Teacher Guide

Welcome to Teachable Moments! Our goal is to provide timely and accurate information to develop knowledge about a newsworthy earthquake for audiences from middle school through college. Please use the slides to get a concise, but thorough overview of the recent earthquake and then use them as is, or customize it for your students and curriculum.

For the 2025-26 school year:

1. **Color-coding for grade levels.** 

middle school + 

high school + 

college

1. **Check out the Slide Guide: Slides or pdf handout that will guide your students through the slide deck:** **middle school** pdf **high school** pdf **college** pdf
2. **Cross Curricular Content slide(s): A quick hit about the city or area that gives you cross-curricular connections:** geography, physics, chemistry, biology, environmental science or even history.
3. **NGSS Connections linked to questions in the Slide Guide are located in the notes sections below each slide guide.**
4. **Fill in the blank sub-plans:** The first two pages can be completed and used all year (hint: sheet protector). The rest are for you to modify or fill-in to customize your sub-plans to fit what you're doing.

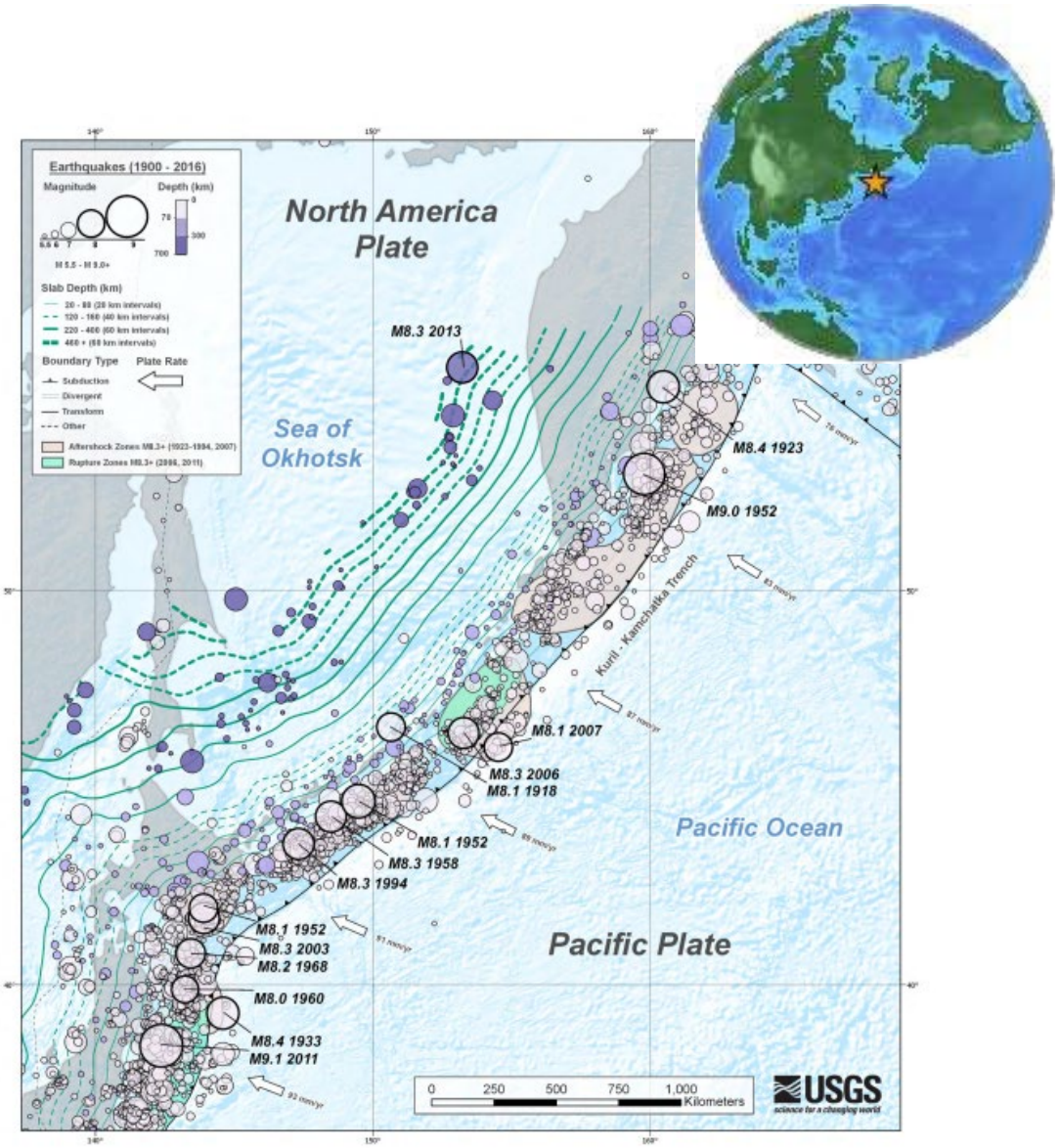
Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

Latitude 52.104°N
Longitude 160.294°E
Depth 39.5 km

The Kamchatka region experienced its most powerful aftershock on September 13, 2025, when a magnitude 7.4 earthquake struck near Petropavlovsk-Kamchatsky. This event is part of the ongoing seismic sequence following the major M8.8 earthquake that occurred on July 29.

The aftershock originated from compressional forces at the boundary where the Pacific Plate subducts beneath the Okhotsk Plate. The recent activity continues to demonstrate the significant seismic potential of this region, which previously produced a landmark 1952 M9 earthquake.

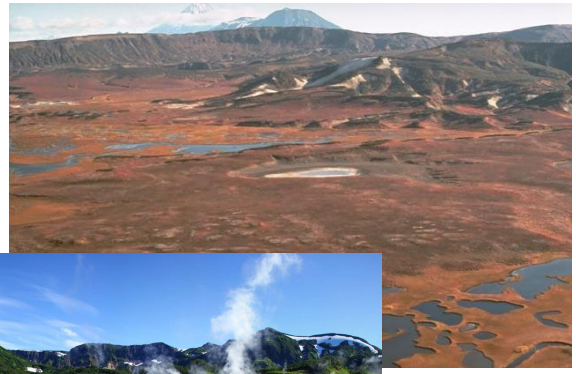


Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

The Petropavlovsk-Kamchatsky is the gateway to the Kamchatka Peninsula, is the administrative center for the Kamchatsky-Krai, and is surrounded by volcanoes. Though the main industry here is fishing and forestry, it is also known for its Shipbuilding, geothermal and hydroelectric energy production, military (Russia's largest submarine base is across Avacha Bay), Coal and other raw materials, and tourism. Visitors go for the mineral hot springs, natural beauty, sport fishing, and skiing.



Notable spots in the Kamchatka Peninsula are the Valley of Geysers, Kamchatka River Valley, and the Kronotsky Nature Reserve. It is a UNESCO World Heritage Site for being the Land of Ice and Fire.

From the last census in 2021, there are 291,705 people on the Kamchatka Peninsula; there are 164,900 of them in Petropavlovsk-Kamchatsky. Most people are Russian (88%), with small % of Koyaks (indigenous population), Ukrainian, and others. Russian law acknowledges religious associations: here, over 30% practice Russian Orthodoxy. Other Christians, native faiths Hinduism and Islam ar also practiced in much smaller numbers.

Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

The climate on the peninsula is mostly subarctic with most of its precipitation coming as snow. Average temperatures in January reach -4° C or 24.8° F with the warmest month, August, reaching maximum temperatures of 17° C or 68° F. There is minimal human development here with 5 nature reserves. Because of the loss of habitat, hunting, and overfishing; there are many endangered species.

Steller Sea Eagle
-vulnerable group

Sable
- least concern group

Sable
-endangered group

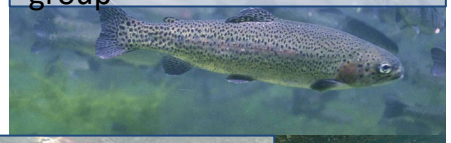
Because of its subarctic climate, there is high level of biodiversity. The tundra and muskeg are dominant, but forests of pine, birch, alder and willow are also abundant.

Kamchatka Brown Bear
- least concern group

Lumpfish
- Near threatened group

Arctic Fox
- least concern group

Rainbow Trout
Critically endangered group



Sockeye Salmon
- least concern group

Magnitude 7.4 Russia

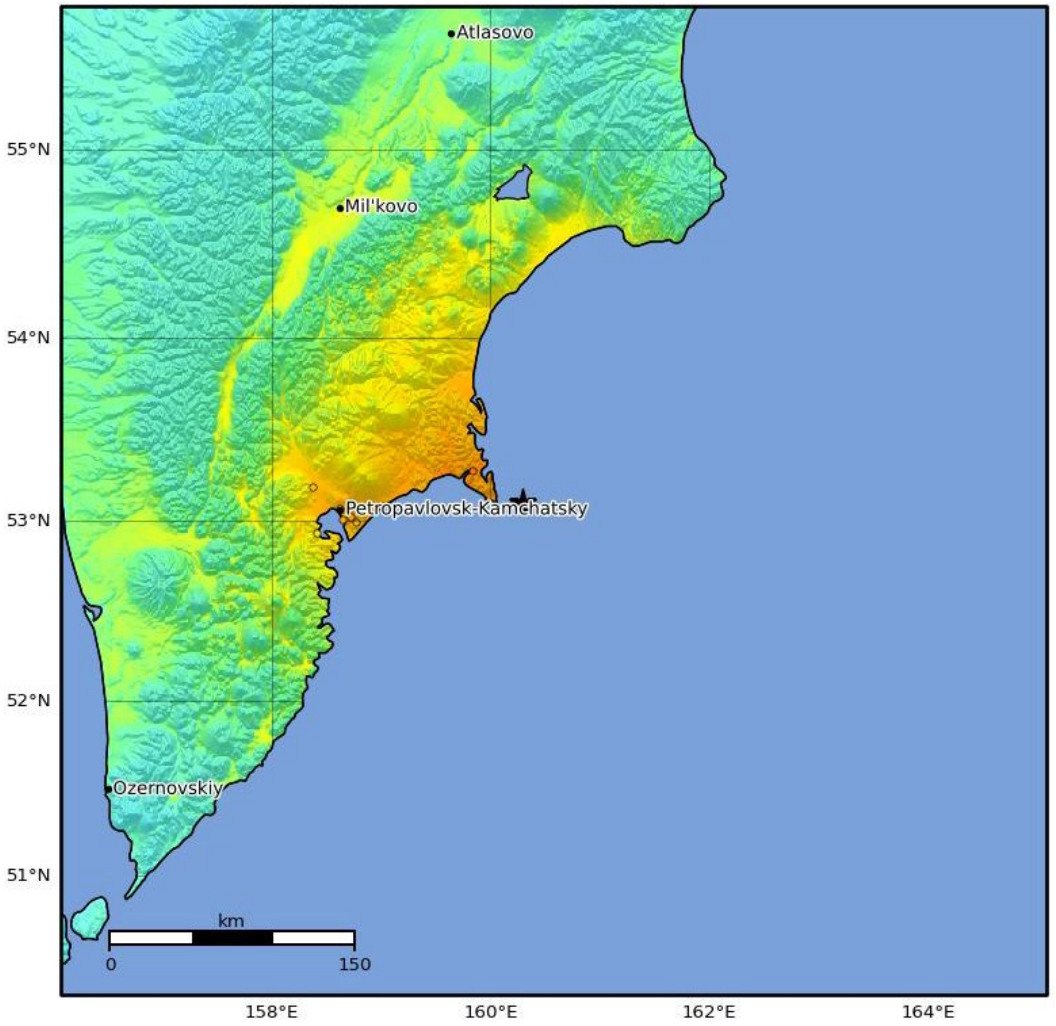
Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

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 the earthquake and 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



Magnitude 7.4 Russia

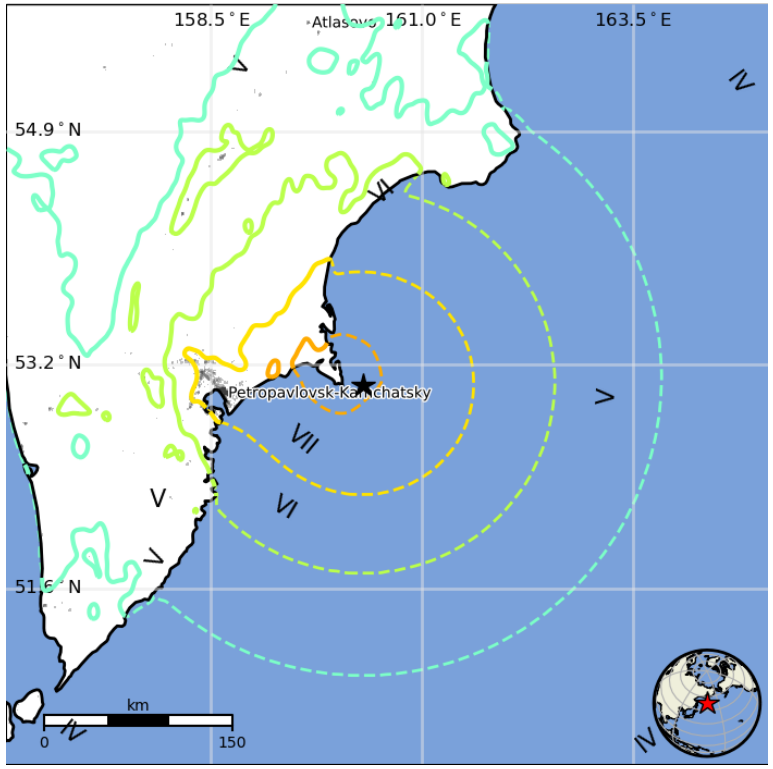
Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels. The USGS estimates that approximately 37,000 people felt severe shaking from this earthquake.

MMI	Shaking	Population
I	Not Felt	0 k*
II-III	Weak	0 k*
IV	Light	5 k*
V	Moderate	6 k*
VI	Strong	18 k
VII	Very Strong	210 k
VIII	Severe	37 k
IX	Violent	0 k
X	Extreme	0 k

*Estimated exposure only includes population within map area (k = x1,000)



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 contour lines. The estimated population exposure to each MMI Intensity is shown in the table.

