Magnitude 7.3 VANUATU
Tuesday, December 17, 2024 at 01:47:26 UTC

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 this historical earthquake and then use them as is or customize it for your students and curriculum.

New for the 2024-25 school year:

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

middle school + 

high school + 

college

1. **Check out the new Slide Guide: Slides or pdf that will guide your students through the slide deck:** middle school pdf high school pdf college pdf
2. **New Geography slide(s): An additional slide about the city or area that gives you cross-curricular connections:** geography, physics, chemistry, biology, environmental science or even history.
3. **NGSS Connections for 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.

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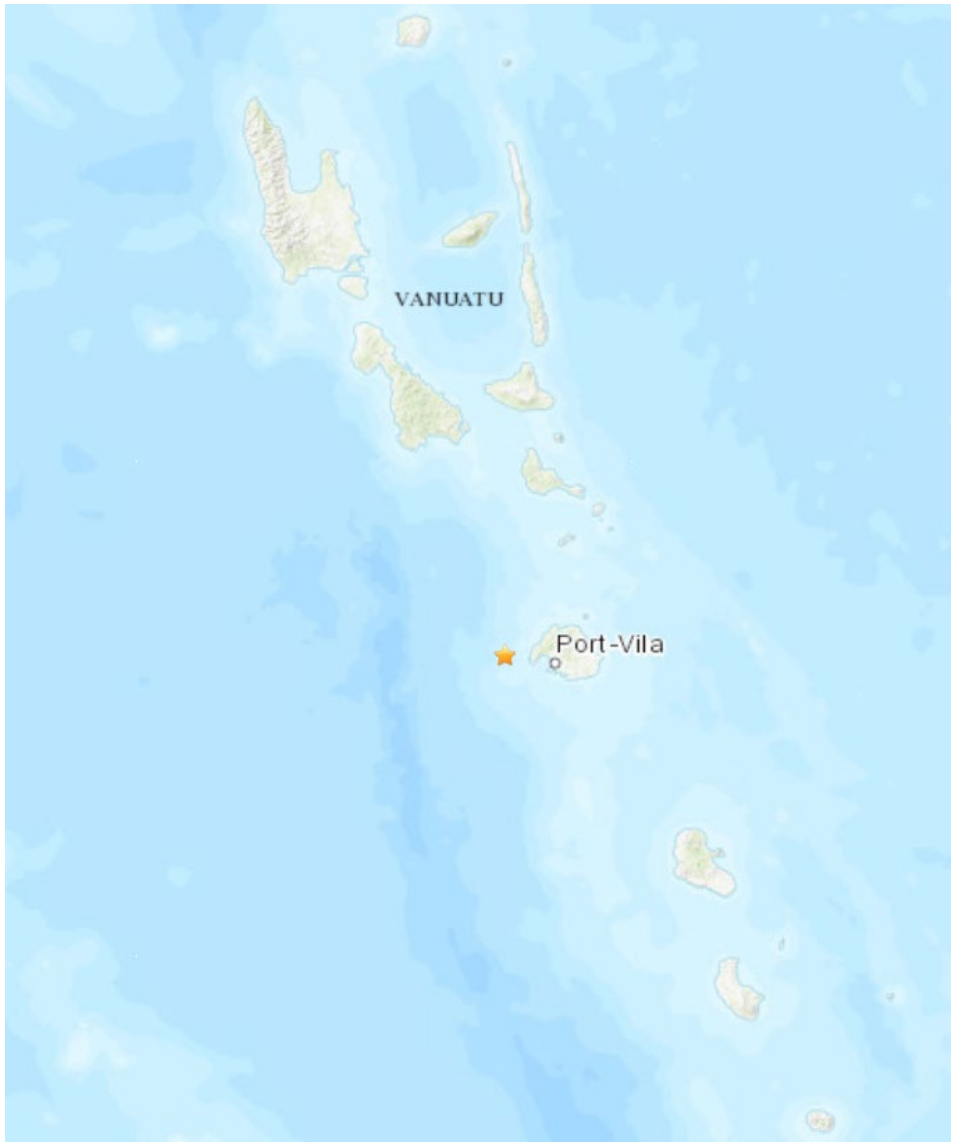
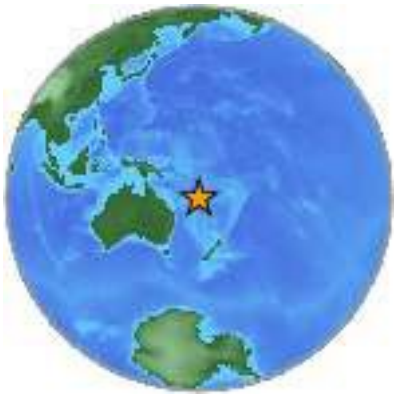
Latitude 17.686°S
Longitude 168.034°E
Depth 57.1 km

