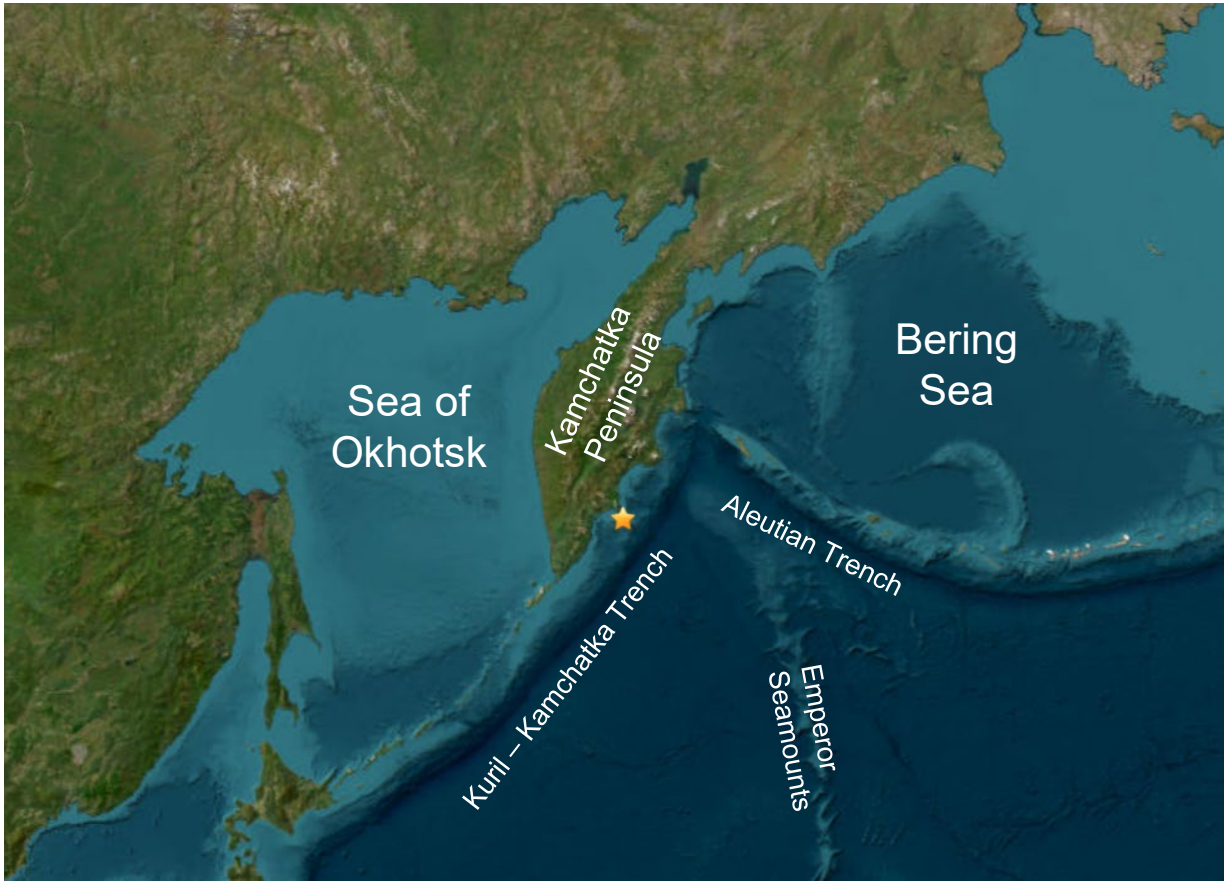
Magnitude 7.0 Kamchatsky, Russia

Saturday, August 17, 2024 at 19:10:26 UTC

Latitude: 52.924°N
Longitude: 160.141°E
Depth: 29.0 km



A magnitude 7.0 earthquake occurred at a depth of 29 km (18 miles) near the intersection of the Aleutian and Kuril-Kamchatka trenches. The epicenter was 102.4 km (63.6 miles) east of Petropavlovsk-Kamchatsky, Kamchatka, Russia.

While there have been no reports of injuries, initial reports indicate some damage to structures.

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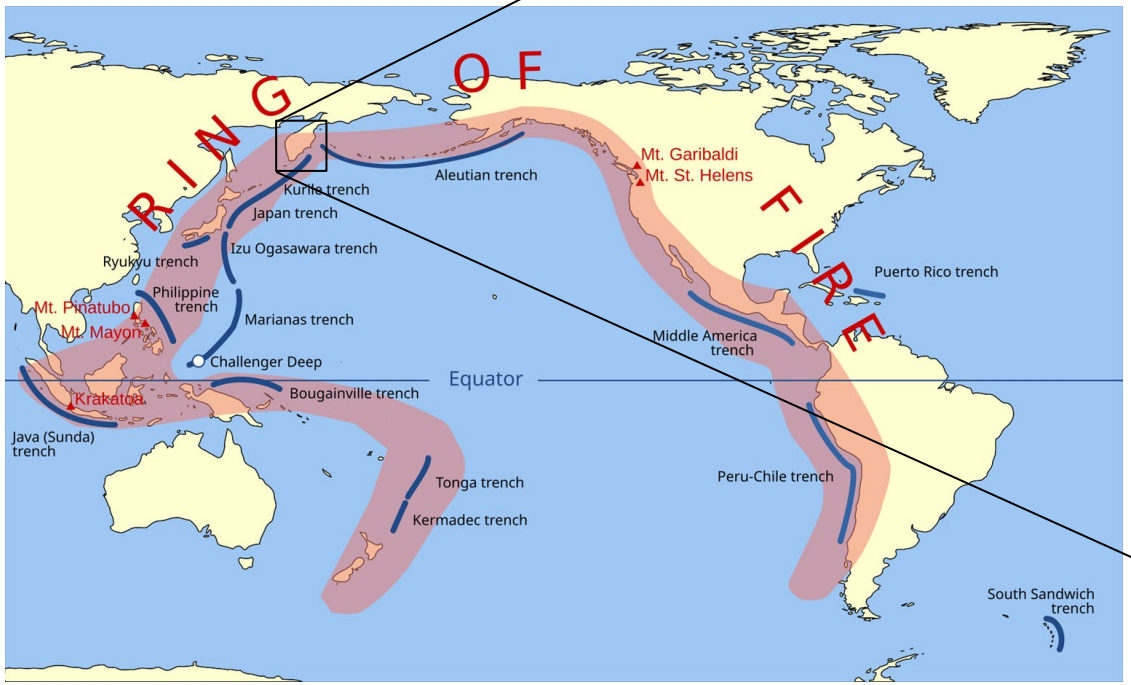
The Kamchatka Peninsula forms part of the circum-Pacific “Ring of Fire,” where two-thirds of the world’s volcanoes and 90% of the world’s earthquakes occur.