Image courtesy of the US Geological Survey

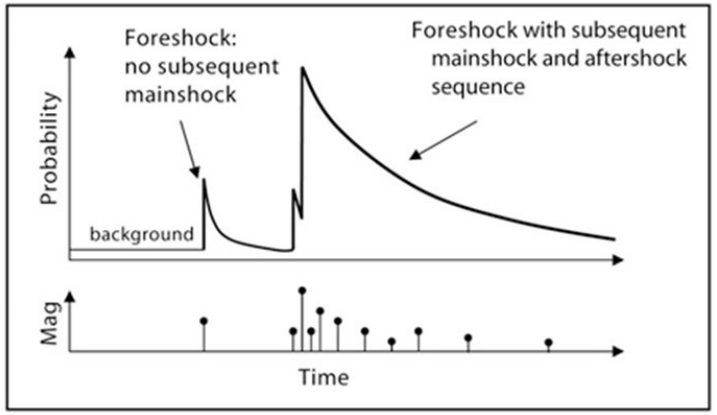
Magnitude 7.4 Russia
Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

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.

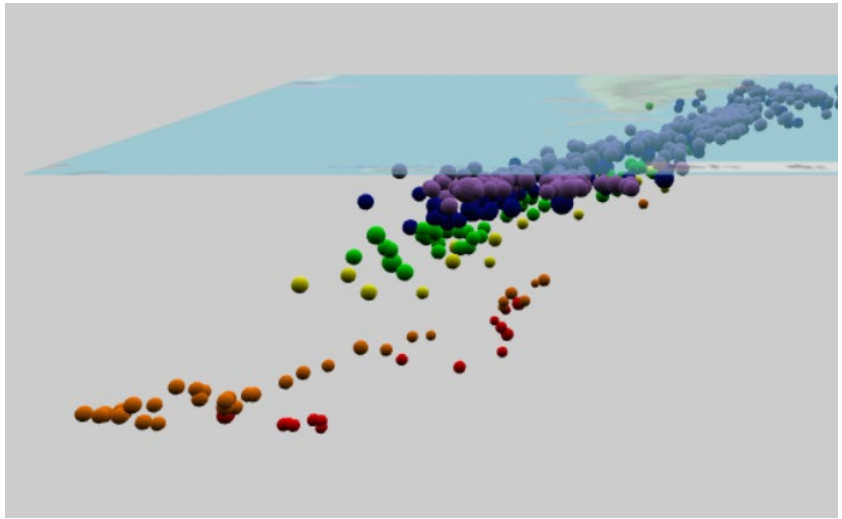
Magnitude 7.4 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

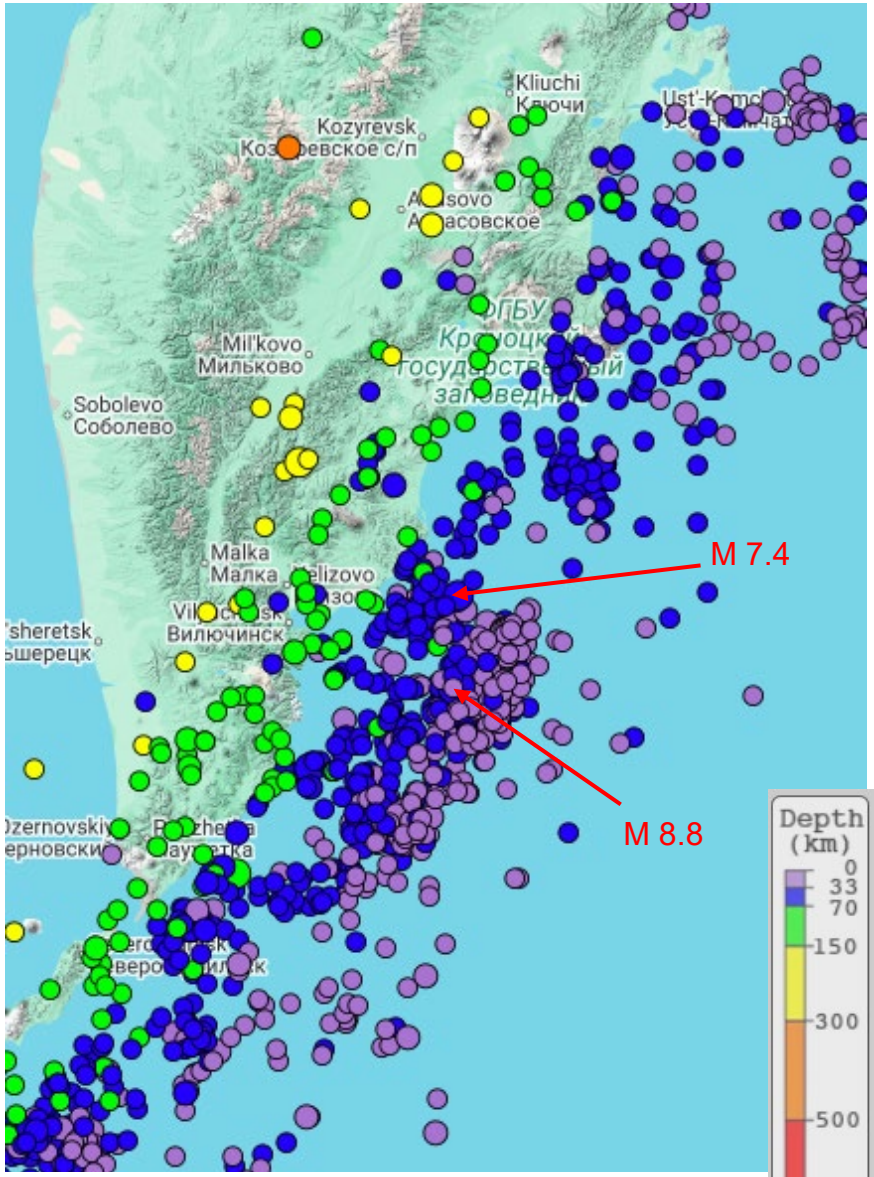
ALL

The map on the right shows historic earthquake activity > M 5 near the mainshock (M8.8) and this aftershock from 1990 to present.

Below is a 3D view of this region, earthquakes are shallow (purple) at the trench and increase in depth towards the west as the Pacific Plate dives beneath the Okhotsk Plate.



