# Mars Seismology

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# How do the geologic differences of Mars and Earth affect seismic wave behavior?

# Methodology

1. Find similar geologic regions on both planets in order to be able to associate differences with the planet itself.
2. Find events of similar magnitudes on both planets.
3. Compare key takeaways from the data such as event length and wave travel time.
4. Compare data takeaways with geological research in order to draw relationships and conclusions.

# The Datasets

## Mars Seismic
- Mseed format
- From NASA InSight

## Earth Seismic
- Mseed format
- From USGS

## Mars Topo
- TIF File
- From NASATrek

## Earth Topo
- TIF File
- From USGS

## How did we choose these datasets?

# Tools Used

## Seismic Data

- Matplotlib: Graph our findings
- Obspy: Read and interpret our mseed data
- Numpy: Scaling axes

## Geologic Data

- Tifffile: Read and interpret TIF data
- Cartopy: Create maps and add features
- Matplotlib: Show mapps and add titles and annotations
- Numpy: Scale longitudes and latitudes

# Pt 1. Geology

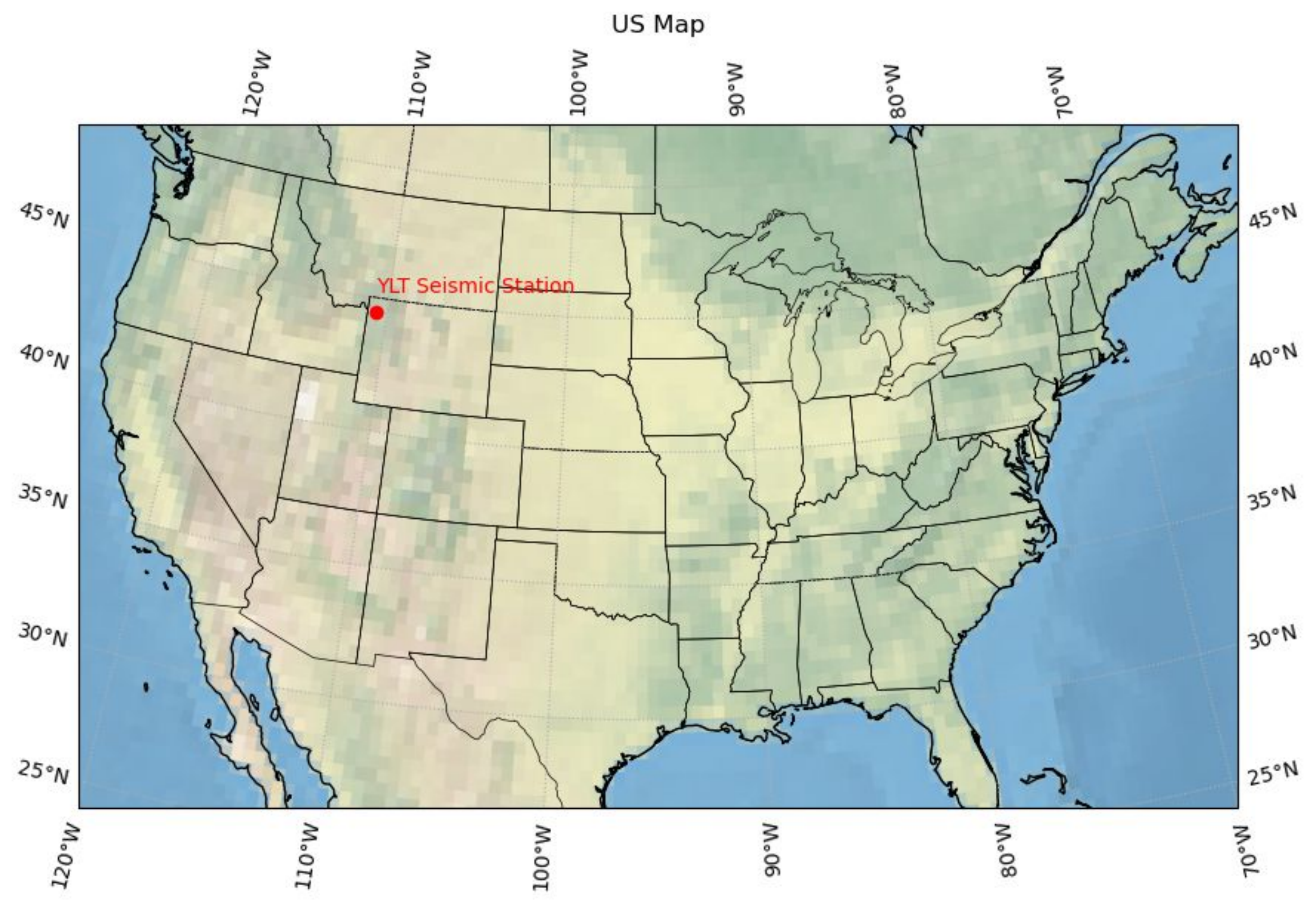
# Our areas of research

## Elysium Planitia

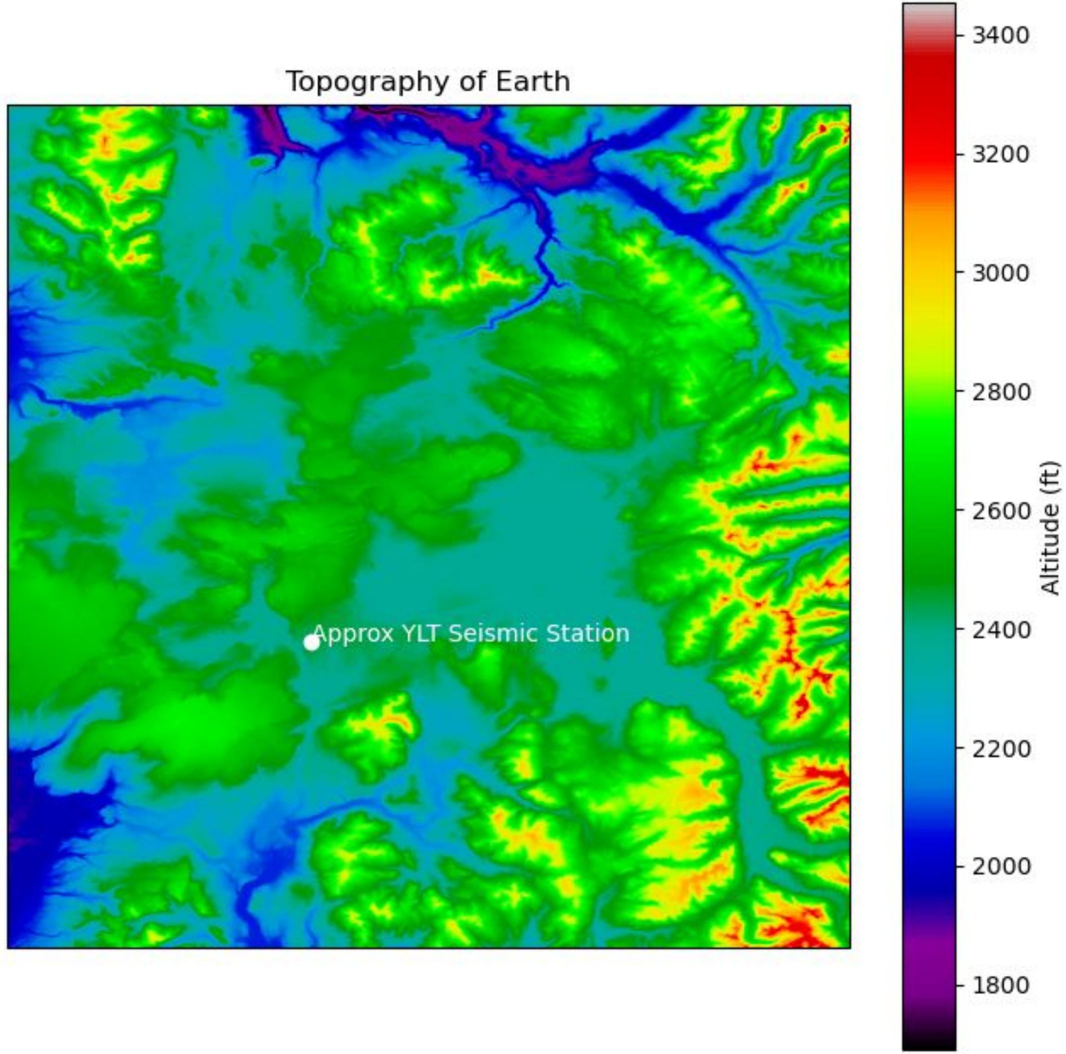
- Landing site of the NASA InSight mission.
- Volcanic area fueled by mantle plumes
- Average quake magnitude of 1-3
- Centralized around one main volcano Elysium Mons