There are around 160 volcanoes along the Kamchatka Peninsula, 29 of which are still active.



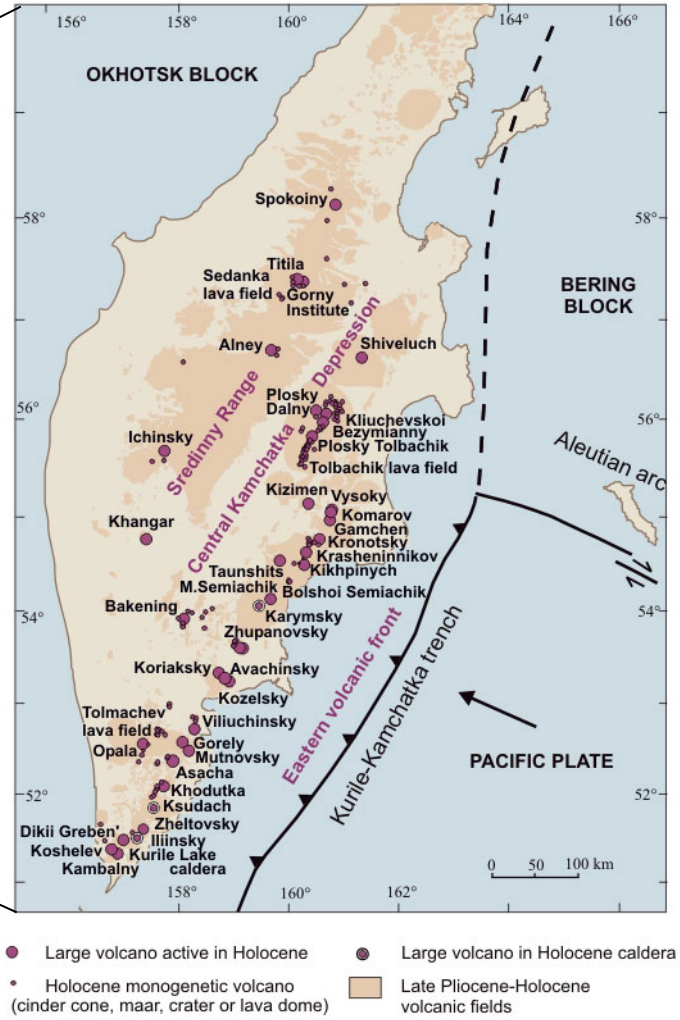


Image courtesy of Gringer, Wikimedia

Image courtesy of Oregon State University

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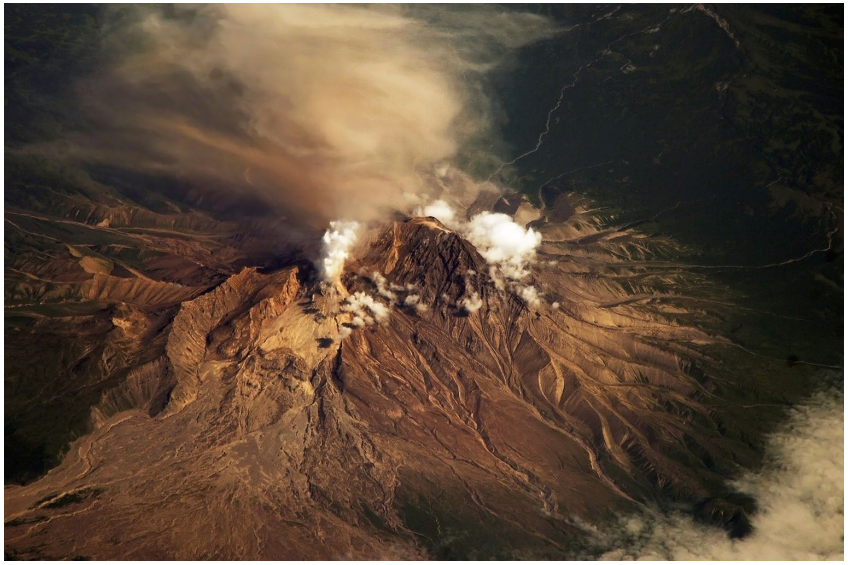
An eruption of the Shiveluch volcano—one of Kamchatka's largest and most active volcanoes—occurred shortly after the August 17 magnitude 7.0 earthquake. The eruption produced an ash column 5 miles high.

While some news outlets reported that the earthquake triggered the eruption, the Tokyo Volcanic Ash Advisory Center issued multiple advisories for the volcano up to 6 hours prior to the earthquake.



NASA Earth Observatory photo of Shiveluch from 2007

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Following the earthquake, the Pacific Tsunami Warning Center warned that hazardous tsunami waves from this earthquake were possible along the coasts within 300 km (190 miles) of the epicenter.

The August 17, 2024, earthquake is located roughly 40 km (25 miles) northeast of the 1952 M 9.0 Kamchatka earthquake, which resulted in a destructive, Pacific-wide tsunami that caused extensive damage to the Kamchatka Peninsula and the Kuril Islands leaving an estimated 10,000 to 15,000 people dead.

The tsunami waves also traveled as far as Peru, Chili, New Zealand, and the Hawaiian Islands. In Alaska, the Aleutian Islands, and California, tsunami waves of up to 1.4 m (4.6 ft) were observed.

