Magnitude 7.3 JAPAN
Wednesday, March 16, 2022 at 14:36:33 UTC

Latitude 37.702° N
Longitude 141.587° E
Depth 63.1 km

A major magnitude 7.3 earthquake struck Wednesday off the coast of Fukushima, Japan at a depth of 63 km (39 miles).

The earthquake shook buildings in downtown Tokyo and triggered a tsunami advisory for a part of the northeast coast. There were no early reports of major damage, but nearly 2 million people lost power as a result of the quake. A high-speed bullet train was reported to have been derailed by the shaking.

This earthquake occurred days after the 11 year anniversary of the devastating 2011 M 9.1 Tohoku earthquake/tsunami and can be considered an aftershock of that event.

Image courtesy of the US Geological Survey

IRIS Teachable Moments

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The March 16, 2022 quake was centered about 60 km off the coast of Fukushima, Japan where a nuclear powerplant suffered significant damage in 2011 after the massive M9.1 Tohoku earthquake.

The 2011 earthquake generated a large tsunami that flooded the power station, knocking out power to cooling units, and ultimately led to a meltdown that released radiation into the surrounding air and water.

The 2022 M7.3 quake was too deep (~60km) to produce a significant tsunami, but the shaking was intense enough to briefly disable power at the Fukushima plant. Thankfully, no radiation leaks or other hazards were observed.

Fukushima Daiichi Nuclear Power Station is located right on the coastline in Fukushima, Japan.

Image courtesy of Tokyo Electric Power Co., TEPCO

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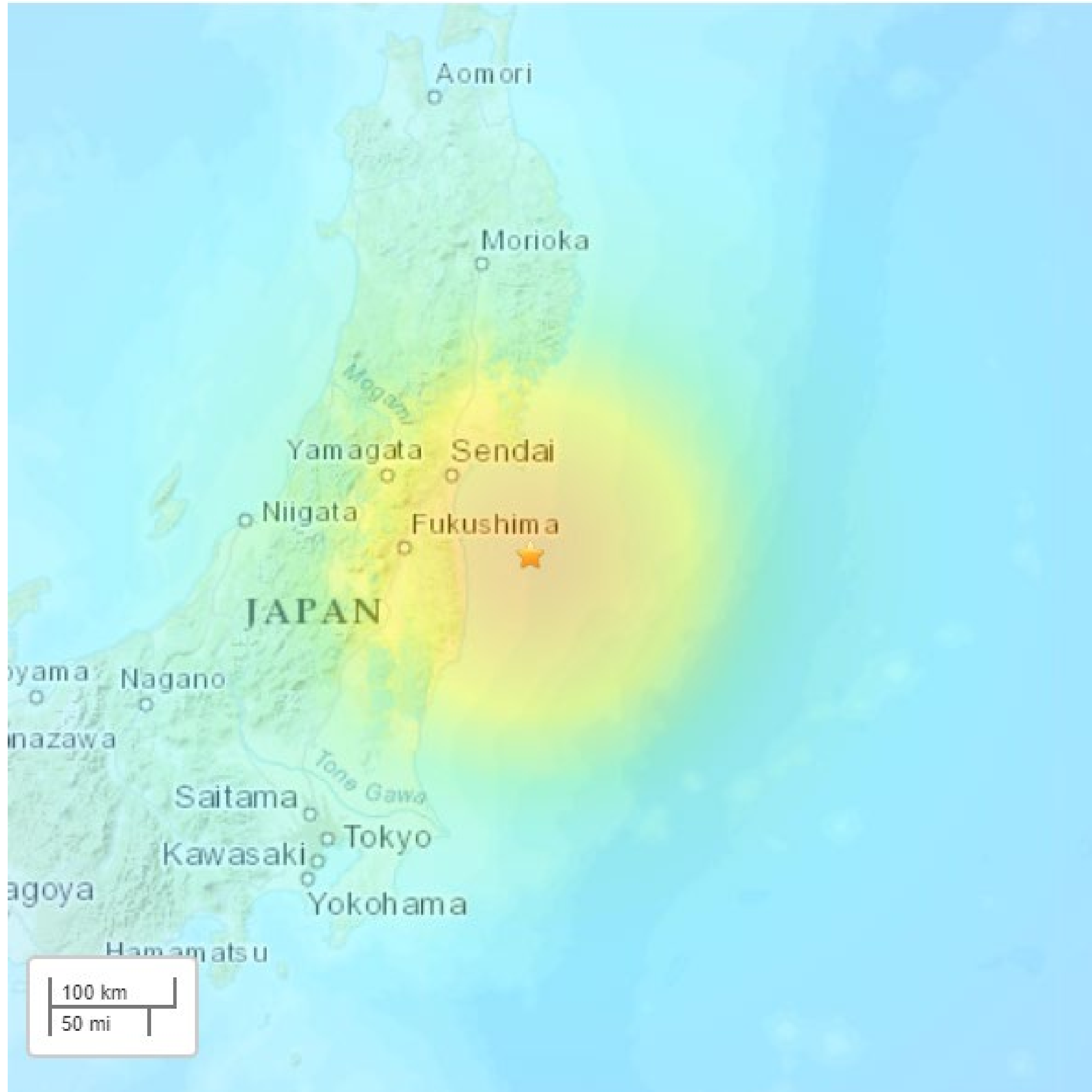
The Modified-Mercalli Intensity (MMI) scale is a ten-stage scale, from I to X, that indicates the severity of ground shaking. Intensity is based on observed effects and is variable over the area affected by an earthquake. Intensity is dependent on earthquake size, depth, distance, and local conditions.