Seismicity Cross Section showing earthquakes highlighting the megathrust plate boundary



Images created with the Interactive Earthquake Browser

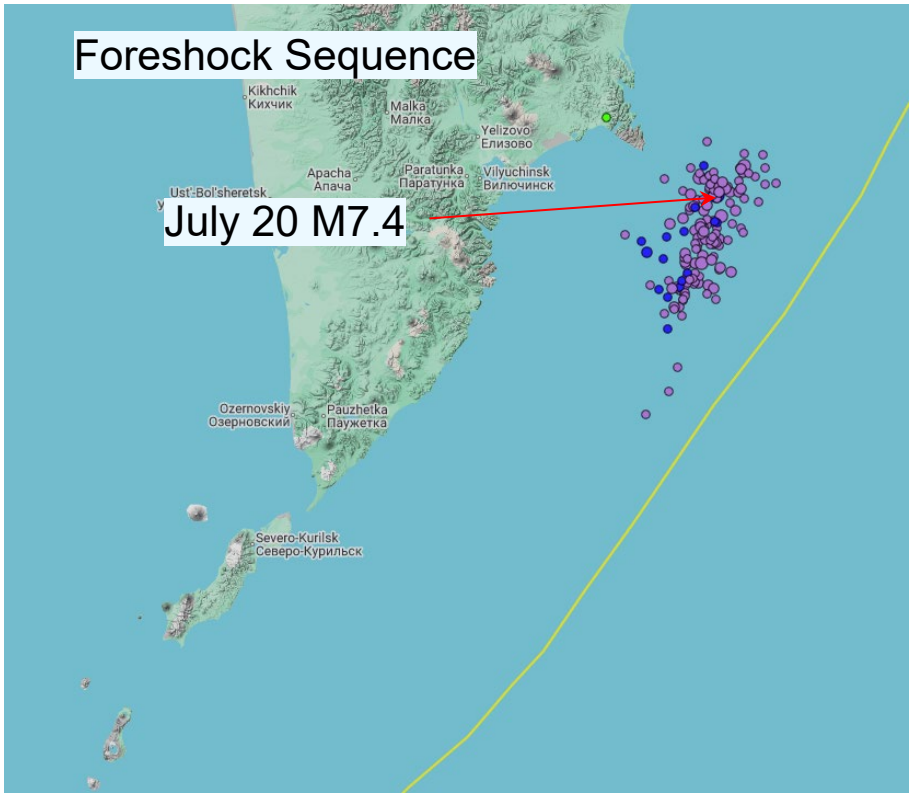
Magnitude 7.4 Russia

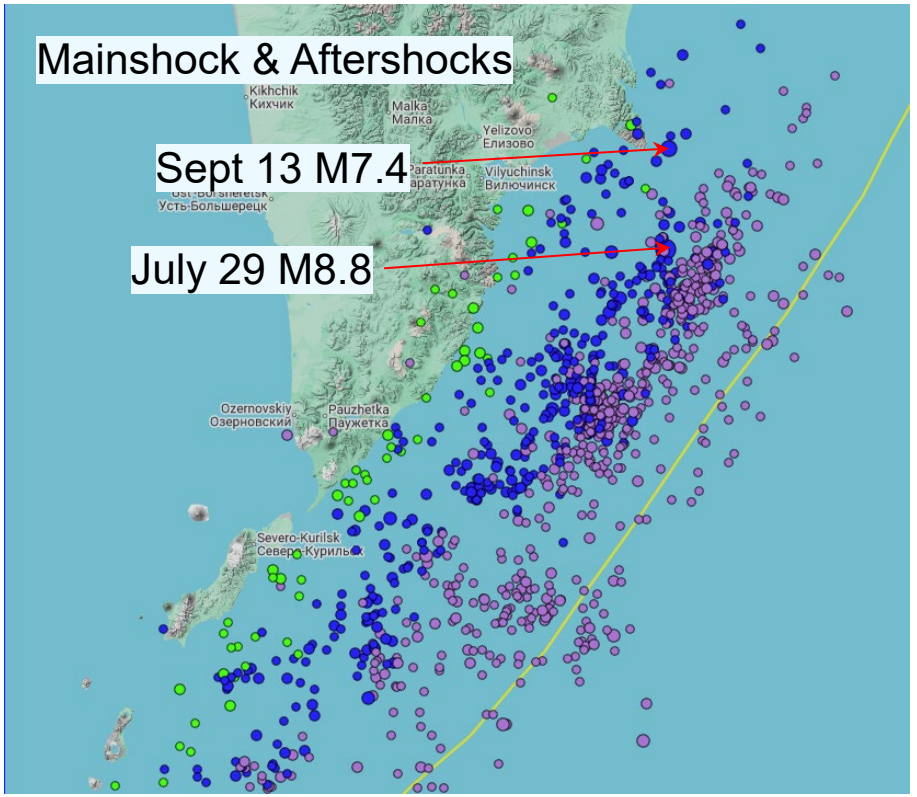
Saturday, September 13, 2025 at 2:37:54 (UTC)

ALL

This Foreshock sequence includes a July 20th 2025 Magnitude 7.4 event. The mainshock is thought to be the July 29th Magnitude 8.8 event with the September 13th Magnitude 7.4 event being the largest aftershock in the sequence.

The Map on the left shows foreshocks from July 20th 2025 to July 28th. The Map on the right shows the mainshock and all aftershocks from July 29th to September 13th 2025, all events are shown within a maximum depth of 100 km.





Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

Aftershock forecast issued August 7, 2025.

Magnitude (M) of aftershock	within 1 Day	within 1 Week	within 1 Month	within 1 Year
M 8 or higher	1 in 600 chance of 1 or more	1% chance of 1 or more	3% chance of 1 or more	8% chance of 1 or more
M 7 or higher	3% chance of 1 or more	15% chance of 1 or more	35% chance of 1 or more	64% chance of 1 or more
M 6 or higher	33% chance of 1 or more	87% chance of 1 or more	Expect about 6	Expect about 15
M 5 or higher	Expect about 8	Expect about 33	Expect about 82	Expect about 210
M 4 or higher	Expect about 110	Expect about 450	Expect about 1100	Expect about 2900
M 3 or higher	Expect about 1500	Expect about 6200	Expect about 16000	Expect about 40000

Courtesy of US Geological Survey

Based on the magnitude, rupture zone, and fault displacement of a mainshock, a forecast can be made for the number of aftershocks of various magnitudes.

This table is the forecast of aftershocks for the **July 29, 2025 M8.8** great earthquake.

- However, through September 13th, 2025, these are the aftershocks we observed:
  - 304, M ≥ 5
  - 17, M ≥ 6
  - 1, M ≥ 7

The forecast for a M≥7 aftershock indicates 35% probability within one month and 64% probability within one year of the mainshock. So, it is not particularly surprising that the September 13, 2025 M7.4 aftershock occurred. However, given that we are about 1.5 months since the July 29 mainshock, it is interesting to note that the numbers of observed M≥5 and M≥6 aftershocks now exceeds the numbers expected within one year of the mainshock.