Flooded street resulting from the arrival of the 1952 Kamchatka tsunami on Midway Island about 3000 km (1900 miles) away from the earthquake epicenter. Photo courtesy U.S. Navy

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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 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

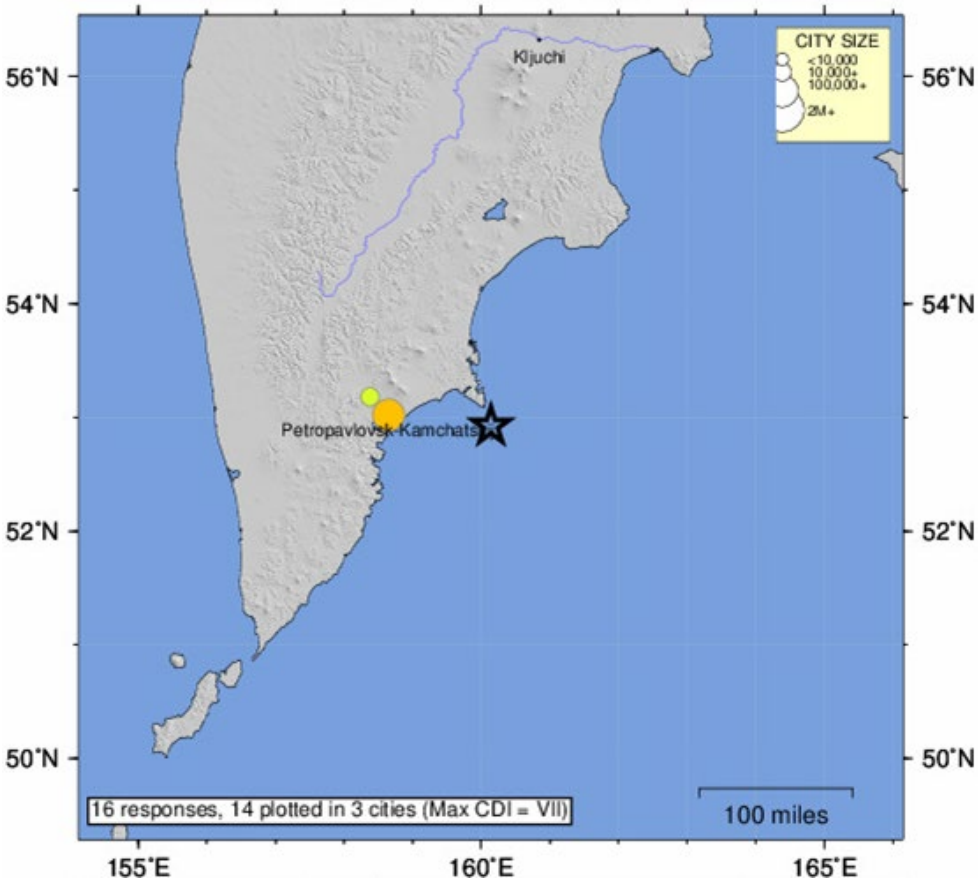

Image courtesy of the US Geological Survey

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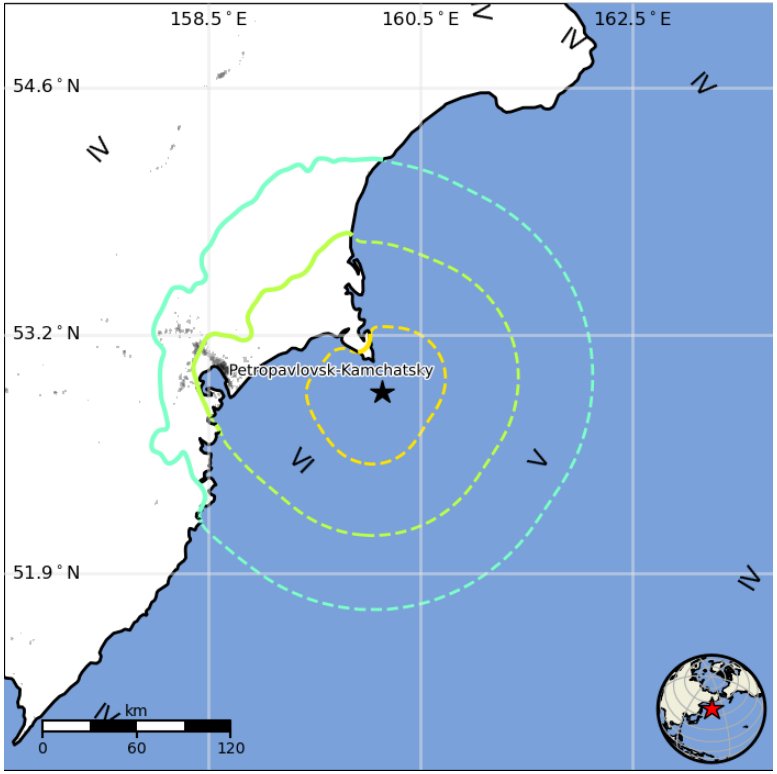
The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels. The USGS estimates that more than 52,000 people felt very strong shaking from this earthquake.

MMI	Shaking	Population
I	Not Felt	0 k*
II-III	Weak	0 k*
IV	Light	14 k*
V	Moderate	27 k
VI	Strong	184 k
VII	Very Strong	52 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 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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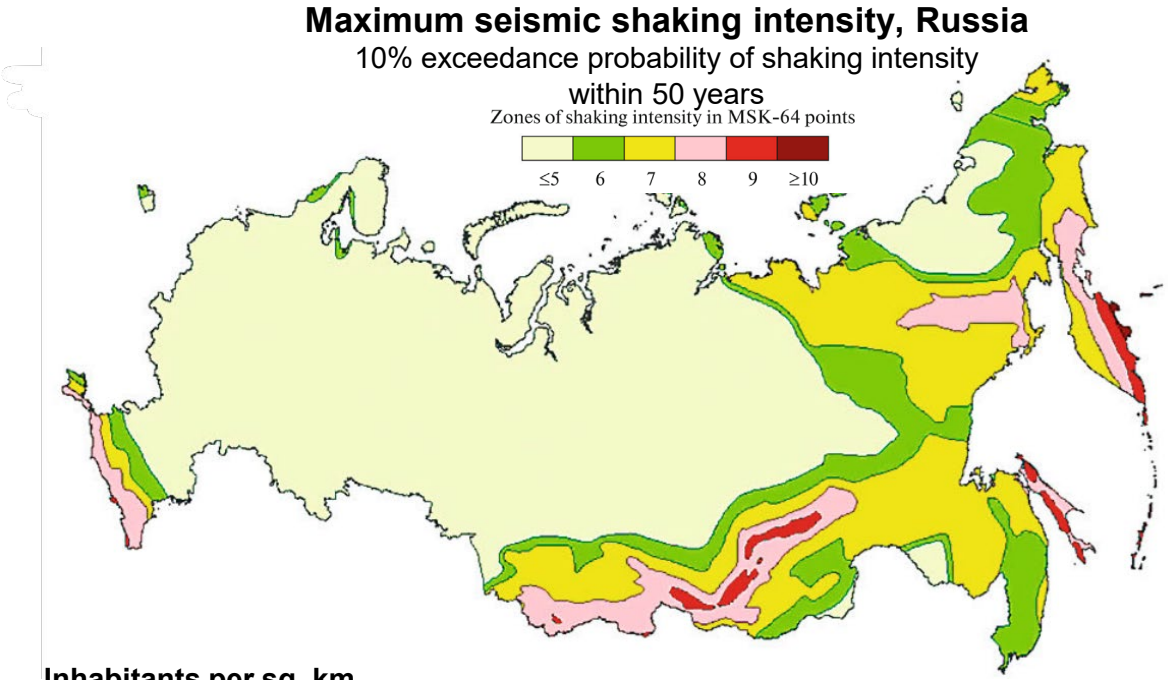
Over 75% of Russia's population live in regions exposed to low seismic hazard.