MMI	Perceived Shaking
X	Extreme
IX	Violent
VIII	Severe
VII	Very Strong
VI	Strong
V	Moderate
IV	Light
II-III	Weak
I	Not Felt



USGS estimated shaking intensity from M 7.3 Earthquake

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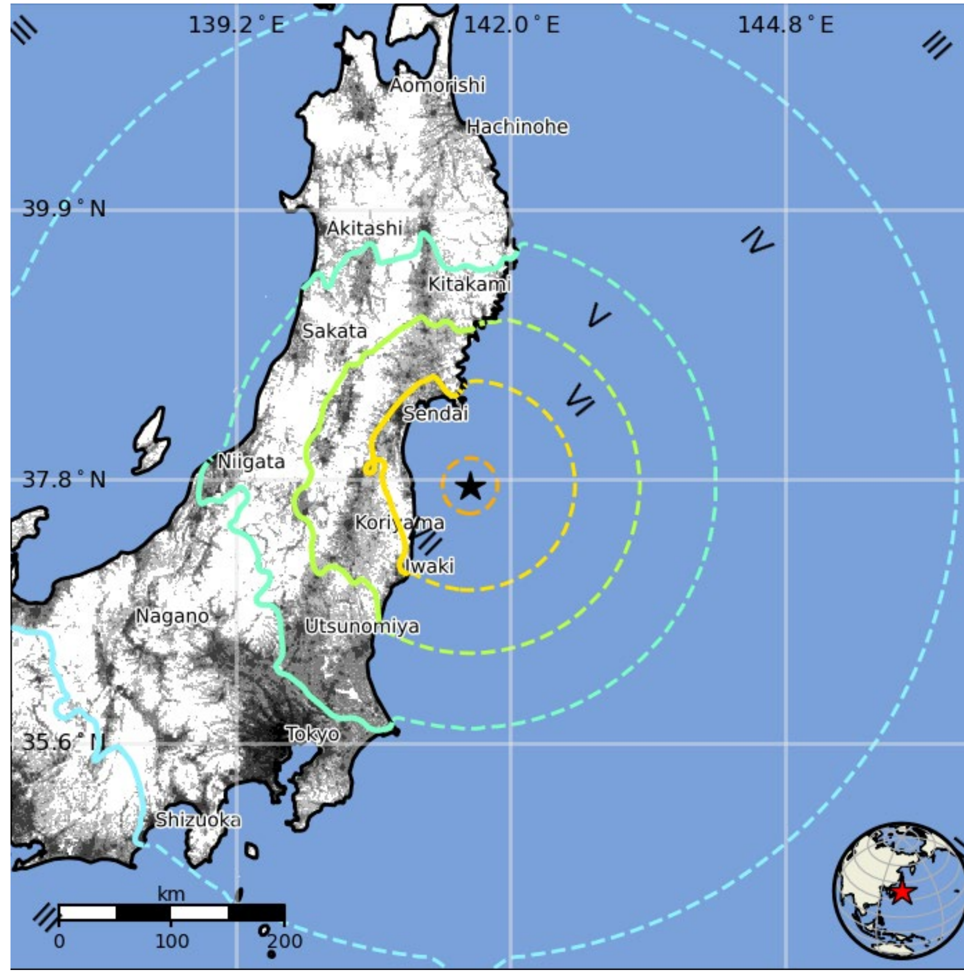
The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels.

The USGS estimates that over 2 million people felt very strong shaking from this earthquake.

I	Not Felt	0 k*
II-III	Weak	5,285 k*
IV	Light	46,939 k
V	Moderate	7,379 k
VI	Strong	3,200 k
VII	Very Strong	2,046 k
VIII	Severe	0 k
IX	Violent	0 k
X	Extreme	0 k



The color-coded contour lines outline regions of MMI intensity. The total population exposure to a given MMI value is obtained by summing the population between the contour lines. The estimated population exposure to each MMI Intensity is shown in the table.

Image courtesy of the US Geological Survey

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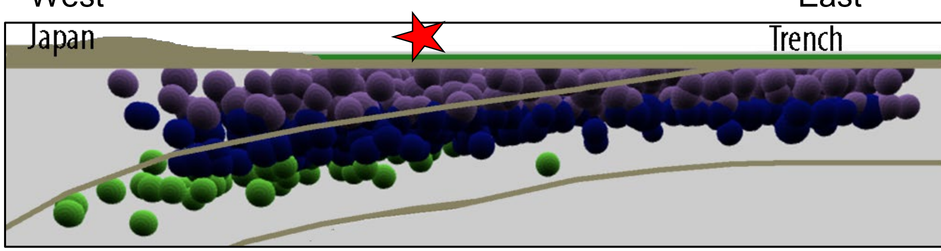
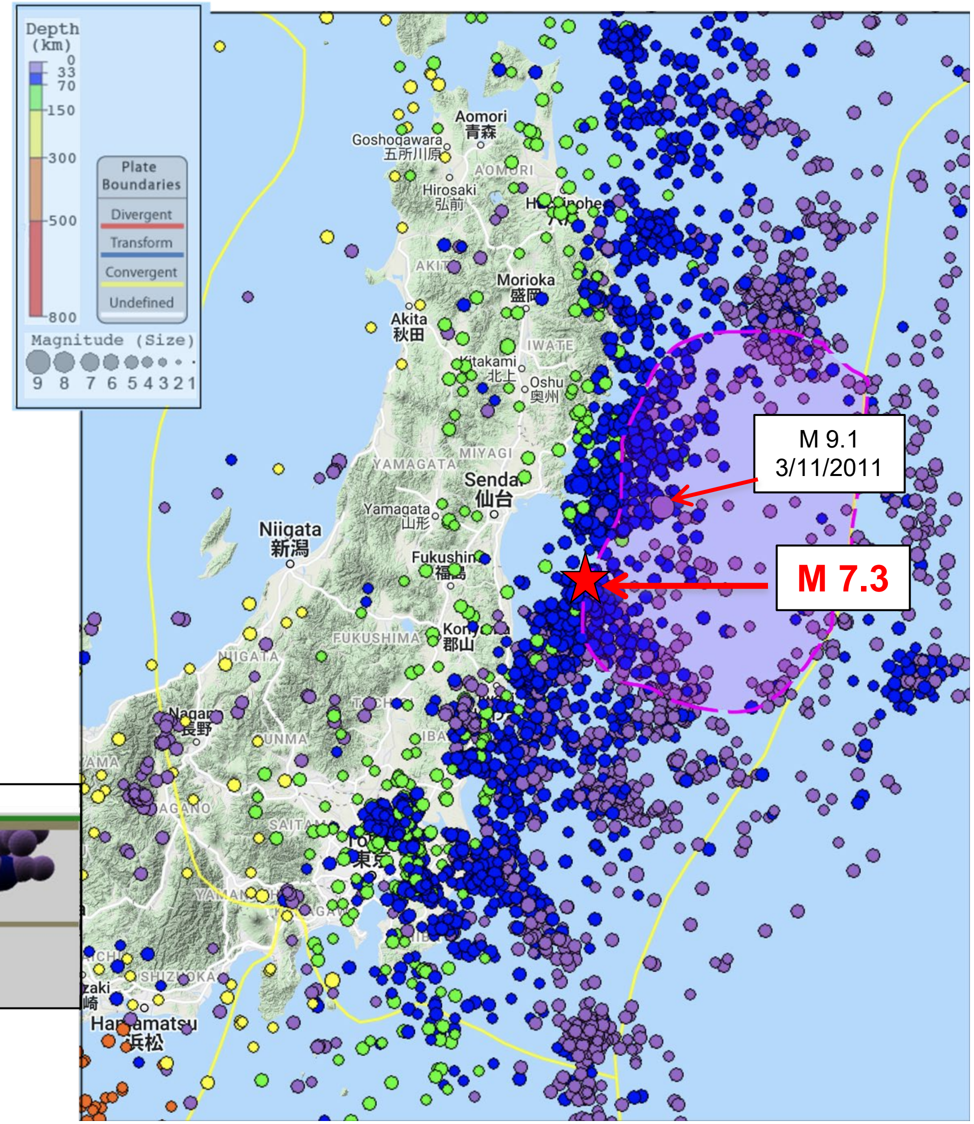
Map on the right shows only earthquakes greater than M4 in past 20 years. The dashed/shaded enclosure marks the rupture zone for the M 9.1 Tohoku-Oki earthquake.

