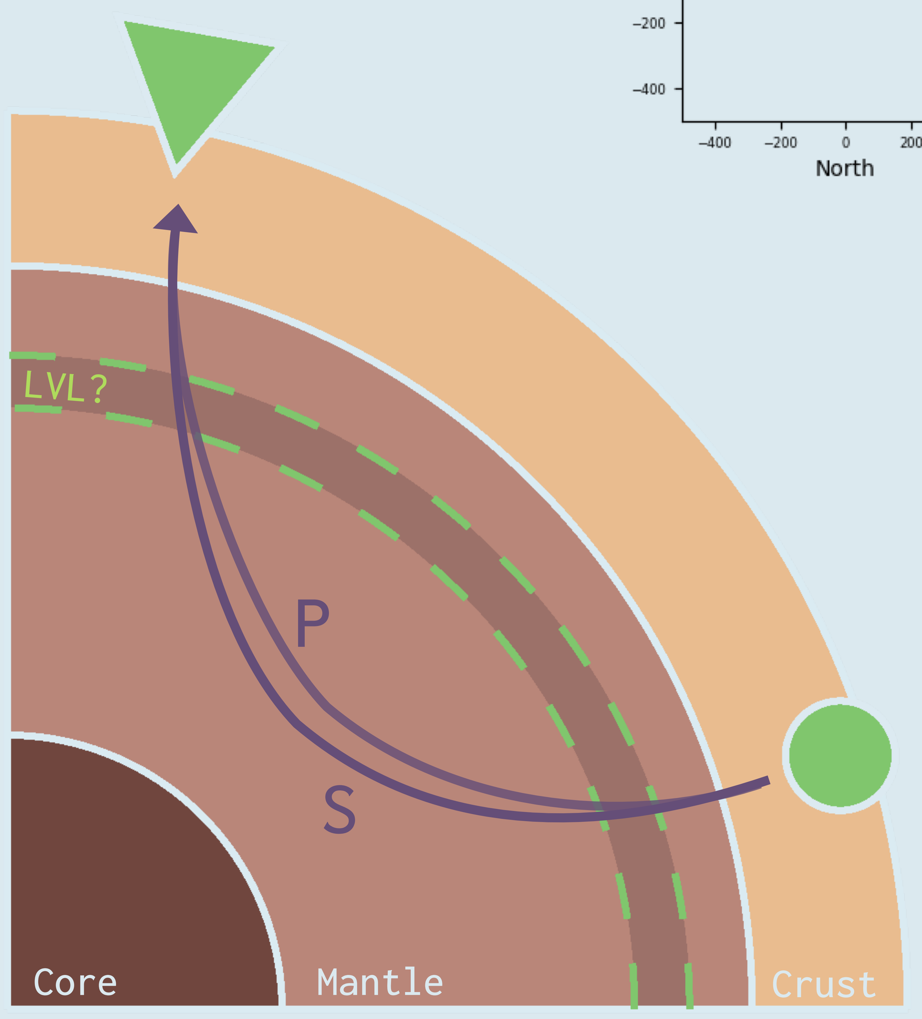


Particle Motion

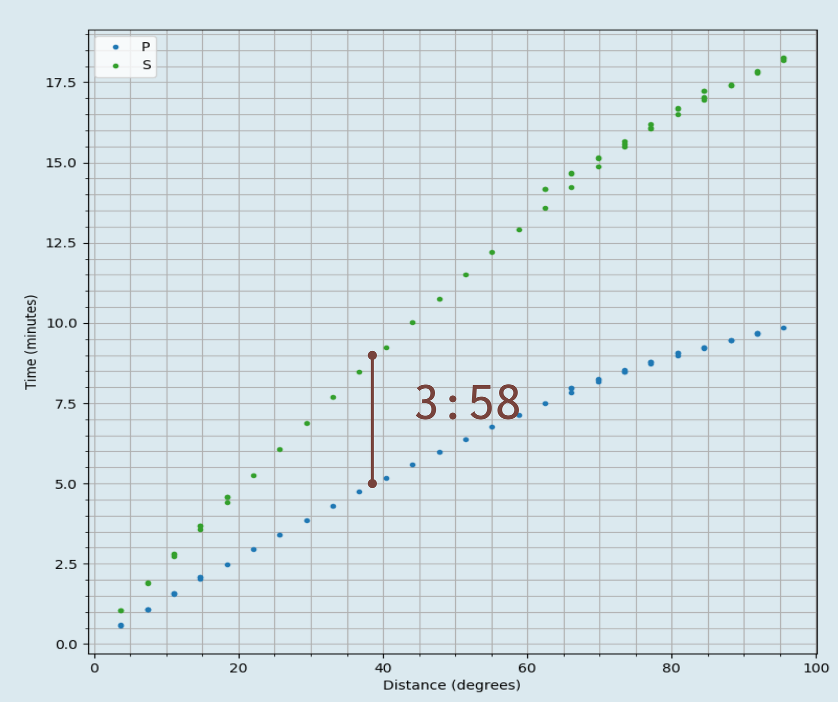
This particle motion seems to show a movement of the event over time from the south-east to the north-east. It is possible that not all of the energy in this time window is P-wave energy.