However, around 35 million people are still exposed to high earthquake hazards, primarily along the Kamchatka Peninsula, the southern Asian, and southwestern European parts of the country as a result of subduction and tectonic collision.

The August 17 earthquake along the Kamchatka Peninsula thankfully occurred in a sparsely populated region.

Image from Zavyalov et al. (2019)



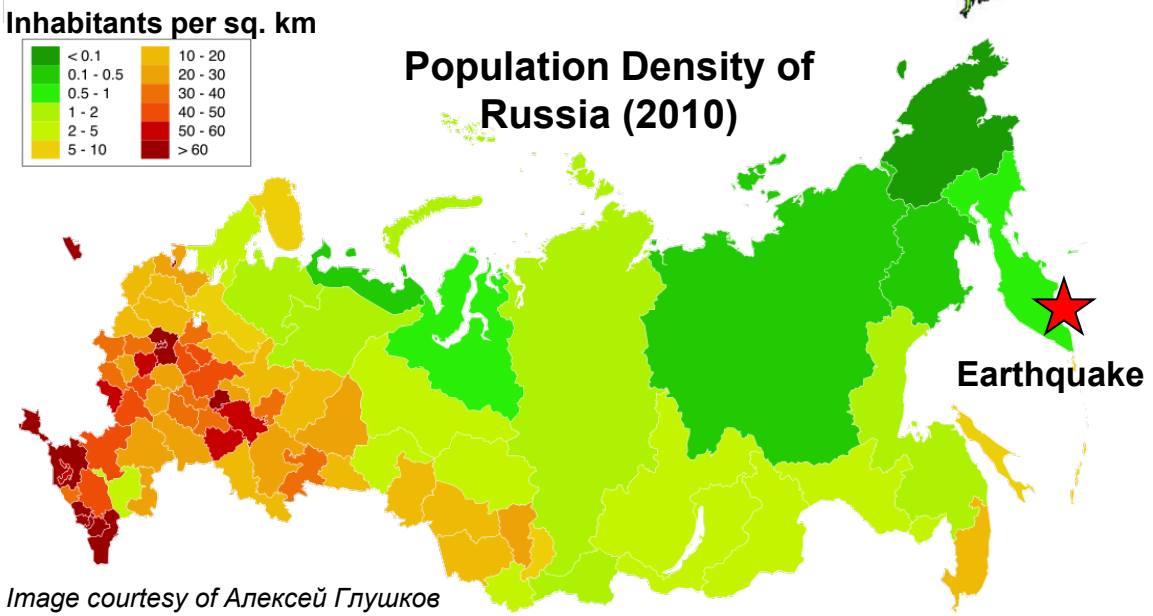


Image courtesy of Алексей Глушков

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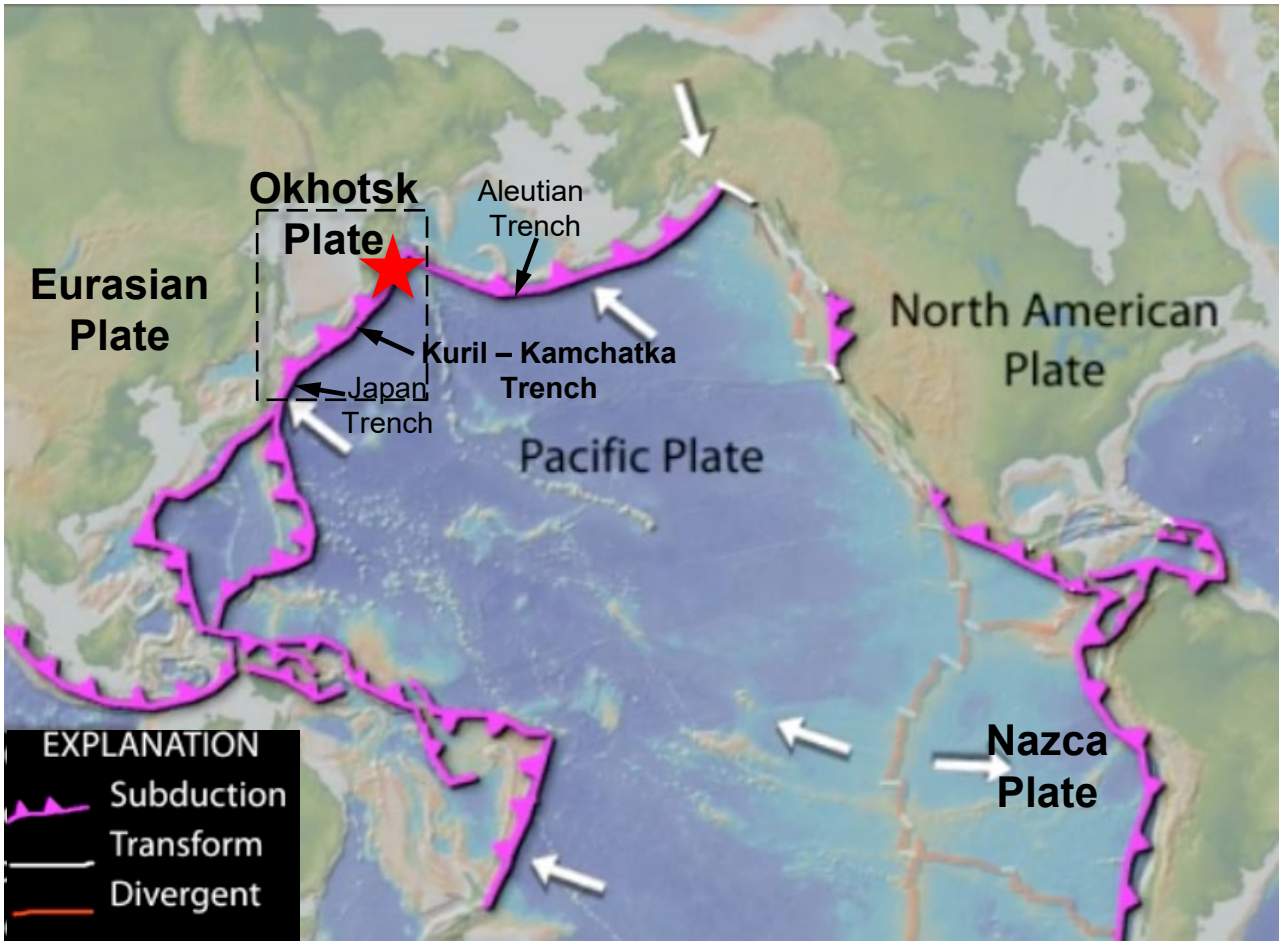
Among subduction zones and deep ocean trenches that surround the Pacific Ocean Basin, perhaps the least well known is the Kuril – Kamchatka Trench between the Japan and Aleutian trenches.