As shown on the cross section below, earthquakes are shallow (purple dots) at the Japan Trench and increase to 600 km depth (red dots) towards the west as the Pacific Plate dives deeper beneath Japan.

This earthquake hypocenter was 63 km deep, in the blue range of the scale.



Seismicity cross section through the subduction zone adjacent to the earthquake showing the relationship between color and earthquake depth.



Images created by the IRIS Earthquake Browser

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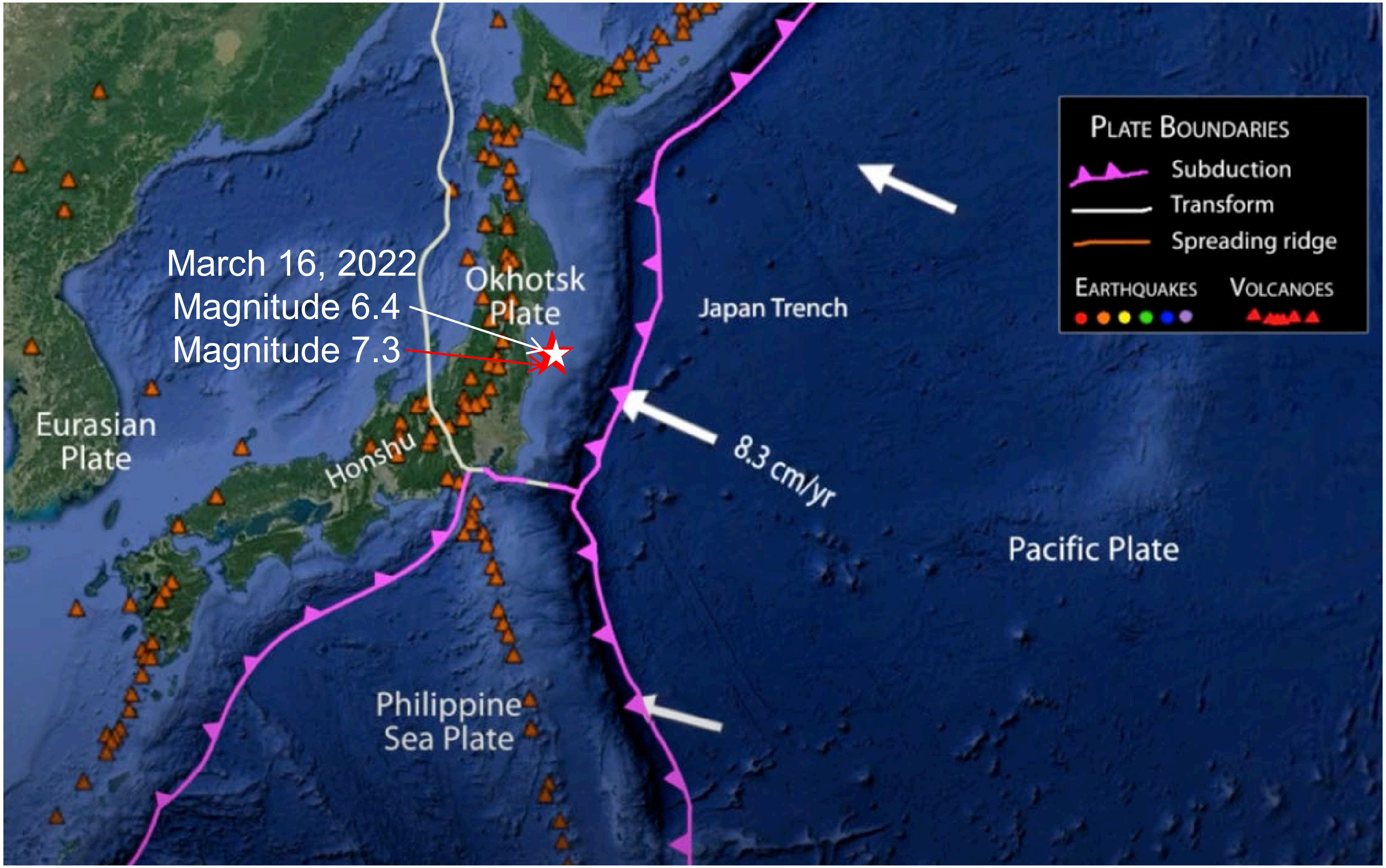

In Northern Honshu, the Pacific Plate subducts beneath the Okhotsk Plate at a rate of 8.3 cm/year. The epicenter of the magnitude 6.4 foreshock is shown by the white star while the epicenter of the magnitude 7.3 mainshock is shown by the red star.