ALL





A major earthquake struck in the southwest Pacific Ocean at a depth of 57.1 km (35.5 miles) about 30 km (18 miles) west of Port Vila, the largest city in Vanuatu. At least 14 people are dead and hundreds more are injured. The earthquake caused widespread damage. Rescuers worked through the night trying to reach people yelling under the rubble. A tsunami warning was issued for the region but was withdrawn less than two hours later.

Widespread damage to communications and other infrastructure has impeded the release of official reports.

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Vanuatu is an archipelago of 83 small islands of volcanic origin which has 113 native languages still spoken; although, the official languages are Bislama, French and English

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The economy is driven by agriculture (coconuts, kava, beef, cocoa and timber, and tourism (scuba diving.) One island is known for its tradition of land diving (called gol).

By Paul Stein from New Jersey, USA - Pentecost Island Vanuatu, CC BY-SA 2.0, https://commons.wikimedia.org/w/index.php?curid=10438860

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This tropical environment has been impacted by its natural hazards which include cyclones, volcanic eruptions and earthquakes. Vanuatu has an increasing population which means pressure on land, fishing, freshwater resources and even job opportunities. There are also signs of deforestation from high-value timber and air and water pollution around urban areas and large villages.

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Like many South Pacific island nations, Vanuatu has a high earthquake hazard with a likelihood for destructive earthquakes. While many earthquakes in the region have little impact on population due to low population density, the December 17 earthquake unfortunately occurred very close to Vanuatu's capital and largest city.