At the Kuril-Kamchatka Trench, the Pacific Plate subducts beneath the Okhotsk Plate at a rate of about 80 mm/yr (8 cm/yr). The red star shows the epicenter of the August 17, 2024 M7.0 earthquake off the east coast of the Kamchatka Peninsula. A detailed map of the area within the dashed outline is presented on the next slide.

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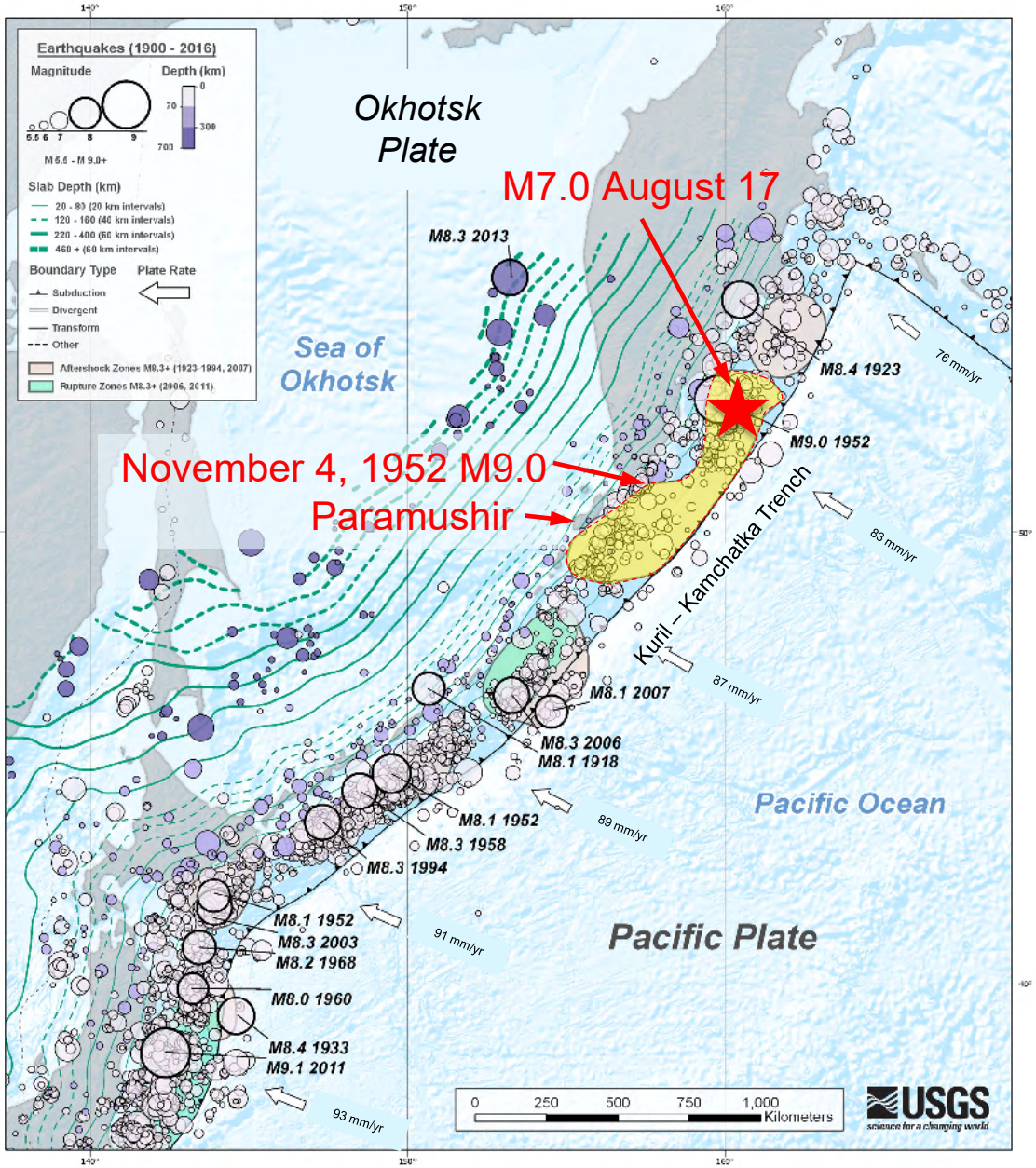
The red star on this map shows the epicenter of the August 17, 2024 M7.0 earthquake. Location, depth, and thrust-fault focal mechanism of this earthquake indicate that it occurred along the plate boundary megathrust between the Okhotsk and Pacific plates.

The Kuril – Kamchatka subduction zone has produced six great (M>8) megathrust earthquakes since 1918.

The largest of these was the November 4, 1952 magnitude 9.0 earthquake, the 5th largest instrumentally recorded earthquake in history. The area shaded yellow shows the rupture zone of the 1952 earthquake that produced a tsunami with runup of 12 meters at Paramushir in the northern Kuril Islands. That tsunami produced significant damage along the coastline in Hawaii.