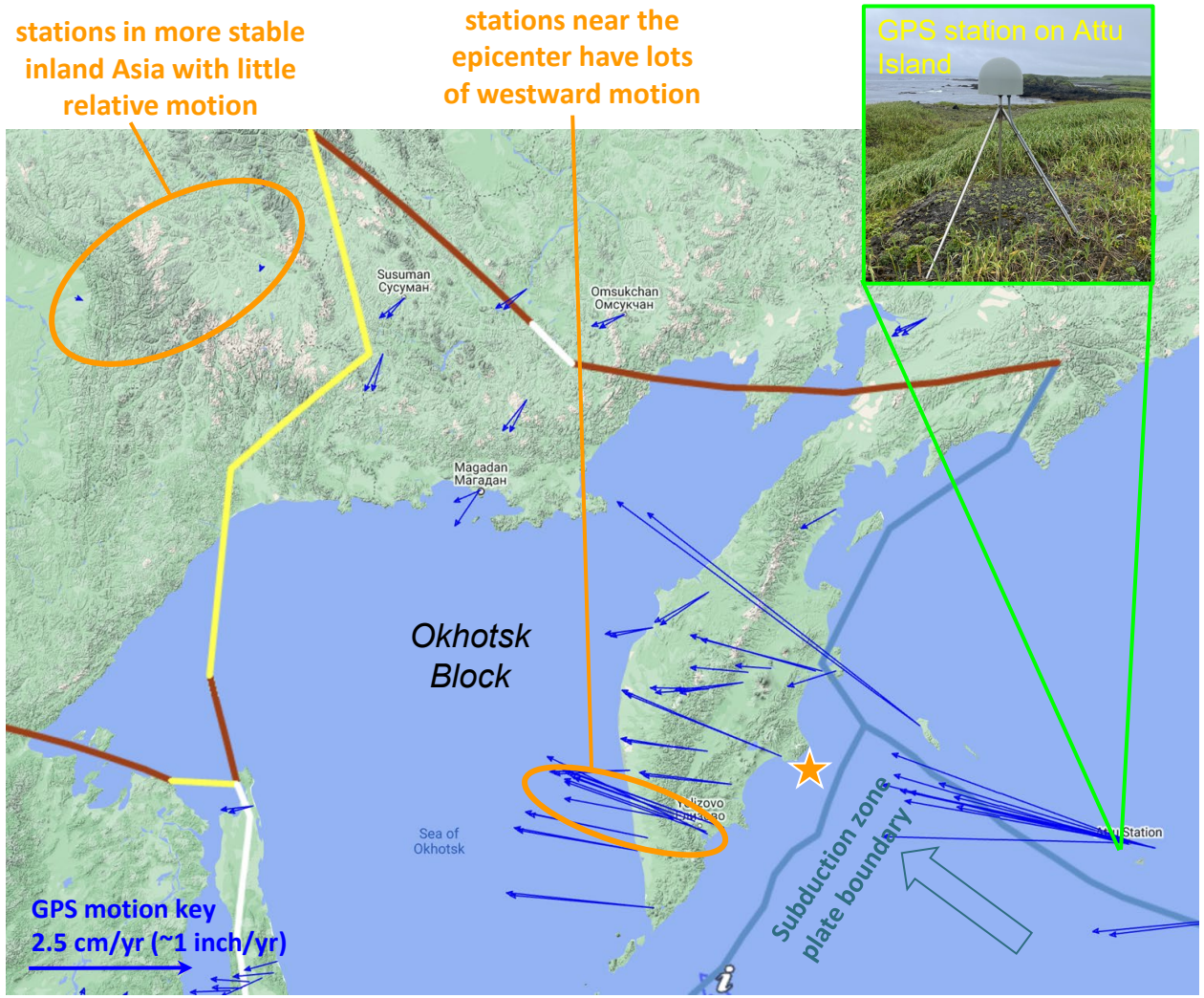
Magnitude 7.4 Russia
Saturday, September 13, 2025 at 2:37:54 (UTC)

Regional Tectonic Plate Motions

Russia and neighboring countries have GPS stations that record the long term motion from plate tectonics (Attu Island is part of Alaska, USA).

Compared to stations in more stable inland Asia, stations in Kamchatka are moving as much as 2.5 cm/yr (~1 inch/yr) towards the west as the Pacific Plate pushes against the Okhotsk Block.

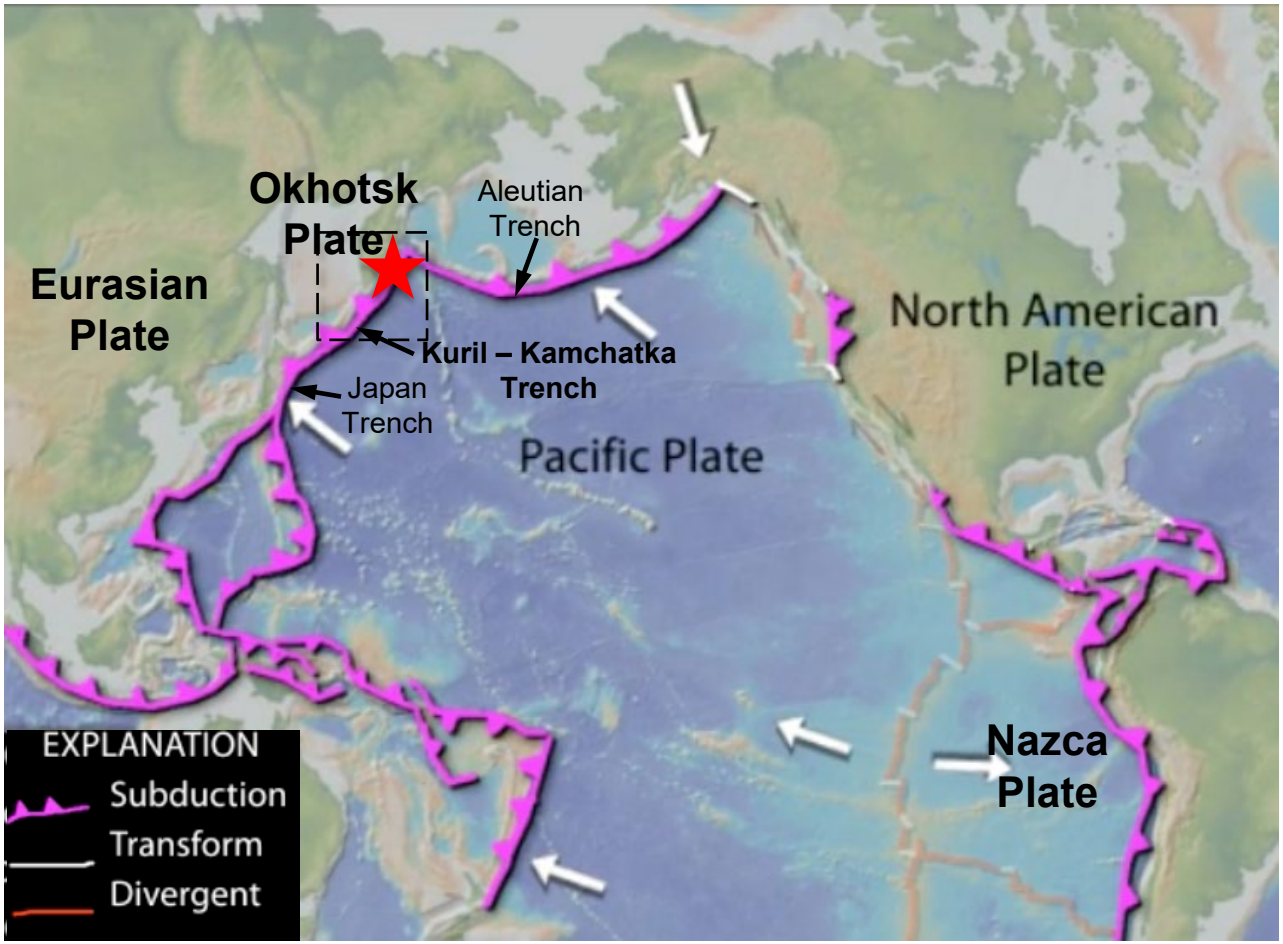
Over decades and centuries this compression accumulates and is occasionally released in earthquakes such as the Mag 8.8 quake on July 29, 2025 and the Mag 7.4 aftershock on Sept 13, 2025.



Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

The epicenter of the September 13, 2025 magnitude 7.4 earthquake off the east coast of the Kamchatka Peninsula is shown by the red star on this map. This earthquake occurred on the plate boundary between the subducting Pacific Plate and the overriding Okhotsk Plate. Near this major earthquake, the Pacific Plate subducts into the Kuril-Kamchatka Trench at a rate of 80 mm/yr (8.0 cm/yr).



A detailed map of the area within the dashed outline is presented on the next slide.

Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

Epicenters & Rupture Zones

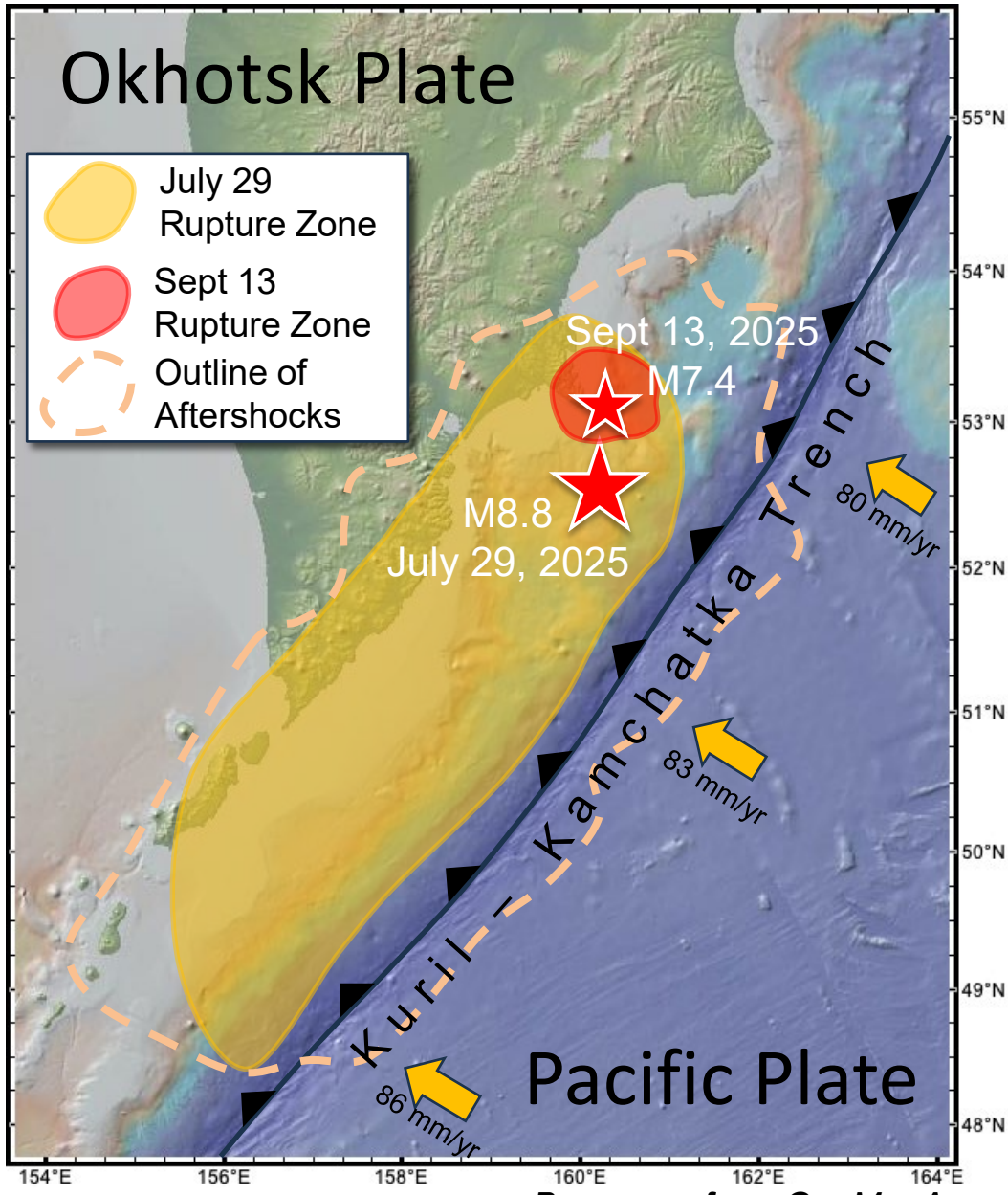
- **Large red star** = July 29, 2025 M8.8 earthquake epicenter
- **Orange shading** = rupture zone of the M8.8 earthquake
- **Small red star** = Sept. 13, 2025 M7.4 earthquake epicenter
- **Red shading** = rupture zone of the M7.4 earthquake

Aftershocks

- Orange dashed line = aftershocks of the July 29 M8.8 earthquake (through Sept. 12)

Key Point

- The Sept. 13 M7.4 earthquake lies within both the rupture zone and aftershock distribution of the M8.8 event.
- It is the **largest aftershock to date** in the sequence.



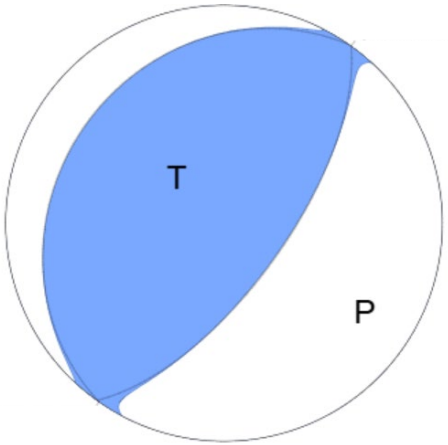
Base map from GeoMapApp

Magnitude 7.4 Russia

Saturday, September 13, 2025 at 2:37:54 (UTC)