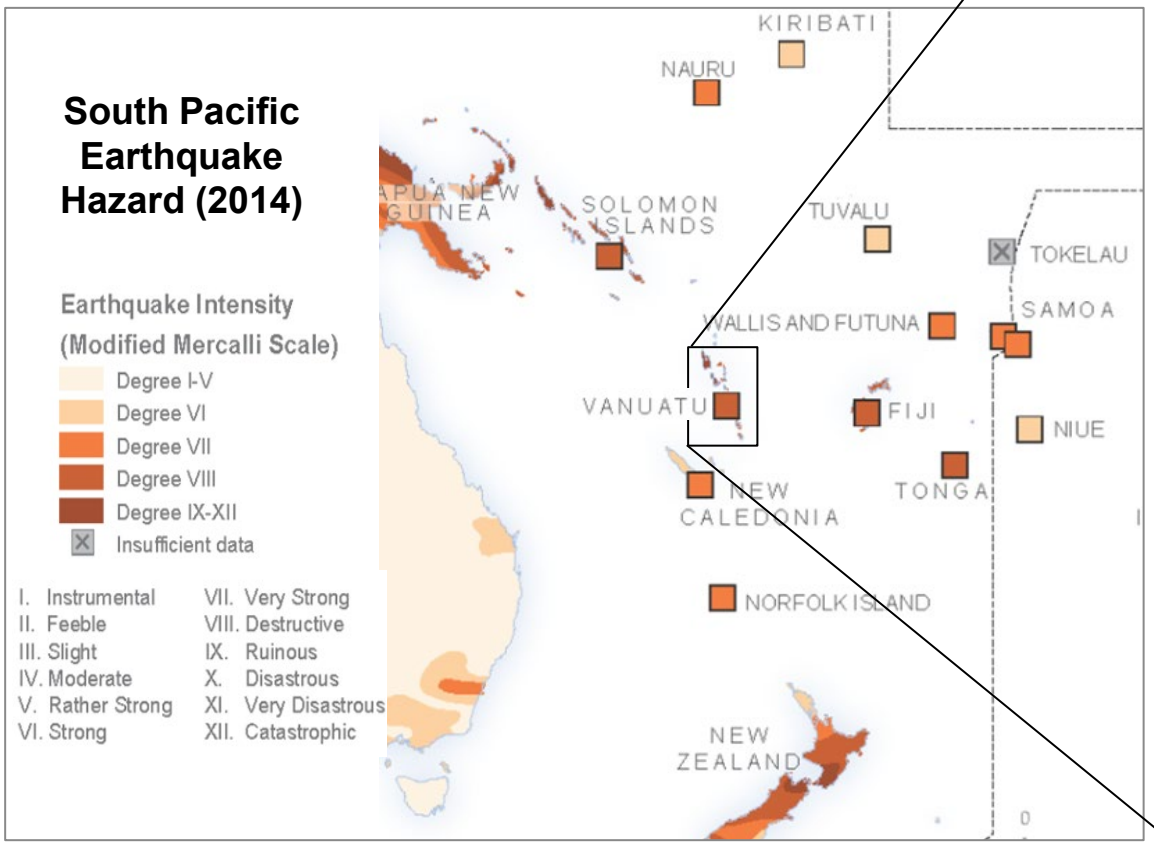
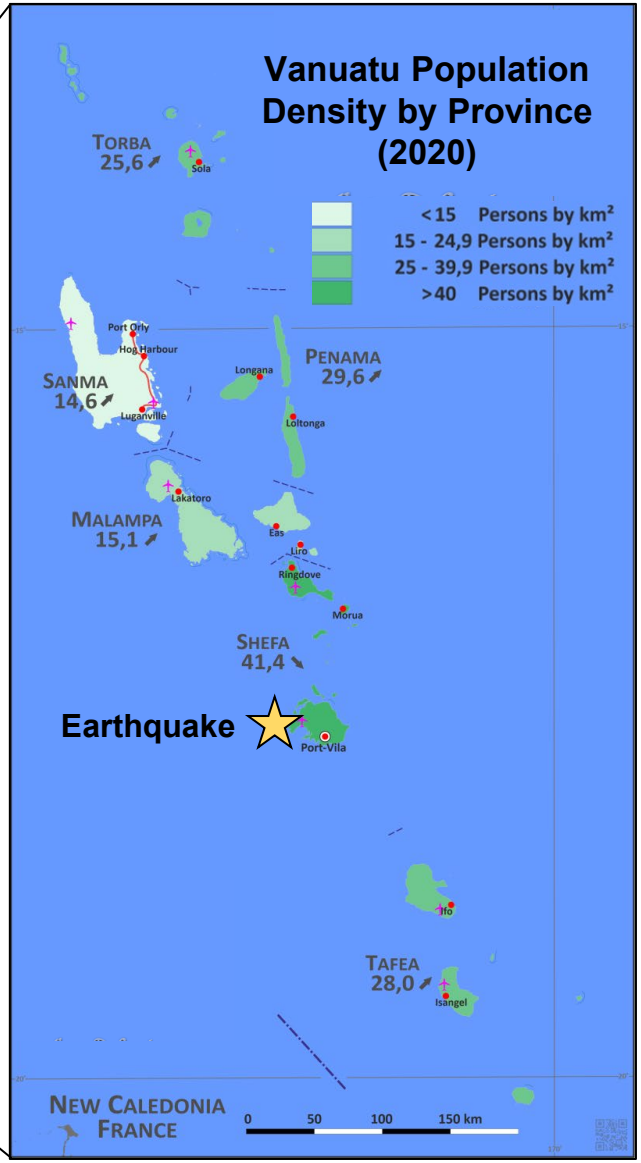


Image courtesy the OCHA

Image courtesy geo-ref.net



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The earthquake generated large landslides, damaging and blocking the road to Port Vila's international shipping terminal as shown in this drone video.