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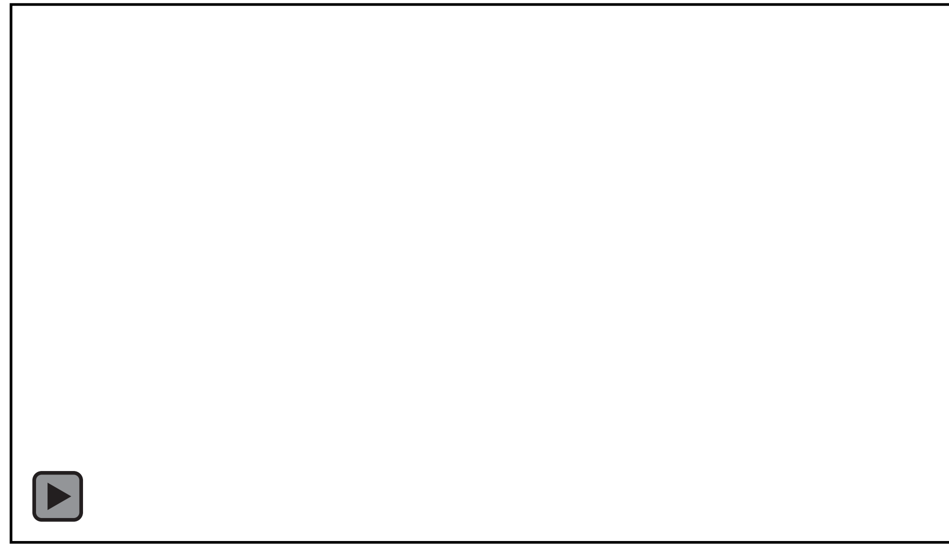
A **foreshock** is a smaller magnitude earthquake that precedes the mainshock.

There are no special characteristics of a foreshock that let us know it is a foreshock until the mainshock occurs.

A **mainshock** is largest magnitude earthquake during an earthquake sequence.

Aftershocks are smaller earthquakes occurring after a large earthquake as the fault adjusts to the new state of stress.

The graph shows how the number of aftershocks and the magnitude of aftershocks decay with increasing time since the main shock. The number of aftershocks also decreases with distance from the main shock.