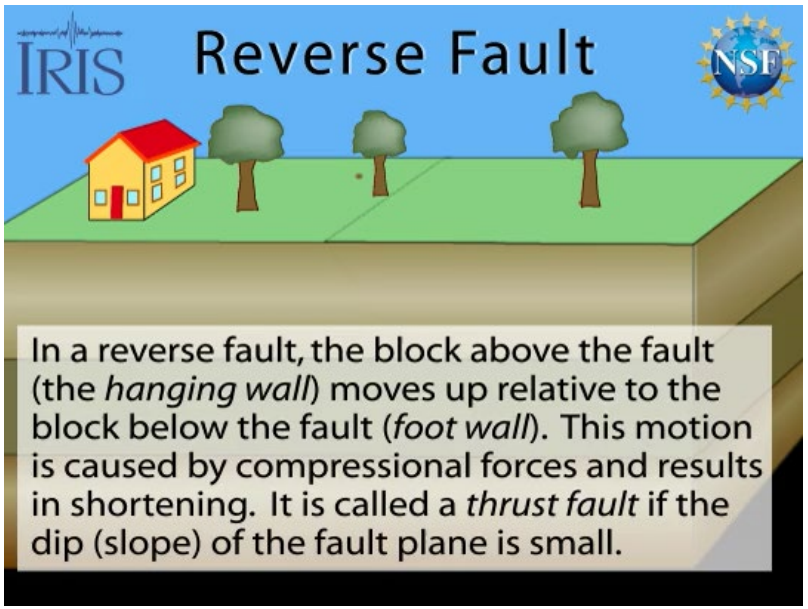
C

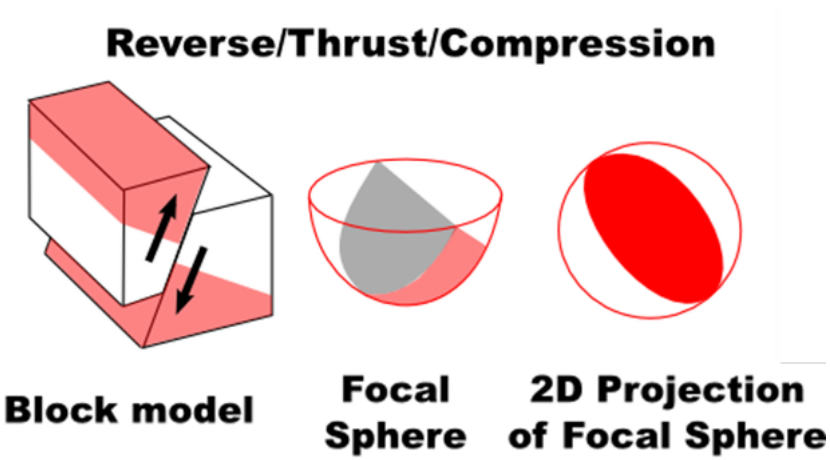
The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Because an earthquake occurs as slip on a fault, it generates primary (P) waves in quadrants where the first pulse is compressional (shaded) and quadrants where the first pulse is extensional (white). The orientation of these quadrants determined 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 stres direction. The Pressure axis (P) reflects the maximum compressive stress direction.





Magnitude 7.4 Russia

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ALL

Population Density of Russia (2024)

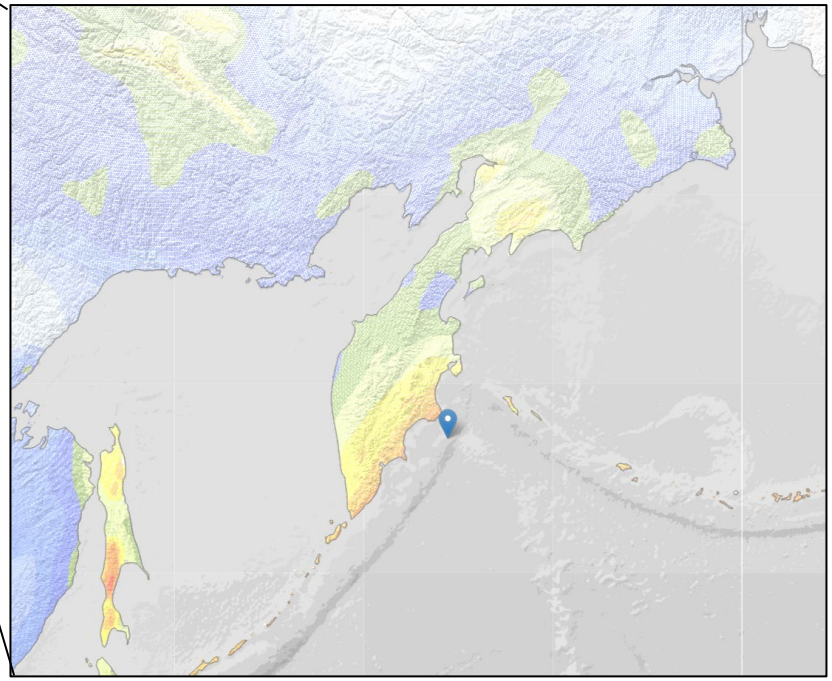
People per square kilometre

0 – 1	100 – 250
1 – 5	250 – 500
5 – 10	500 – 1,000
10 – 25	1,000 – 2,500
25 – 50	2,500 – 5,000
50 – 100	5,000+

Seismic Hazard PGA (g)

- 0.00 - 0.01
- 0.01 - 0.02
- 0.02 - 0.03
- 0.03 - 0.05
- 0.05 - 0.08
- 0.08 - 0.13
- 0.13 - 0.20
- 0.20 - 0.35
- 0.35 - 0.55
- 0.55 - 0.90
- 0.90 - 1.50
- > 1.50

Seismic Hazard Map (2023)



Over 75% of Russia's population live in regions exposed to low seismic hazard.

However, residents of the Kamchatka Peninsula, especially the ~181,000 residents of the largest city Petropavlovsk-Kamchatsky, are exposed to high seismic hazard.

The September 13 earthquake occurred 70 miles east of Petropavlovsk-Kamchatsky, shaking city residents.

Magnitude 7.4 Russia

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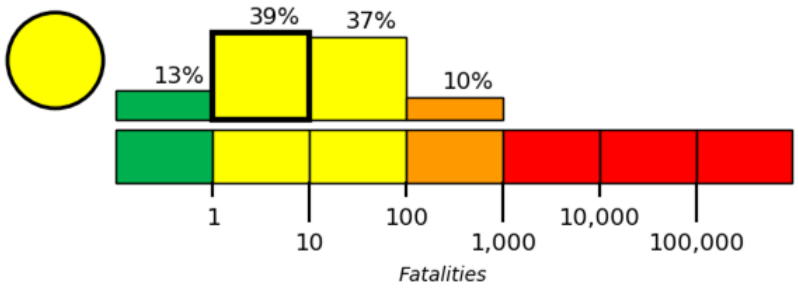
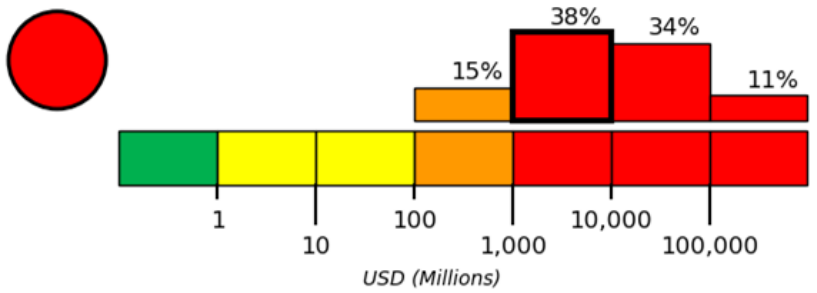
Estimated Fatalities



Estimated Economic Losses



The USGS Prompt Assessment of Global Earthquakes for Response (PAGER) estimated that some casualties are possible and that extensive shaking damage is probable from the September 13 magnitude 7.4 earthquake. The PAGER system takes into account the distribution and severity of shaking, the population exposed to shaking, and how vulnerable the population is to building damage.

While there have been no confirmed reports of fatalities or extensive damage following the magnitude 7.4 earthquake, the PAGER model provides estimated losses independent of the actual losses. The PAGER model results are not updated with time, as actual reported losses tend to slowly increase over time following a deadly earthquake.