Video: Dan McGarry (@VanuatuDan on X)

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Members of Australia's Federal Police and other rescue workers stand by a collapsed building in Port Vila, Vanuatu, Thursday, Dec. 19, 2024, following a magnitude 7.3 earthquake that struck just off the coast of Vanuatu in the South Pacific Ocean, Tuesday, Dec. 17. (Australian Federal Police via AP)

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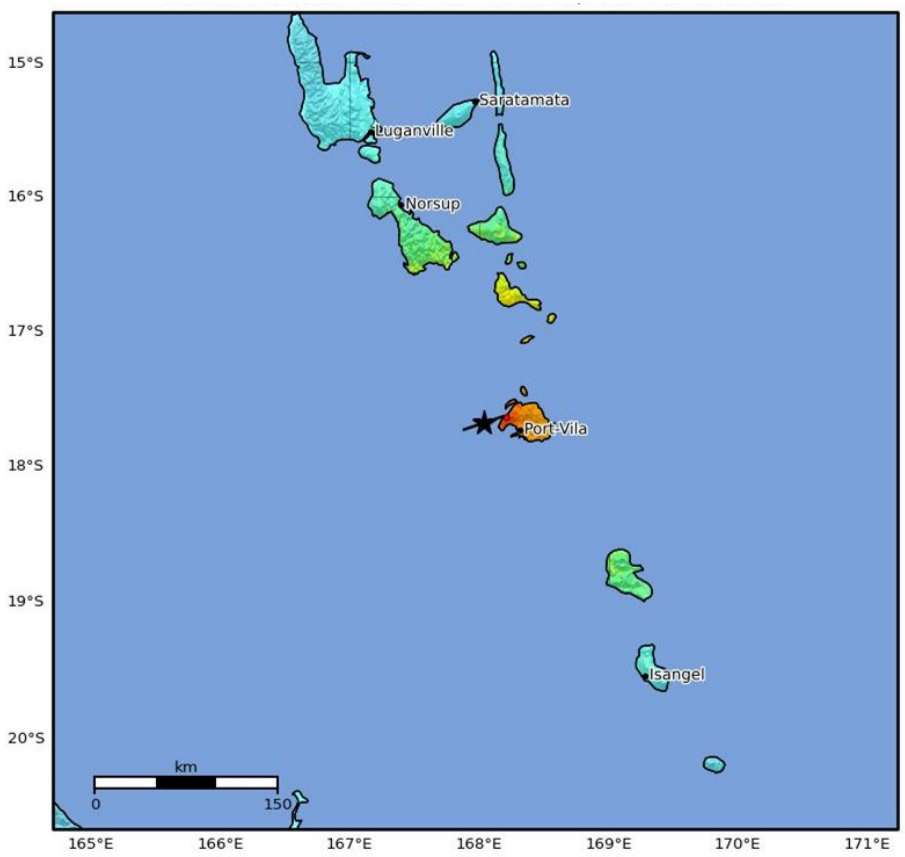
The Modified-Mercalli Intensity (MMI) scale is a ten-stage scale, from I to X, that indicates the severity of ground shaking.

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



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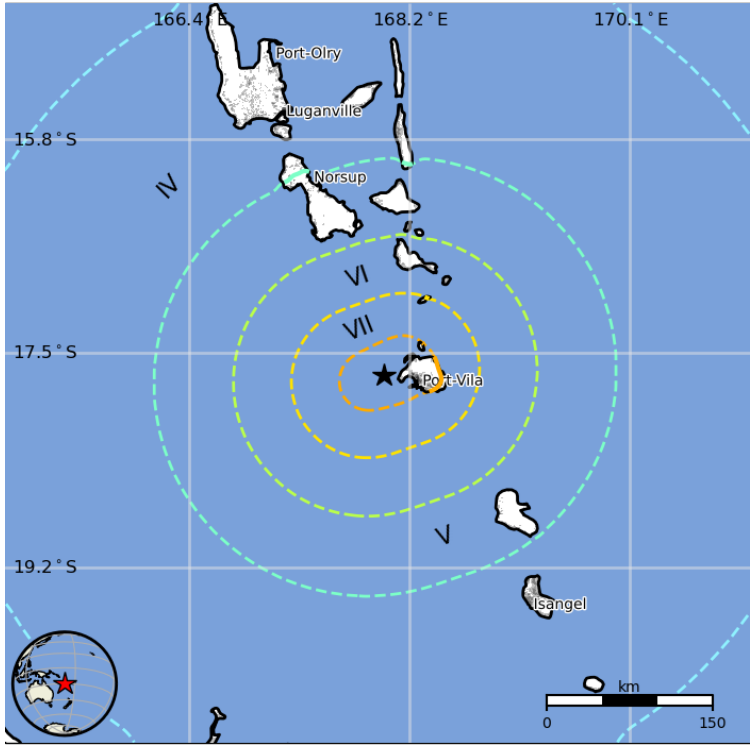
The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels. The USGS estimates that approximately 83,000 people felt severe shaking from this earthquake.