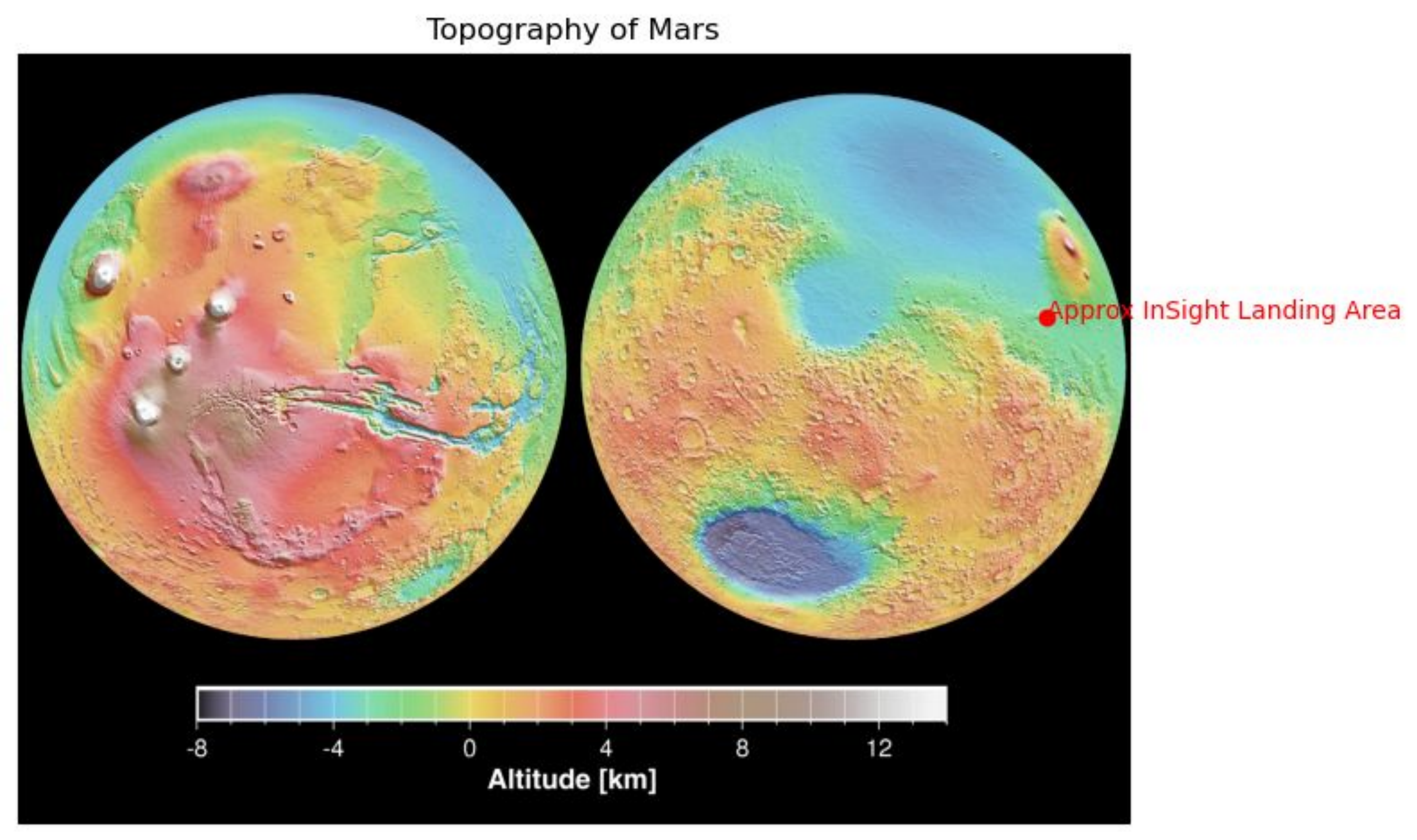
## Yellowstone, Wyoming

- USGS monitored seismic stations
- Geothermal and volcanic area fueled by mantle plumes
- Home to the Yellowstone Caldera supervolcano