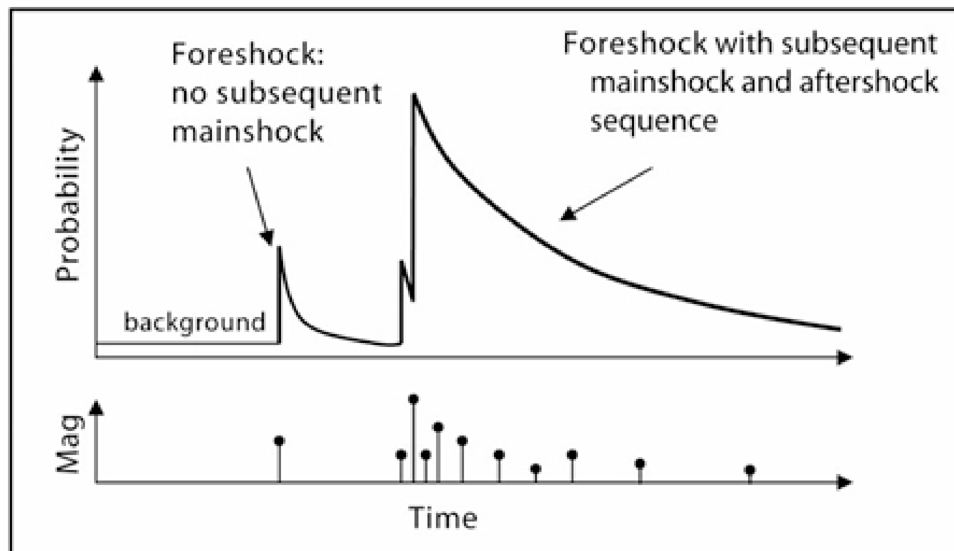


Image courtesy of the US Geological Survey

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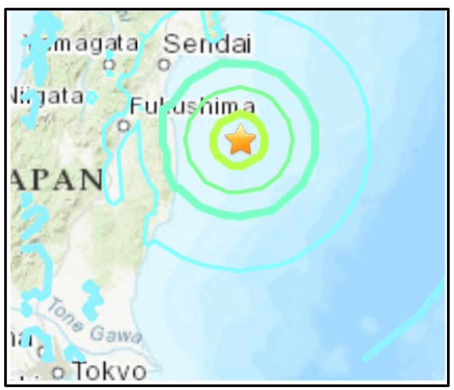
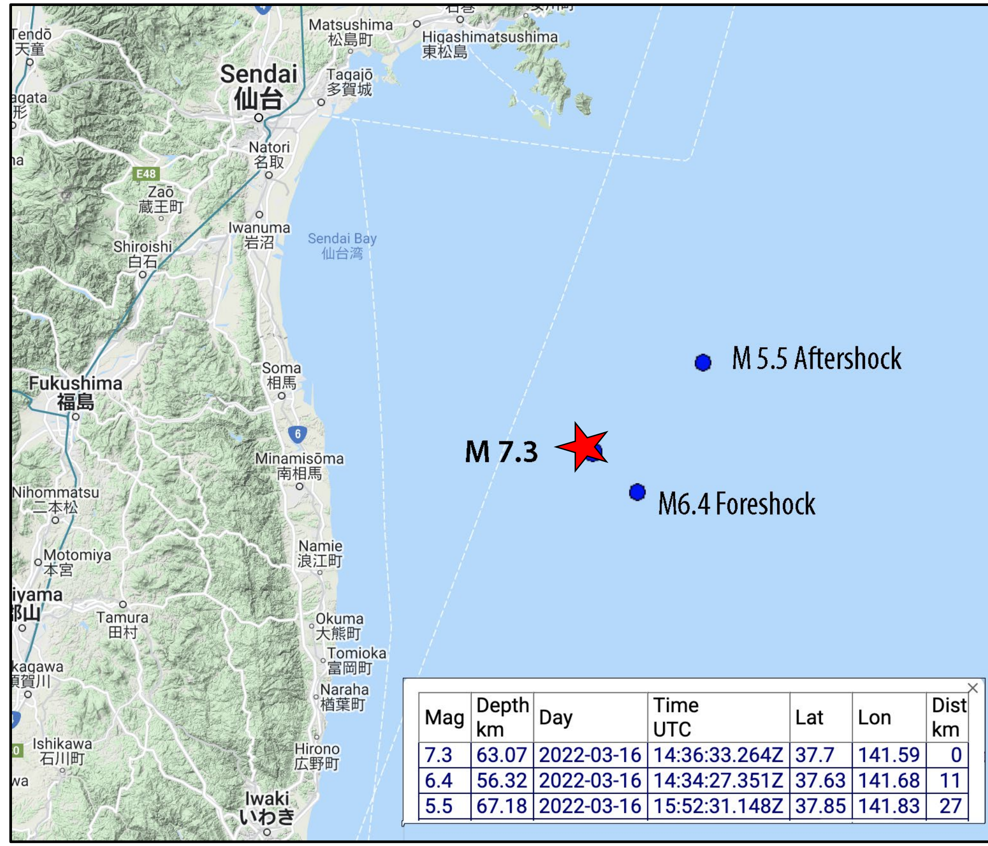
Teachable Moments

Map on the right shows a M 6.4 foreshock ~2 min before the M 7.3 earthquake. The USGS intensity map below shows that ground shaking along the nearby coast was light.





Mag	Depth km	Day	Time UTC	Lat	Lon	Dist km
7.3	63.07	2022-03-16	14:36:33.264Z	37.7	141.59	0
6.4	56.32	2022-03-16	14:34:27.351Z	37.63	141.68	11
5.5	67.18	2022-03-16	15:52:31.148Z	37.85	141.83	27

A smaller M 5.5 aftershock occurred 1 hr 16 min after.

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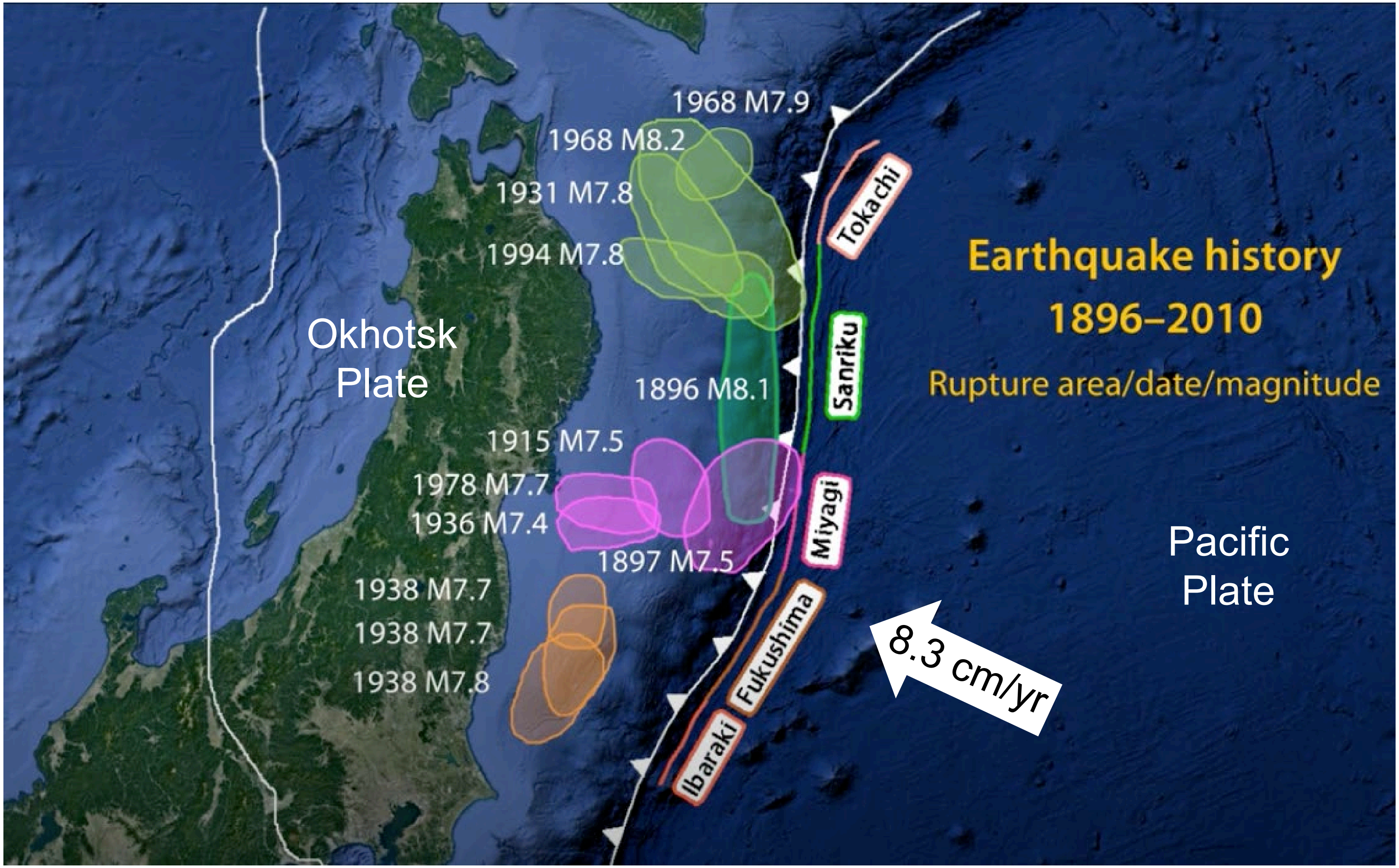

On this map, the year, magnitude, and rupture area are shown for magnitude 7.4 and larger earthquakes on the Pacific – Okhotsk subduction plate boundary from 1896 to 2010, just prior to the March 11, 2011 magnitude 9.1 great earthquake.