Possible Ray Paths of Seismic Waves



Time Travel Plot for Gudkova Model

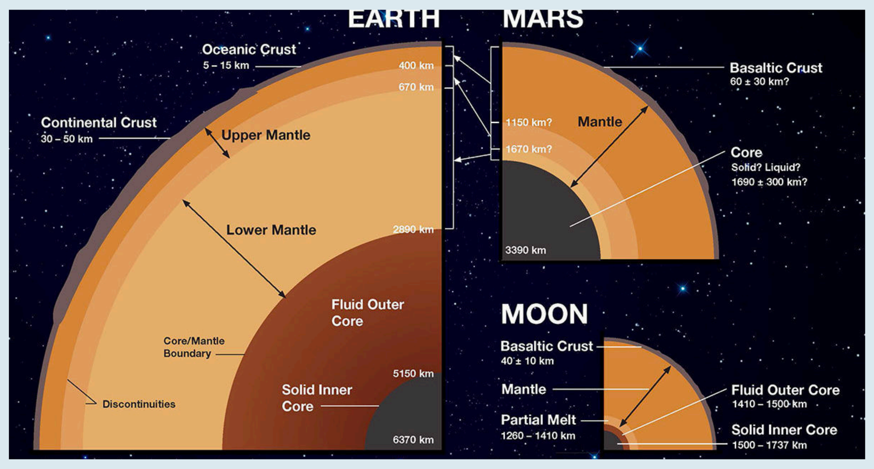


Everything we thought we knew about Marsquakes

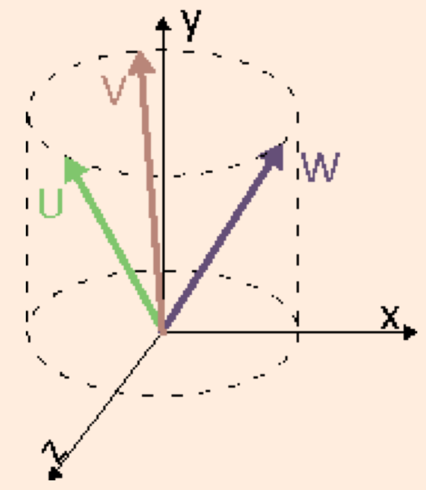
Fig 1. This figure comes from NASA's Bruce Murray Space Image Library

Mars' crust is composed of a single tectonic plate and therefore intraplate tectonics, such as faulting, and impacts are expected to be the major contributors to the seismicity of the planet[1,2].

The lander is located about 1600km west of the Cerberus Fossae region, which is hypothesized to be an active tectonic structure and a major contributor to Mars' seismicity[3,4].