US Map
YLT Seismic Station
120°W
110°W
100°W
90°W
80°W
70°W
45°N
40°N
35°N
30°N
25°N


Topography of Earth
Approx YLT Seismic Station
3400
3200
3000
2800
2600
2400
2200
2000
1800
Altitude (ft)



Topography of Mars
Approx InSight Landing Area
-8
-4
0
4
8
12
Altitude [km]

## Earth

- Crust thickness: 47-52km
- High tectonic activity
- Crust is 5% Fe and 2.1% Mg
- Density: 2.6 g/cm^3
- Very sedimentary crust (75%)

## Mars

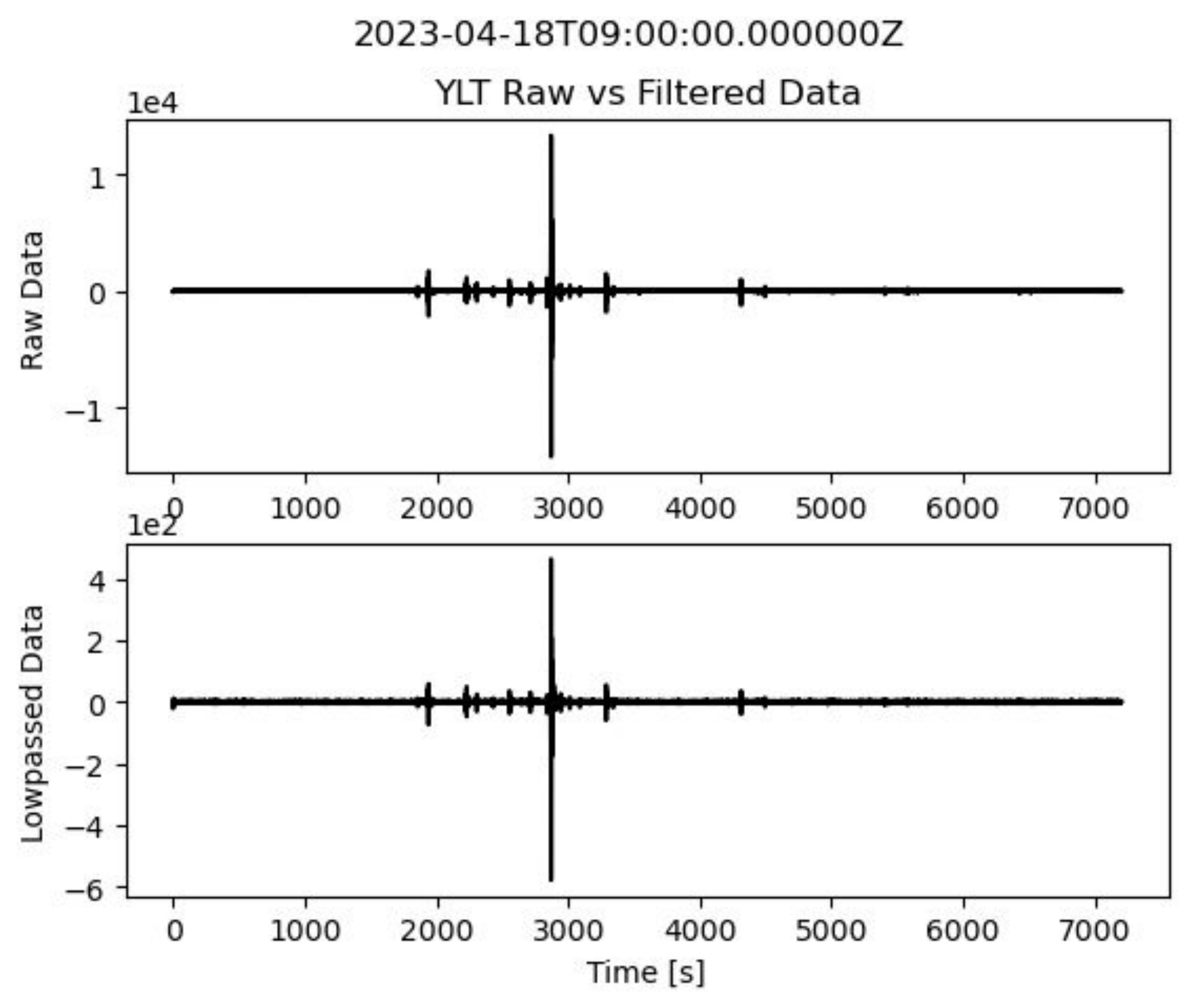
- Crust thickness: 30-47km
- No tectonic activity
- Crust is 14% Fe and 5.5% Mg
- Density: 2.5 g/cm^3
- Very igneous crust (mostly basalt)