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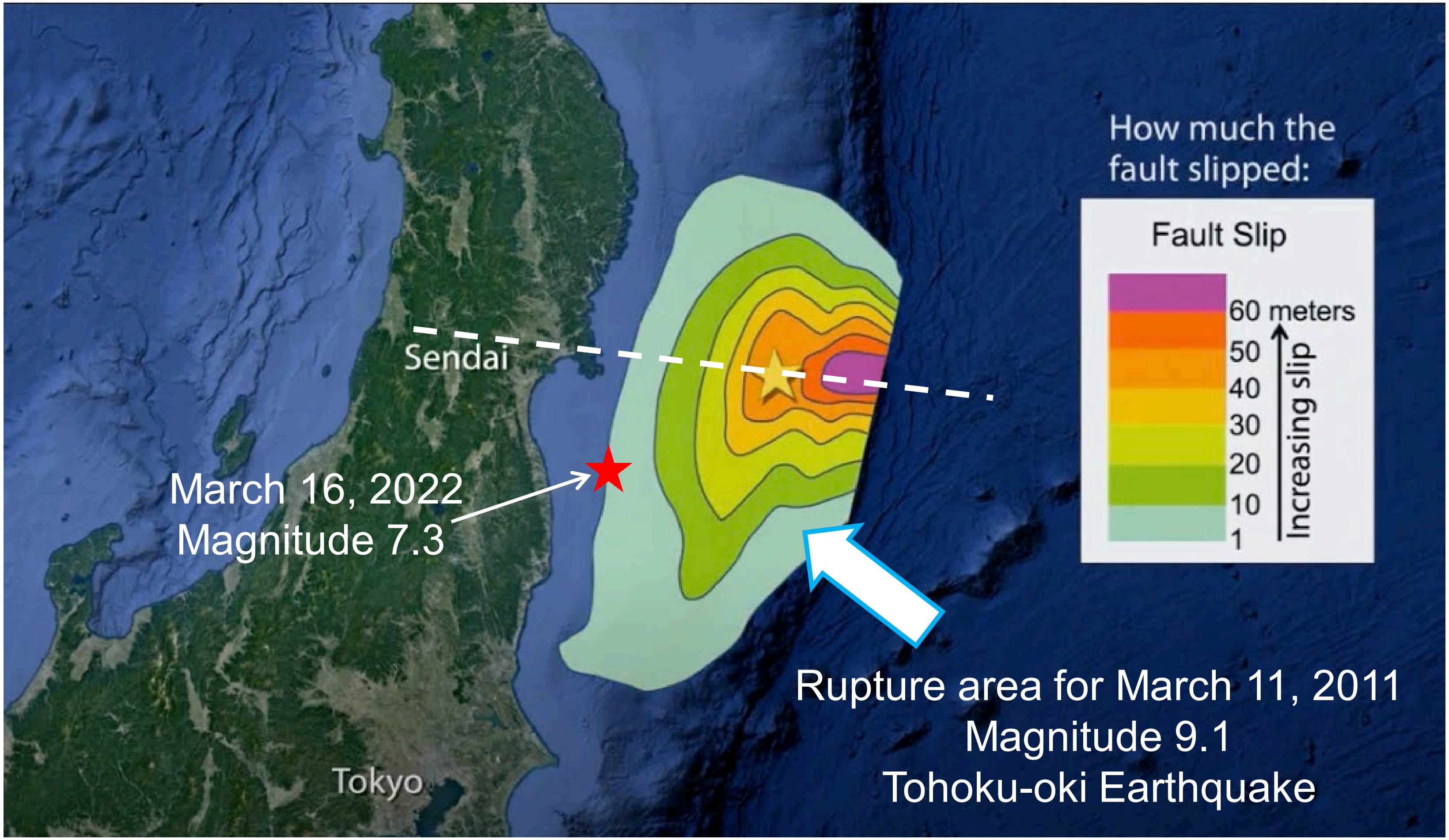

On March 11, 2011, the M 9.1 Tohoku-oki earthquake ruptured a 500-km-long by 200-km-wide area of the Pacific – Okhotsk megathrust plate boundary. Fault slip reached over 60 meters near the Japan Trench. This great earthquake, the largest in Japan's history, and the resulting tsunami took almost 20,000 lives and caused approximately $200 billion damage. The March 16, 2022 M 7.3 earthquake is located near the western edge of the Tohoku-oki rupture zone. A cross section along the dashed line is shown on the next slide.