Collecting and analyzing data from IRIS Webservices

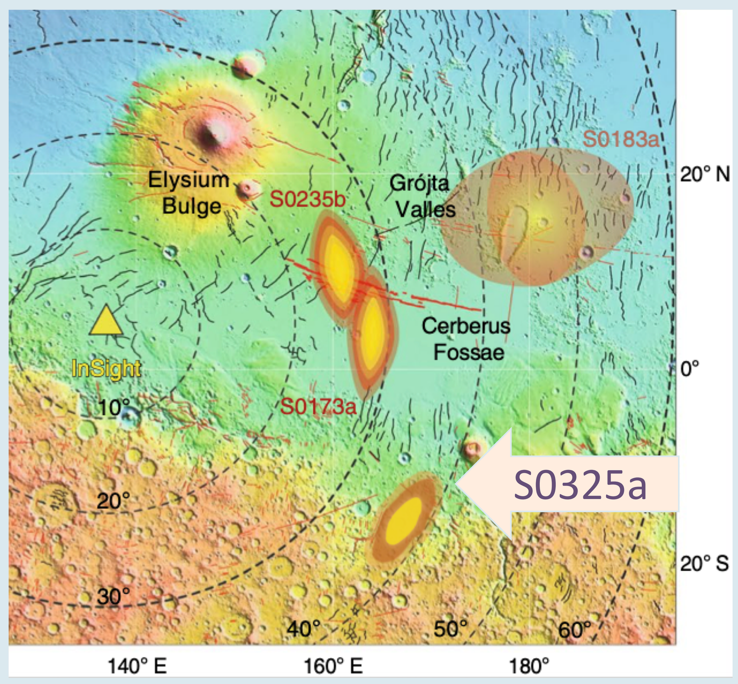


The instrument of interest for this project is the very broadband (VBB) seismometer, which is a part of the seismometer package, Seismic Experiment for Internal Structure (SEIS). The waveform data was downloaded directly from the Incorporated Research Institutions for Seismology (IRIS) database web service exploited by a function of the python package ObsPy. Using the equation below, we orientated the data such that each data stream now pointed in the north, east and vertical direction.

$$\begin{pmatrix} D_E \\ D_N \\ D_Z \end{pmatrix} = \begin{pmatrix} \cos(\varphi_U)\sin(\theta_U) & \cos(\varphi_U)\cos(\theta_U) & -\sin(\varphi_U) \\ \cos(\varphi_V)\sin(\theta_V) & \cos(\varphi_U)\cos(\theta_U) & -\sin(\varphi_V) \\ \cos(\varphi_W)\sin(\theta_W) & \cos(\varphi_U)\cos(\theta_U) & -\sin(\varphi_W) \end{pmatrix}^{-1} \begin{pmatrix} D_U \\ D_V \\ D_W \end{pmatrix} \quad (1)$$

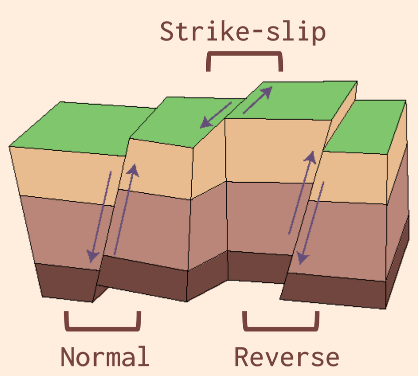
Locating Marsquakes with a single detector

Fig 2. This figure was adopted from Giardini et al. 2020 to include the new event.[5]



After analyzing the candidates in different frequency spaces, we identified one event as likely having seismic origin in addition to our two previously stated references. The event, now known as S0325a, occurred on 26 October 19 with the P-wave arriving at 06:58:58 UTC and the S-wave arriving at 07:02:56 UTC.

Based on orbital imagery Cerberus Fossae is predicted to be an active graben system[4]. It is hypothesized that majority of the faults in this system will be reverse faults due to the global contraction of the planet[1].



The three possible types of source mechanism is a normal, reverse of strike-slip fault. Each can be characterized by a unique set of strike, dip and rake angles.

Event Name:	Distance:	Back Azimuth:	Source Mechanism
S0173a	29°	91°	Likely shear factor
S0235b	27.5°	74°	Likely shear factor
S0325a	38.5°	123°	Likely shear factor

What does this tell us about Mars and the future of planetary sciences?

Based on the estimated location of S0325a, it can be concluded that the event most likely did not originate from Cerberus Fossae. However, there is evidence of faulting in this new area as seen by orbital imagery[5]. The particle motion suggests a moving source mechanism but dust devils would not be strong enough to produce low-frequency events.

By also gaining a better understanding of seismology using a single instrument, we can begin to develop better technology and data processing techniques. These updated methods can then be used to investigate the interior of other small bodies in our solar system, like Europa or Titan.

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