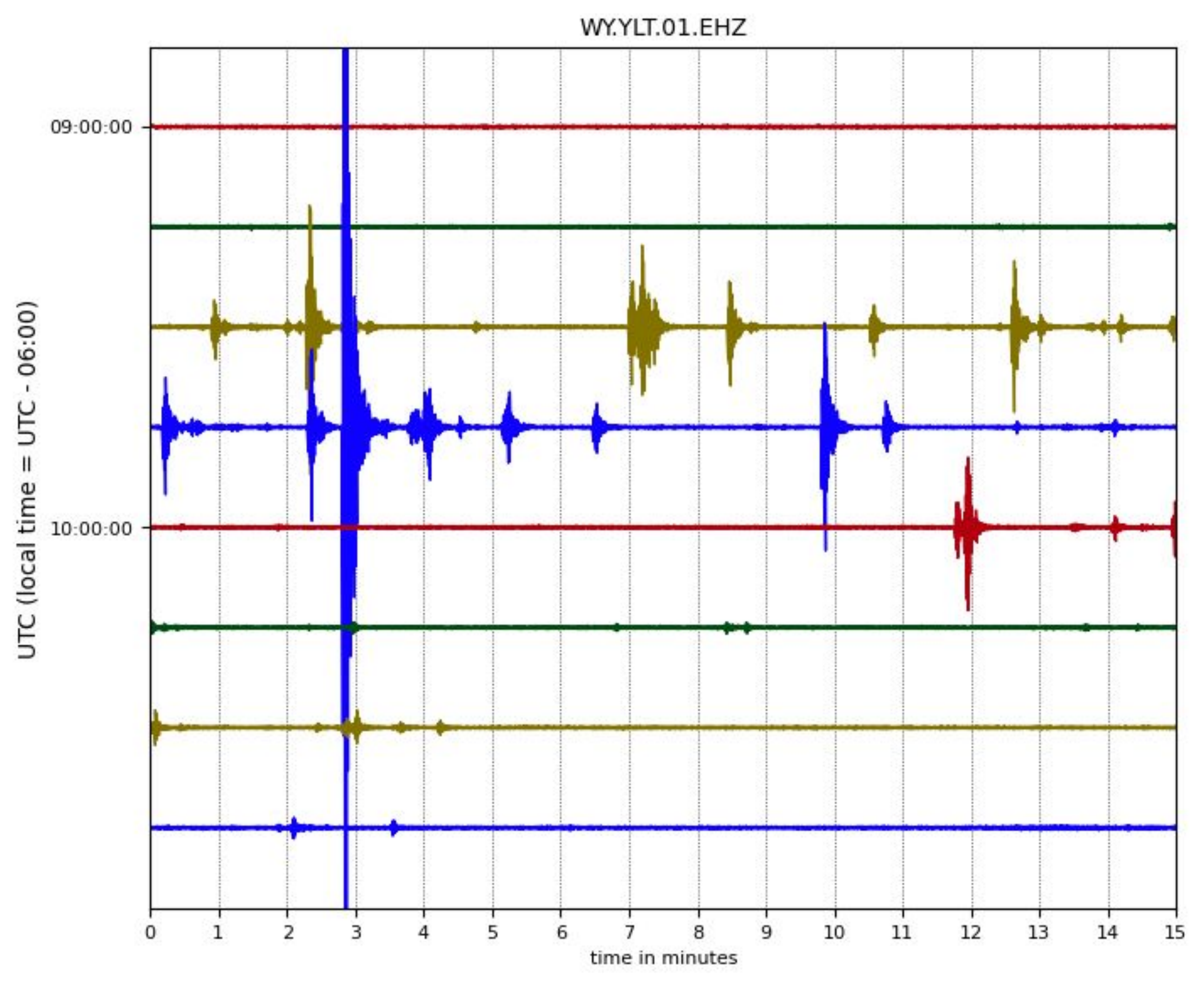
## Both

- Volcanism fueled by mantle plumes
- Both crusts are mostly O and Si. Mars - 66% Earth - 78%