MMI	Shaking	Population
I	Not Felt	0 k*
II-III	Weak	1 k*
IV	Light	161 k
V	Moderate	38 k
VI	Strong	20 k
VII	Very Strong	8 k
VIII	Severe	83 k
IX	Violent	1 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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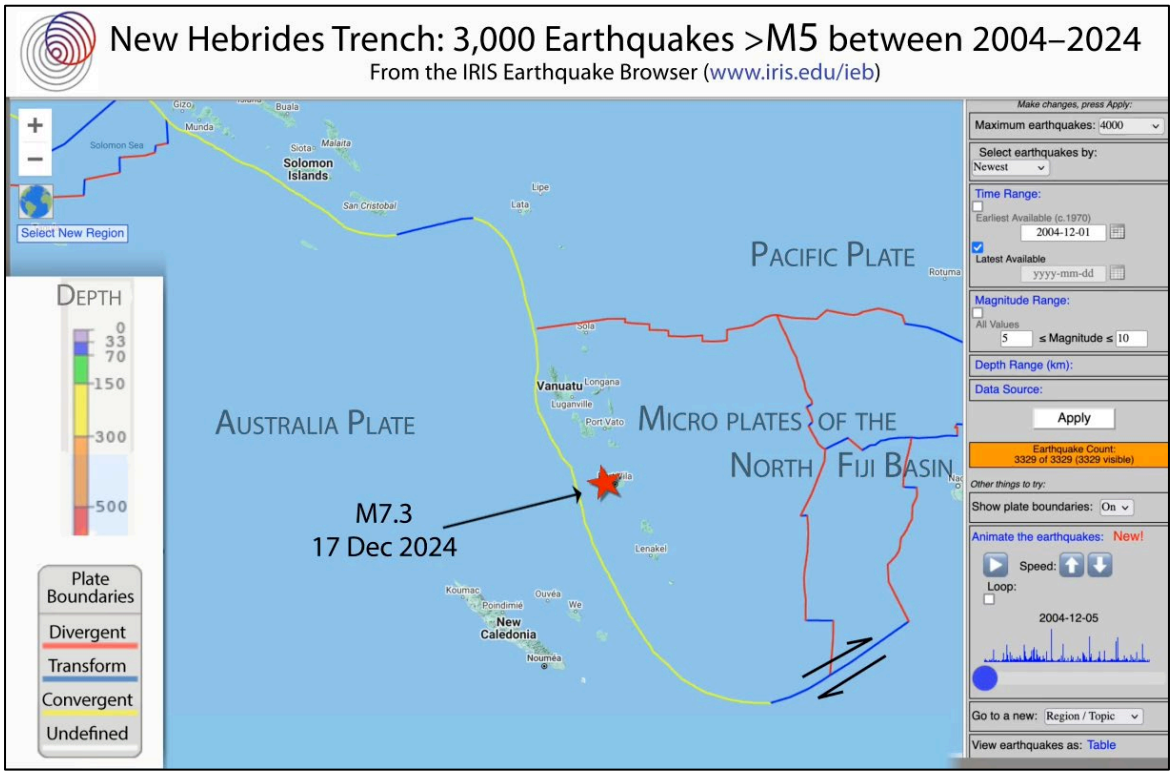
This animation uses the Interactive Earthquake Browser (www.iris.edu/ieb) to examine earthquakes in the region.

"Time Range" is set for 2004 to present.
"Magnitude Range is set for > M5.