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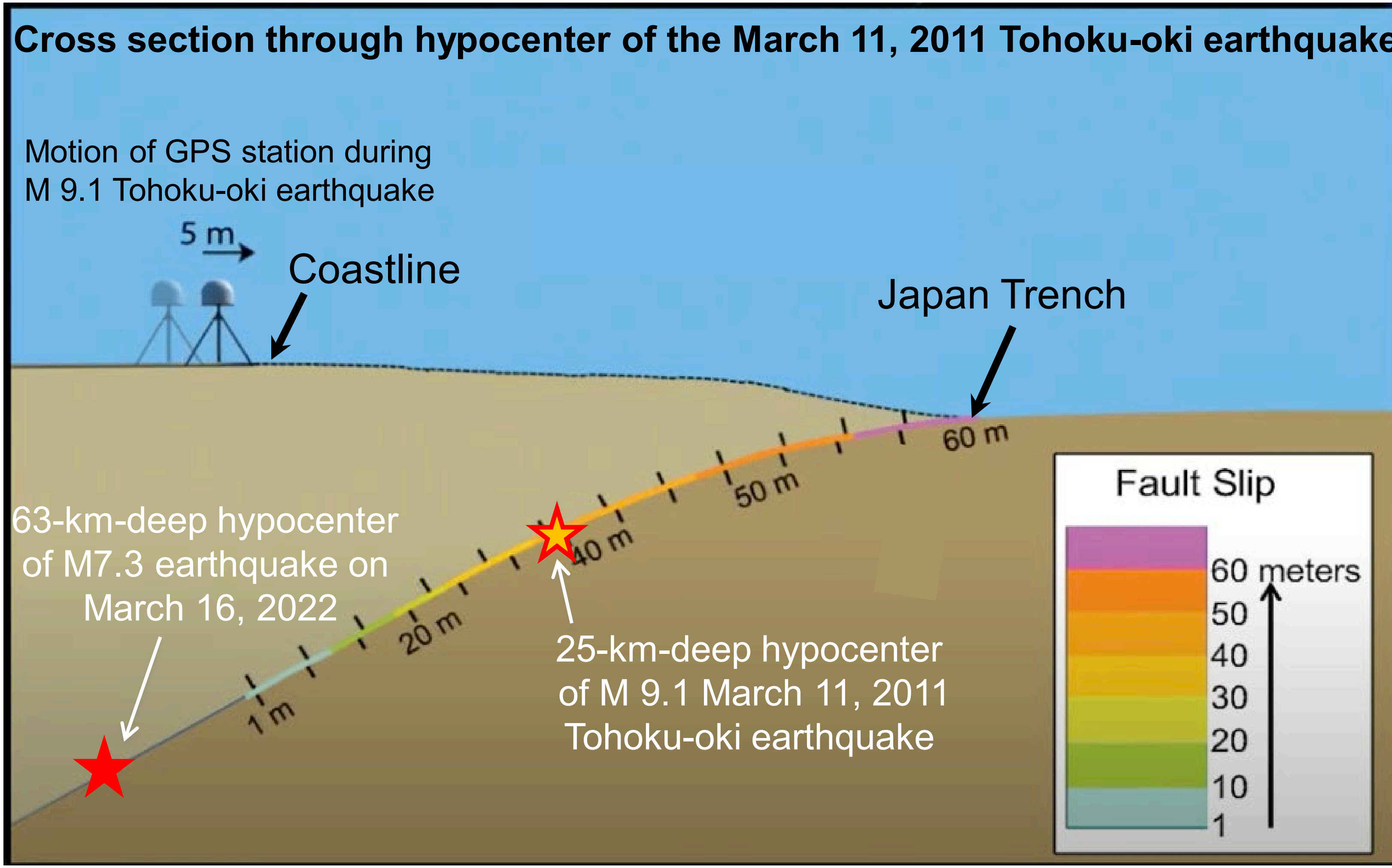

Fault slip during the M 9.1 Tohoku-oki earthquake is shown on this cross section through its hypocenter at ~25 km depth. Fault slip was 40 meters at the hypocenter and over 60 meters at the Japan Trench. Fault slip decreased downdip from the hypocenter to about 1 meter at ~50 km depth. The hypocenter of March 16, 2022 M 7.3 earthquake projects into this cross section at or just beyond the downdip limit of the 2011 rupture.

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An animation prepared for the 10th Anniversary of the March 11, 2011 M9.1 Japan earthquake and tsunami featuring lessons learned from that natural disaster.

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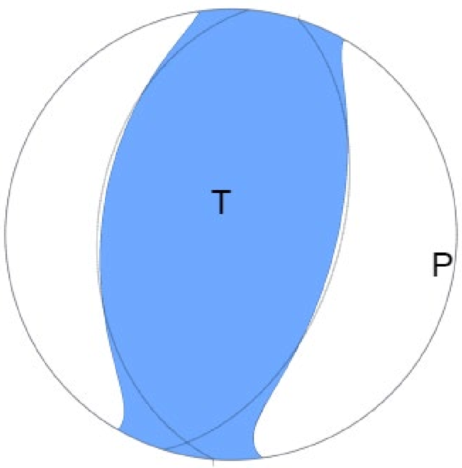
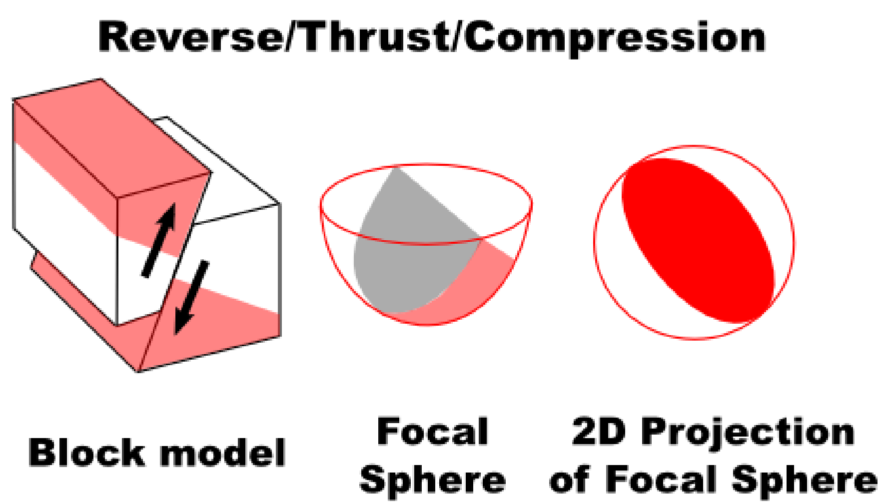
The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Because an earthquake occurs as slip on a fault, it generates primary (P) waves in quadrants where the first pulse is compressional (shaded) and quadrants where the first pulse is extensional (white). The orientation of these quadrants calculated from recorded seismic waves determines the type of fault that produced the earthquake.