# Pt 2. Seismology

# Earth Seismic Data

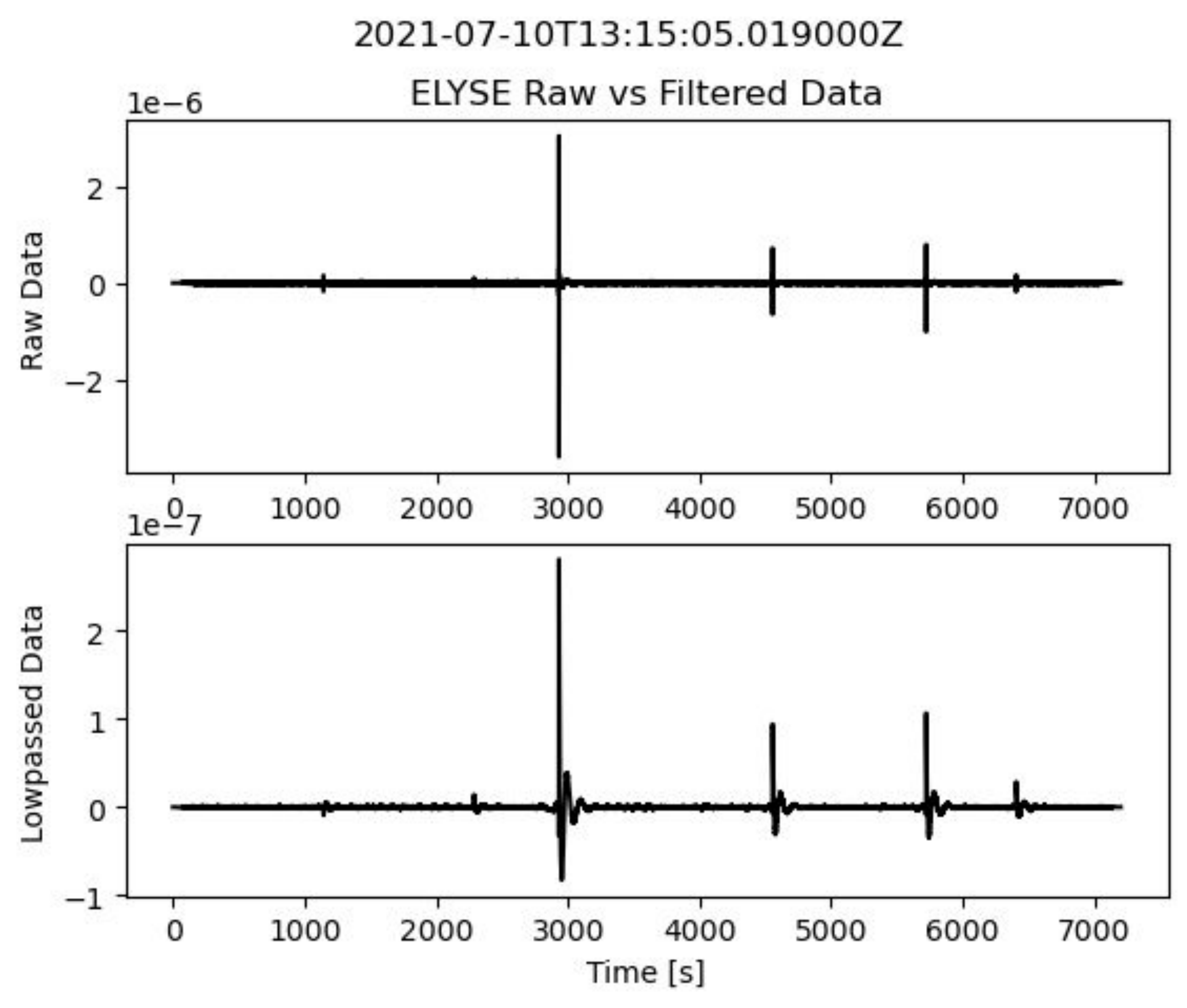




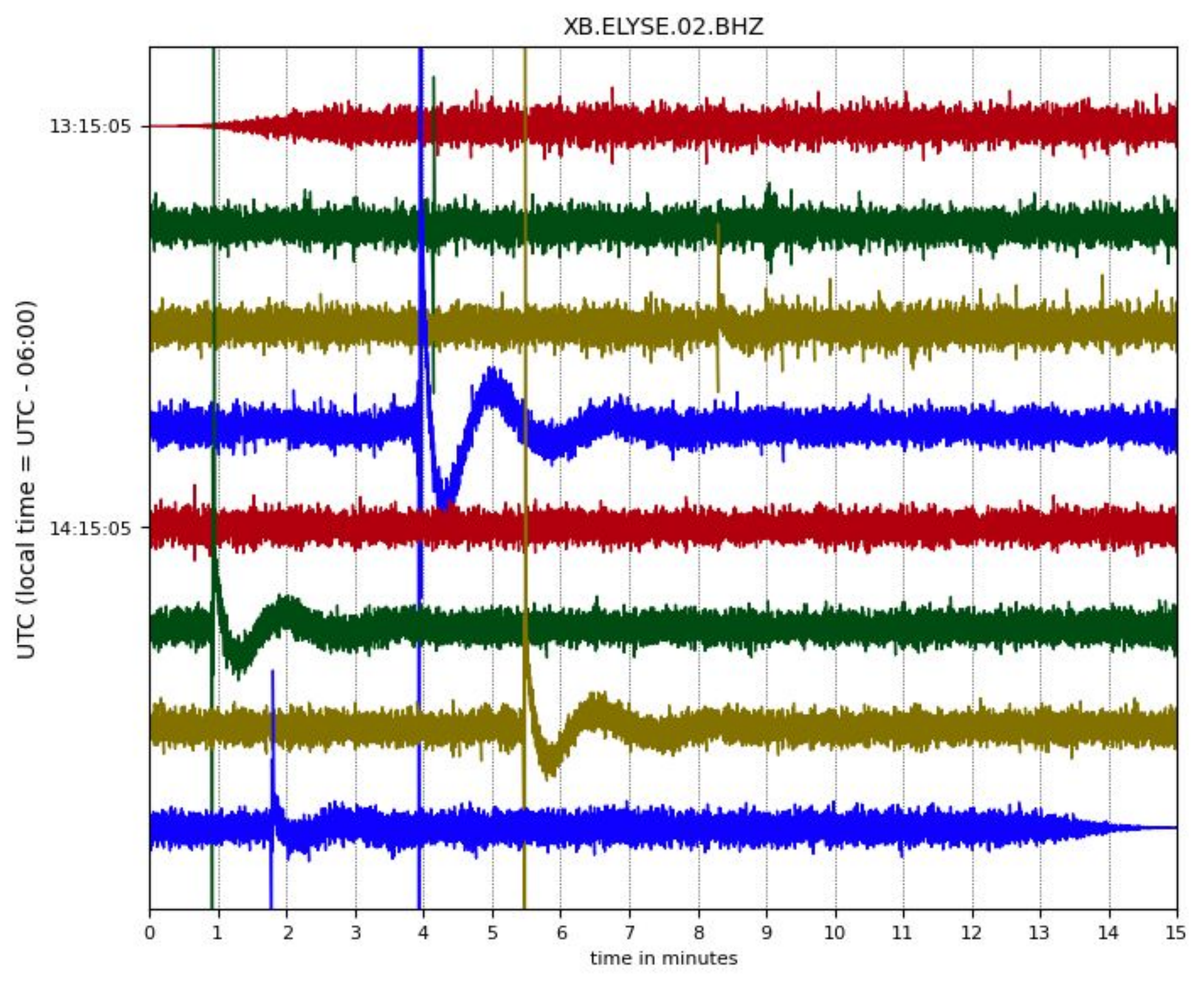
WY.YLT.01.EHZ
09:00:00
10:00:00
UTC (local time = UTC - 06:00)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
time in minutes

# Key Takeaways

1. Big spikes in seismic data occur over a small period of time with very small wave amplitudes towards the end of the event.
2. The event begins at approximately 9:31 and ends at  approximately 10:49 with the peak occurring at approximately 9:43.
3. The total time of the event was 78 minutes with 12 minutes before the beginning and peak, and 66 minutes between peak and end.