There have been over 3,330 earthquakes greater than magnitude 5 in the past 20 years, and over 17,000 measurable earthquakes have been recorded in that same period.

Red star indicates the M7.3 earthquake.



For a narrated description of the tectonics of the New Hebrides subduction zone, please see the next slide.

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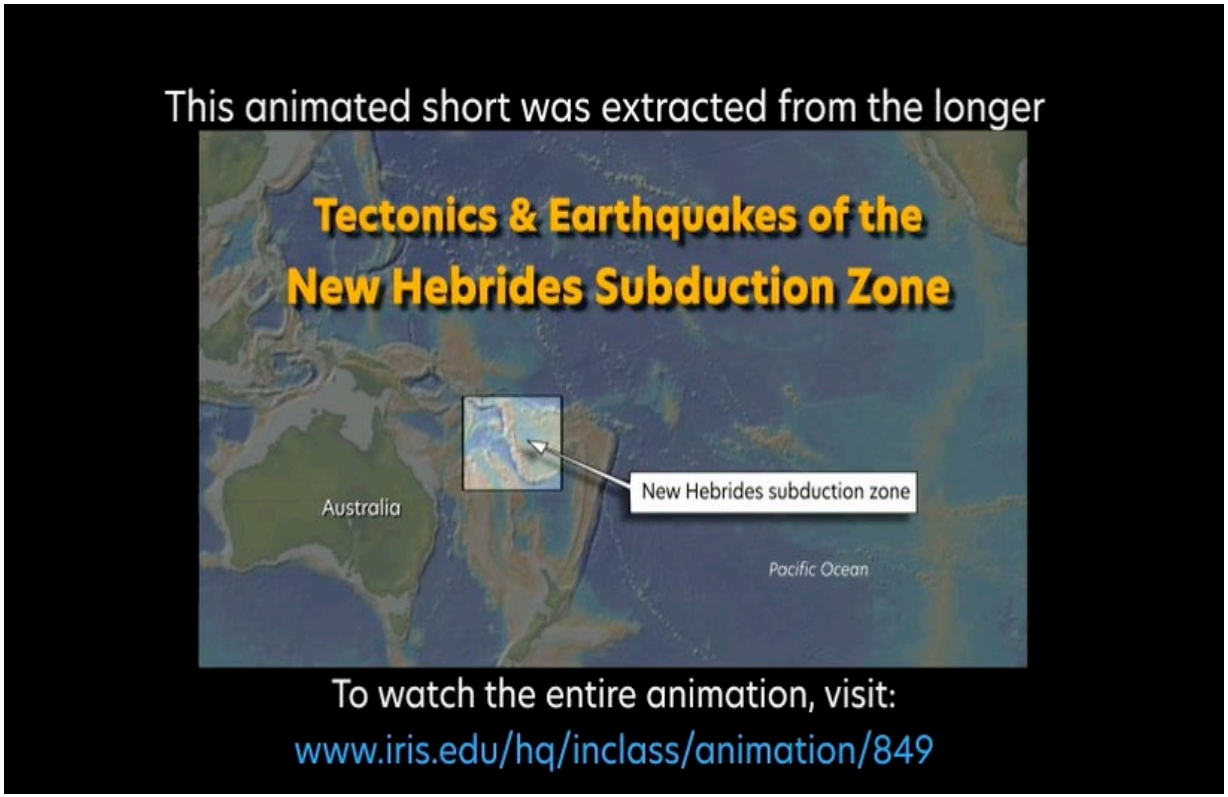
This narrated animation, which covers the tectonic and volcanic setting of the New Hebrides, is an extract from a more-comprehensive look at the earthquake history of this subduction zone.

We recommend watching the entire animation (link below) because the Australia Plate and Pacific plates converge to form a back-arc region that is far more complex and compelling!