Magnitude 7.4 Russia

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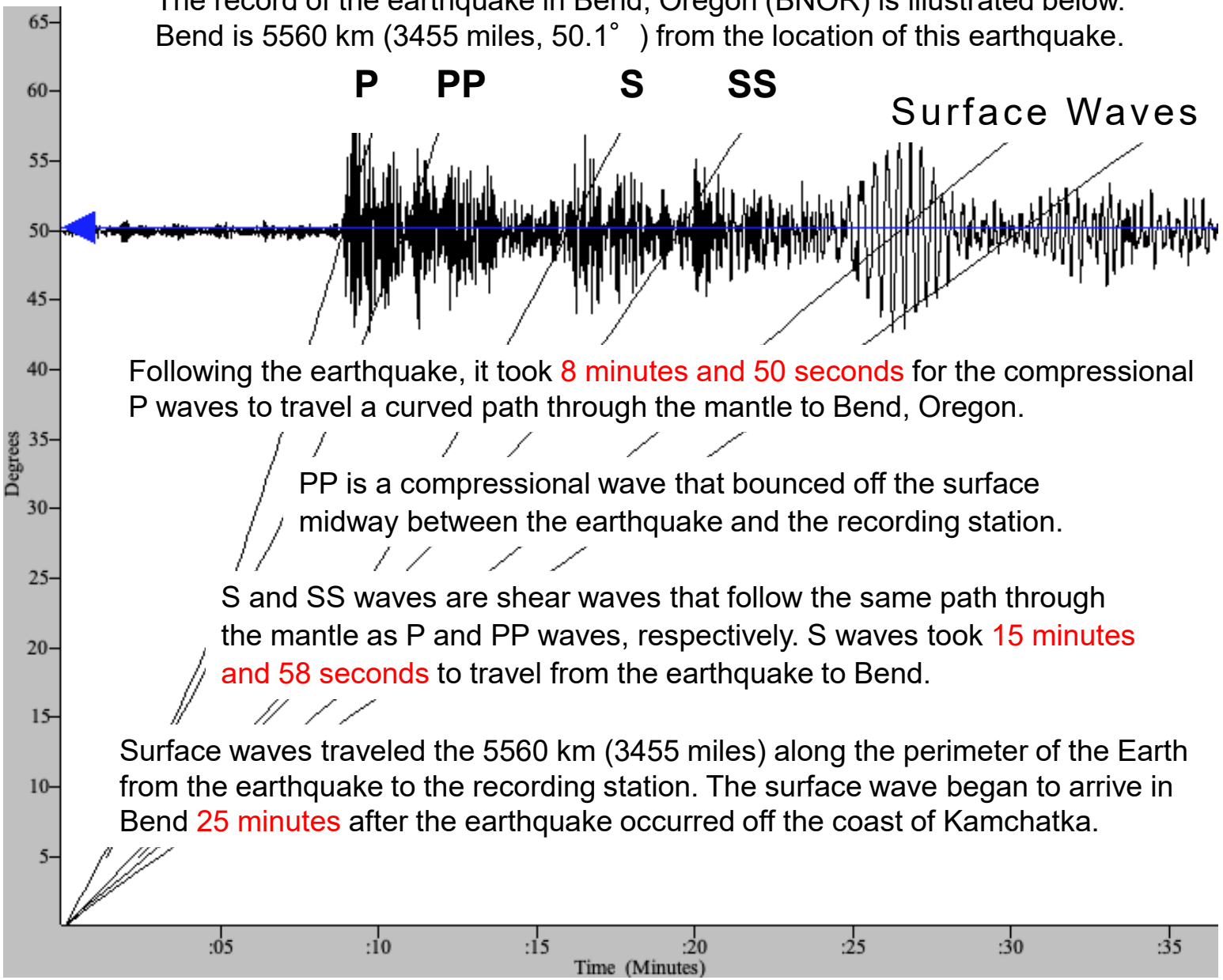
ALL

The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 5560 km (3455 miles, 50.1°) from the location of this earthquake.



Following the earthquake, it took 8 minutes and 50 seconds for the compressional P waves to travel a curved path through the mantle to Bend, Oregon.

PP is a compressional wave that bounced off the surface midway between the earthquake and the recording station.

S and SS waves are shear waves that follow the same path through the mantle as P and PP waves, respectively. S waves took 15 minutes and 58 seconds to travel from the earthquake to Bend.

Surface waves traveled the 5560 km (3455 miles) along the perimeter of the Earth from the earthquake to the recording station. The surface wave began to arrive in Bend 25 minutes after the earthquake occurred off the coast of Kamchatka.

ALL

Slide Guide

1. Where was the epicenter of this earthquake? (What city/region was it closest to?) When did the earthquake happen? What was its magnitude?
2. How many people are estimated to have felt the earthquake?
3. Which type of boundary is this earthquake related to?
4. What impact did the earthquake have on the location in which it was felt the strongest? (buildings, streets, animals, people…)
5. What additional hazards occurred in addition to the ground shaking? (tsunamis, floods, sinkholes, landslides, fires, volcanoes…)
6. How long did it take the first P-wave to travel to the seismic station in this slide stack?
7. What are 2 more questions you have about earthquakes that can NOT be answered with this slide stack?

Extension Questions

1. Seismic waves travel through the earth. Why did you or did you not feel the earthquake?
2. If you were going to write a news story on this earthquake, what would the headline be? *HINT: Think about where this earthquake occurred, the impact it had on the people living in the area, any effects the earthquake had on the area itself.*

HS

Slide Guide

1. Where was the epicenter of this earthquake? (What city/region was it closest to?) When did the earthquake happen? What was its magnitude?
2. How many people are estimated to have felt the earthquake?
3. What relationship is shown between the seismic hazard map and population density?
4. Which plates are involved and what type of boundary are they creating?
5. What impact did the earthquake have on the location in which it was felt the strongest? (buildings, streets, animals, people…)
6. What additional hazards occurred in addition to the ground shaking? (tsunamis, floods, sinkholes, landslides, fires, volcanoes…)
7. How long did it take the first P-wave to travel to the seismic station in this slide stack?
8. What are 2 more questions you have about earthquakes that can NOT be answered with this slide stack?

Extension Questions

1. Seismic waves travel through the earth. Why did you or did you not feel the earthquake?
2. If you were going to write a news story on this earthquake, what would the headline be? *HINT: Think about where this earthquake occurred, the impact it had on the people living in the area, any effects the earthquake had on the area itself.*

C

Slide Guide

1. Where was the epicenter and hypocenter of this earthquake? (What city/region was it closest to? Longitude/latitude/depth?) When did the earthquake happen? What was its magnitude?
2. What impact did the earthquake have on the location in which it was felt the strongest? *(buildings, streets, animals, people…)*
3. Draw the block model of the fault for this earthquake. Overlay a drawing of the focal mechanism to show how the 2D projection was created. Label it with the type of fault.
4. How are the related tectonic plates involved in creating the nearby boundary? *(Include the type of boundary, and the velocity and name of the plates.)*
5. What additional hazards occurred in addition to the ground shaking? *(tsunamis, floods, sinkholes, landslides, fires, volcanoes…)*
6. Relate the area's population density to its seismic hazard level and earthquake history.

Extension Question

1. What efforts have there been to mitigate impacts from earthquakes? What additional mitigation efforts should be implemented?

Teachable Moments are a service of

The EarthScope Consortium

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