# Mars Seismic Data



XB.ELYSE.02.BHZ
13:15:05
14:15:05
UTC (local time = UTC - 06:00)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
time in minutes

# Key Takeaways

1. Bigger spikes occur over a longer period of time, with a more even time distribution between spikes in amplitude.
2. The event began at approximately 13:53 and ended at approximately 15:02 with the peak occurring at 14:04.
3. The total event duration was 69 minutes with 11 minutes between the start and peak and 62 minutes between peak and end.

# Pt 3.
# Our Findings

- Seismic waves travel more uniformly on Mars than on Earth
- Assuming that the biggest amplitude change is the S wave arrival, S waves arrive quicker and are over quicker on Mars.

Based on these points we can conclude that **seismic waves travel faster on Mars than on Earth.** But **why**?

1) Mars is less dense due to its chemical composition allowing waves to travel faster through it.
2) Martian crust is less thick and has a smaller radius, giving waves a shorter distance to travel.
3) The Martian crust is more igneous and volcanic rock tends to have a higher porosity, making it easier for the waves to travel through.

Understanding the relationship between seismic waves and geology on Mars can help us better understand the planets history!

# Limitations/Weaknesses

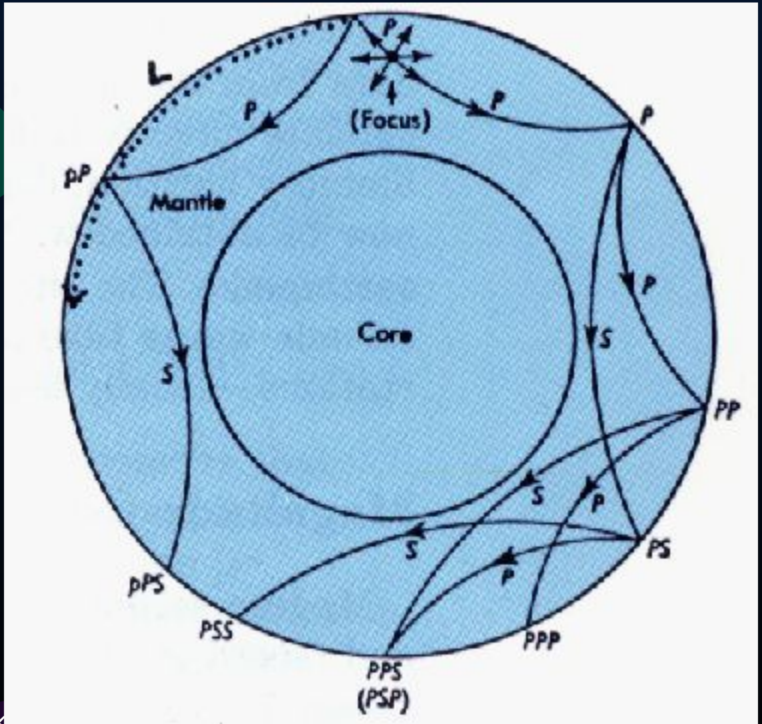



Image from USGS

The main limitation of our research is our inability to know the location of the seismic station in respect to the earthquake epicenter. Because of this, it is harder to find P and S wave arrival times and therefore more difficult to know the exact wave speeds.

# References


"Waveform Plotting Tutorial." Waveform Plotting Tutorial - ObsPy 1.4.0 Documentation, 21 Nov. 2022, https://docs.obspy.org/tutorial/code_snippets/waveform_plotting_tutorial.html.

https://apps.nationalmap.gov/downloader/

https://astrogeology.usgs.gov/search/map/Mars/Topography/HRSC_MOLA_Blend/Mars_HRSC_MOLA_BlendDEM_Global_200mp_v2

https://usgs.maps.arcgis.com/apps/webappviewer/index.html?id=fc004c3d21b64c398ed5458580ab7c58

https://service.iris.edu/fdsnws/dataselect/docs/1/builder/

http://www.fdsn.org/pdf/SEEDManual_V2.4_Appendix-A.pdf

https://github.com/UMD-InSight/InSight-seismic-data-downloader

https://bigthink.com/hard-science/mars-earthquake-marsquake/

https://www.researchgate.net/figure/Topographic-map-of-the-region-around-the-InSight-landing-site-NSY-showing-major_fig2_325998973

https://www.lpi.usra.edu/education/IYPT/Mars.pdf

https://www.usgs.gov/programs/earthquake-hazards/seismographs-keeping-track-earthquakes

https://nssdc.gsfc.nasa.gov/planetary/factsheet/marsfact.html