Map courtesy of US Geological Survey

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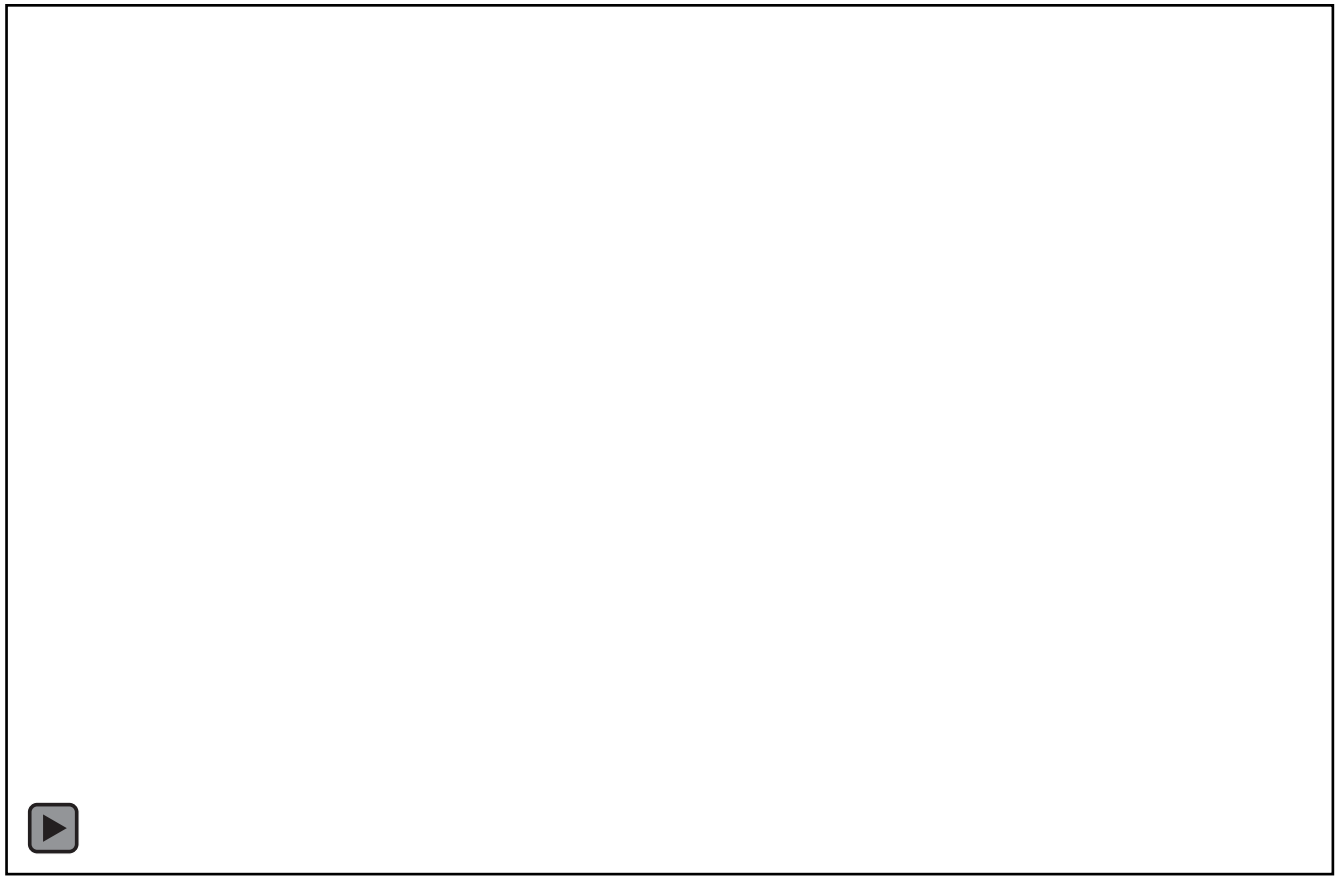
This animation shows 20 years of seismic activity adjacent to the tectonic boundary where the Okhotsk, North American and Pacific Plates converge.



Animation created using EarthScope's Interactive Earthquake Browser

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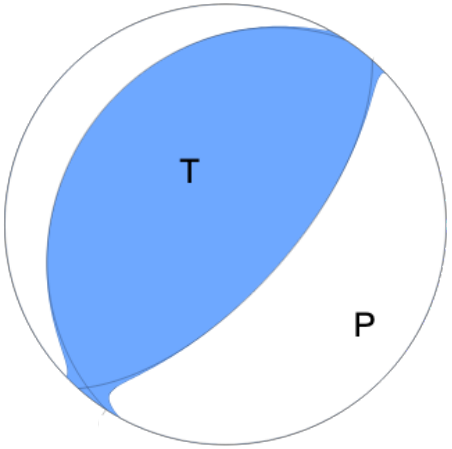
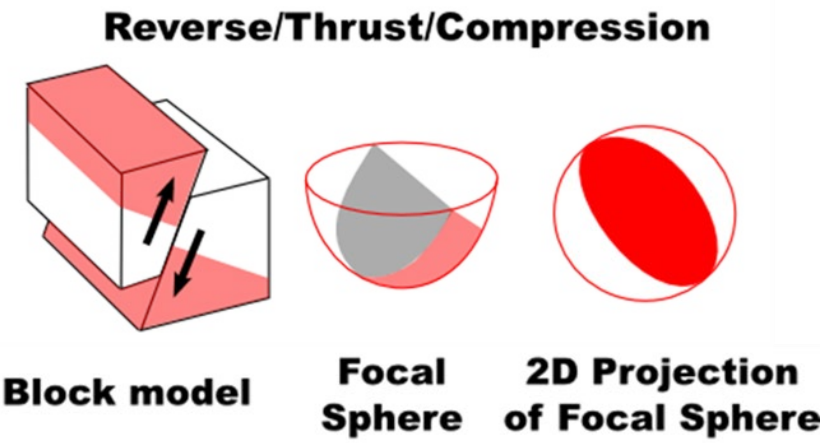
The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Because an earthquake occurs as slip on a fault, it generates primary (P) waves in quadrants where the first pulse is compressional (shaded) and quadrants where the first pulse is extensional (white).

The orientation of these quadrants 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 stress direction. The pressure axis (P) reflects the maximum compressive stress direction.