USGS W-phase Moment Tensor Solution

The tension axis (T) reflects the minimum compressive stress direction. The pressure axis (P) reflects the maximum compressive stress direction.

In this case, the earthquake location and focal mechanism indicate it was due to thrust faulting on the plate boundary between the subducting Pacific Plate and the overriding Okhotsk Plate.



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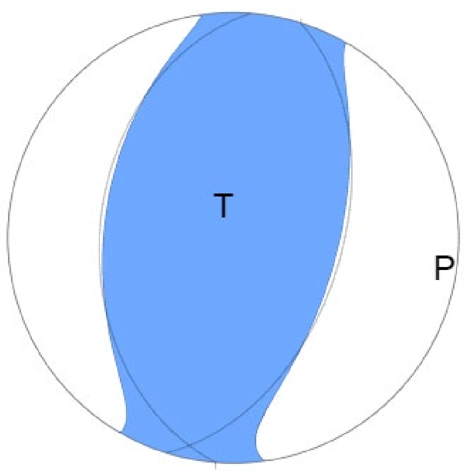
This animation explores the motion of a reverse fault, and how reverse faults are represented in a focal mechanism.

Remember, this was the focal mechanism solution for this earthquake. It was estimated by an analysis of observed seismic waveforms, recorded after the earthquake, observing the pattern of "first motions", that is, whether the first arriving P waves push up or down.



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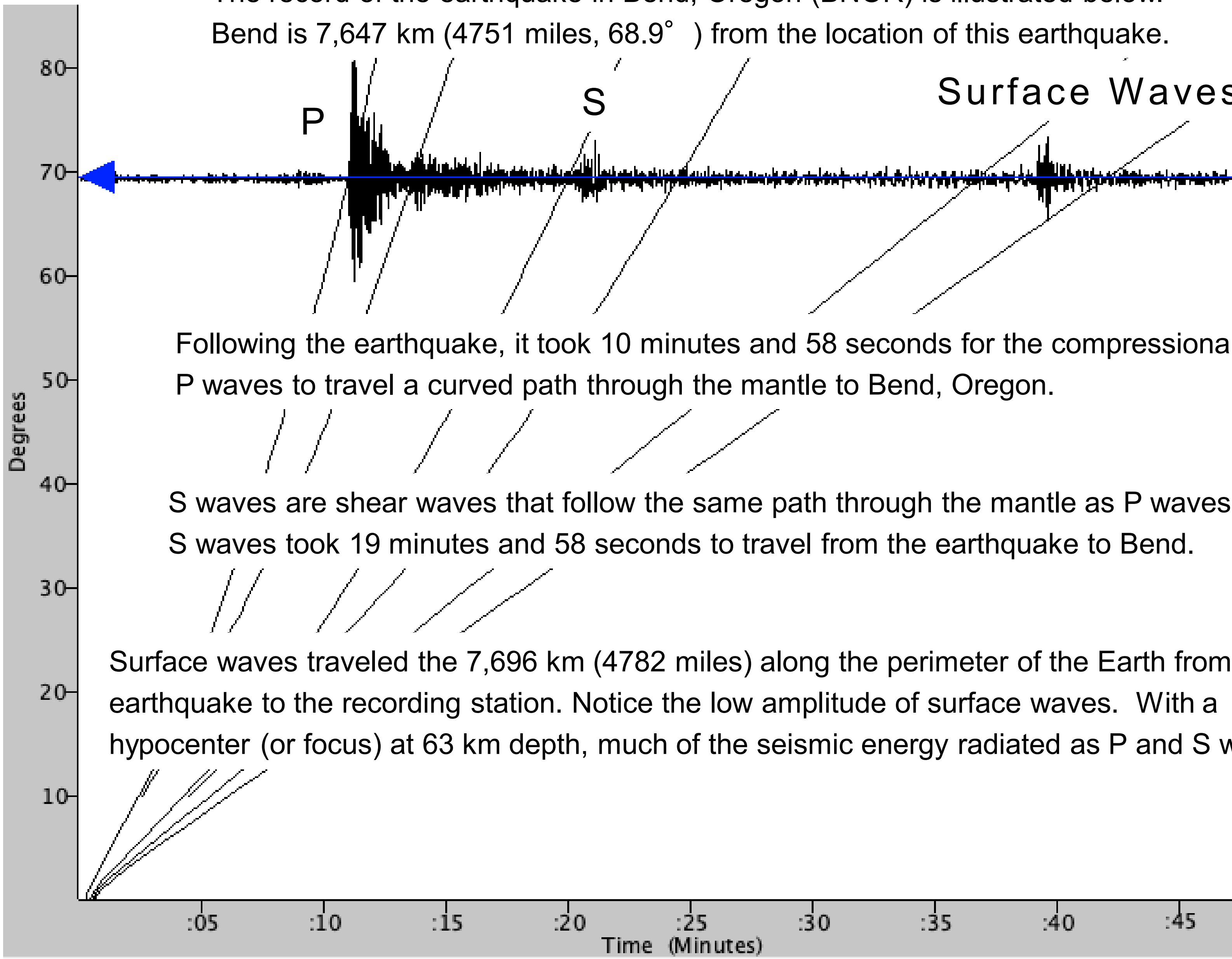
The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 7,647 km (4751 miles, 68.9°) from the location of this earthquake.



Following the earthquake, it took 10 minutes and 58 seconds for the compressional P waves to travel a curved path through the mantle to Bend, Oregon.

S waves are shear waves that follow the same path through the mantle as P waves. S waves took 19 minutes and 58 seconds to travel from the earthquake to Bend.

Surface waves traveled the 7,696 km (4782 miles) along the perimeter of the Earth from the earthquake to the recording station. Notice the low amplitude of surface waves. With a hypocenter (or focus) at 63 km depth, much of the seismic energy radiated as P and S waves.

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