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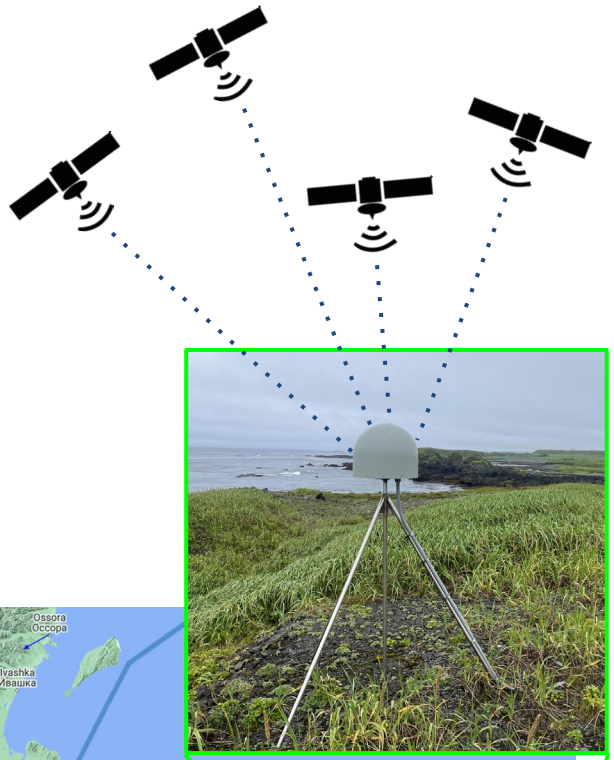
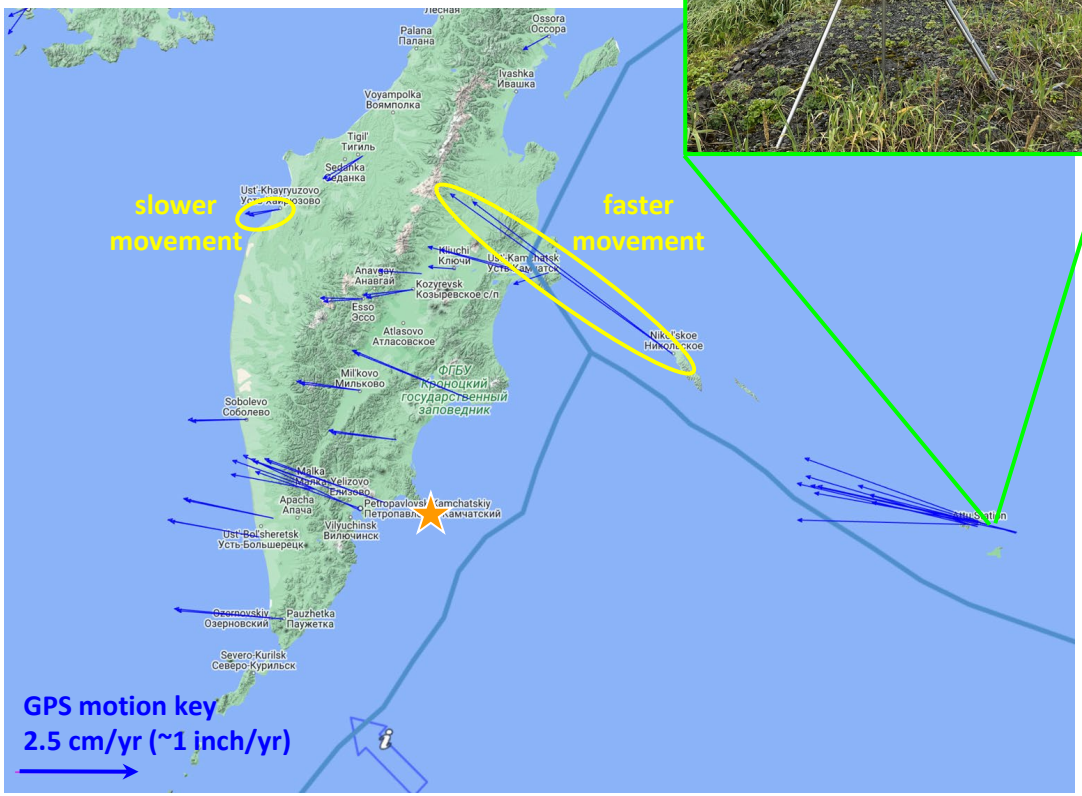
One of the ways we know the rates of plate motion is from GPS stations.

GPS stations receive signals from satellites and use the time offset between when the signal leaves the satellite and when it arrives at the station to determine distance. If a station receives signals from 4 or more stations, it is able to determine its location (6 or more satellites is much better).

This is the same way GPS works in phones and other devices but the high-precision stations can determine location within millimeters (<¼ inch) rather than 5-10 meters (15-30 feet).

Over time, changing locations allow scientists to determine station movement from plate tectonics, which are shown as vectors (arrows).





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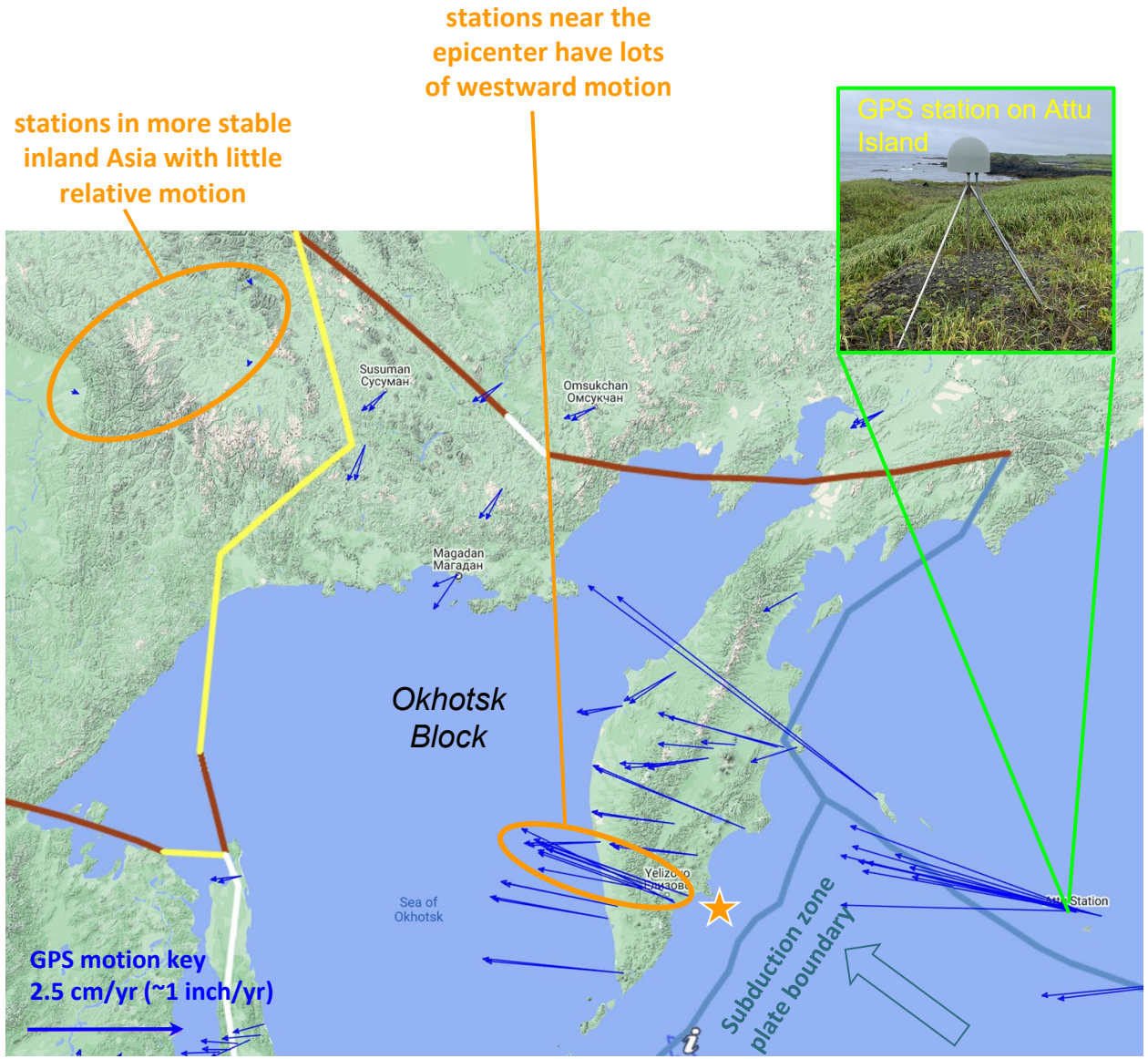
Russia and neighboring countries have GPS stations that record the long term motion from plate tectonics (Attu Island is part of Alaska, USA).

Compared to stations in more stable inland Asia, stations near Kamchatsky 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 magnitude 7.0 quake on August 17, 2024.



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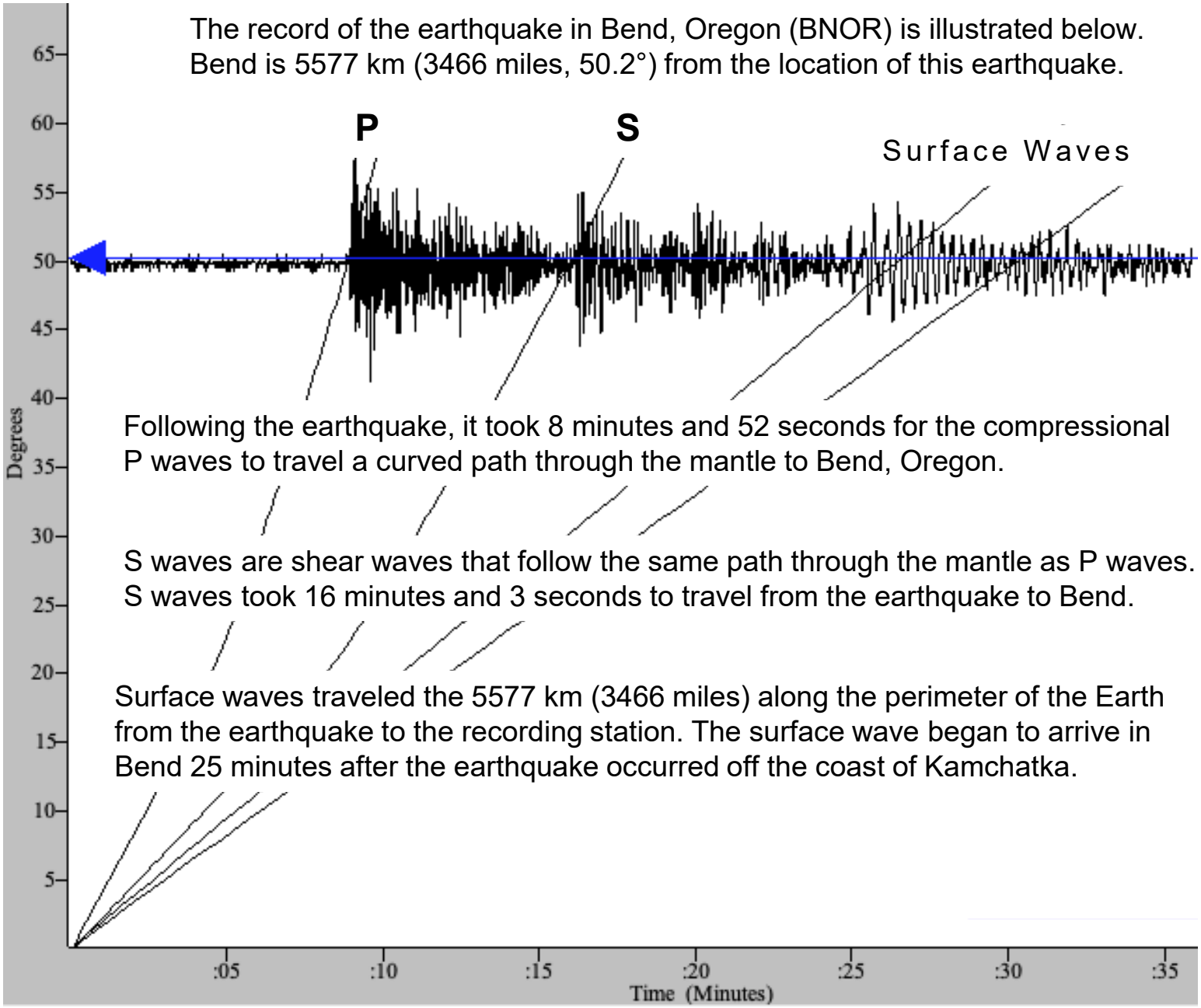
The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 5577 km (3466 miles, 50.2°) from the location of this earthquake.



Following the earthquake, it took 8 minutes and 52 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 16 minutes and 3 seconds to travel from the earthquake to Bend.

Surface waves traveled the 5577 km (3466 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.

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