[Link to 7-minute animation www.iris.edu/hq/inclass/animation/849]

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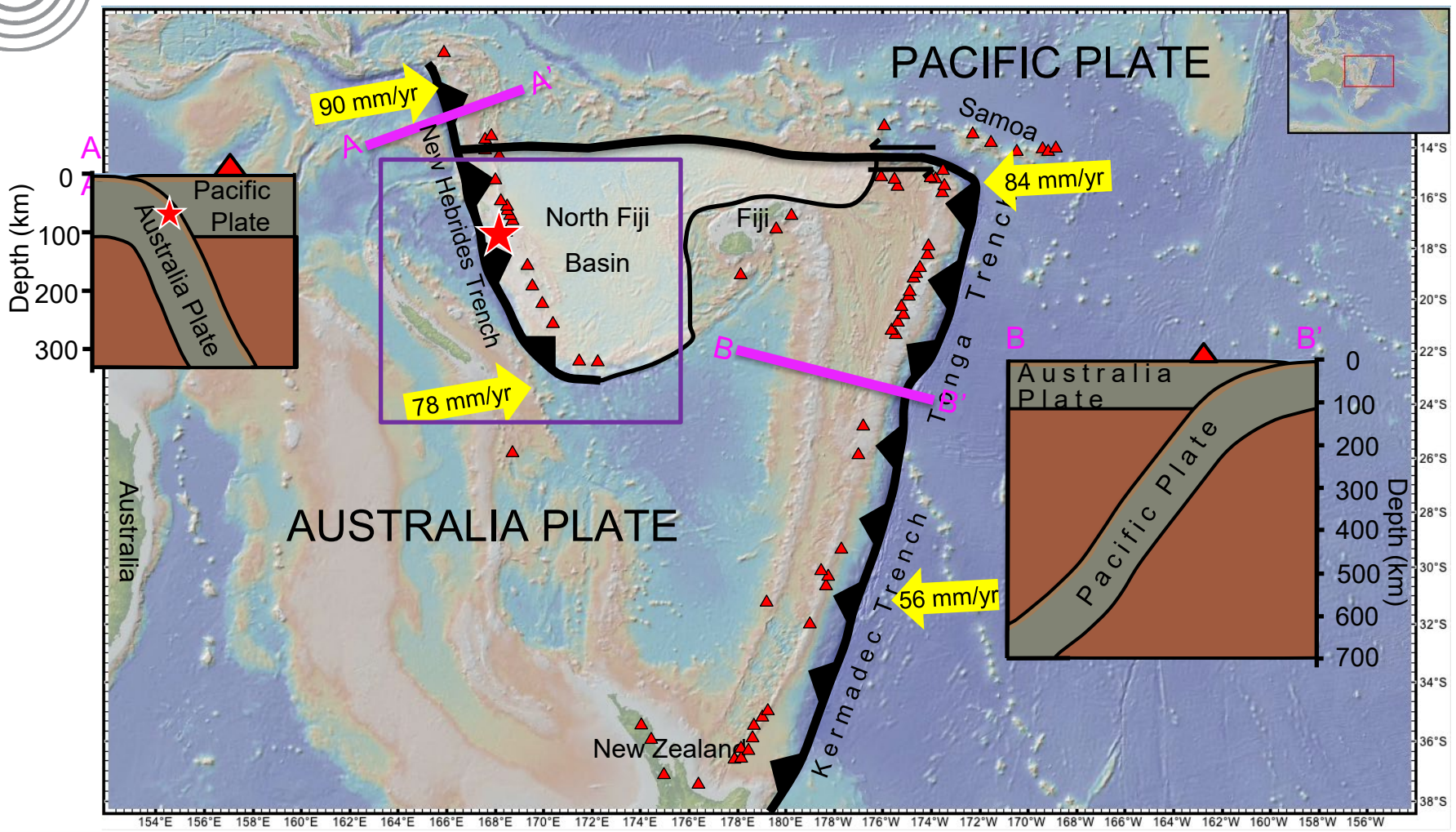

The Pacific and Australia plates converge across two major subduction zones north of New Zealand. At the Tonga and Kermadec trenches, the Pacific Plate subducts toward the west beneath the Australia Plate. At the New Hebrides Trench, the Australia Plate subducts toward the east beneath the Pacific Plate and North Fiji Basin. Rates of plate motions are shown by the yellow arrows and cross sections are shown along the pink lines. The December 17 earthquake (red star) occurred within the upper part of the Australia Plate in the central New Hebrides Trench. Tectonics within the area outlined by the purple square are shown on the next slide.

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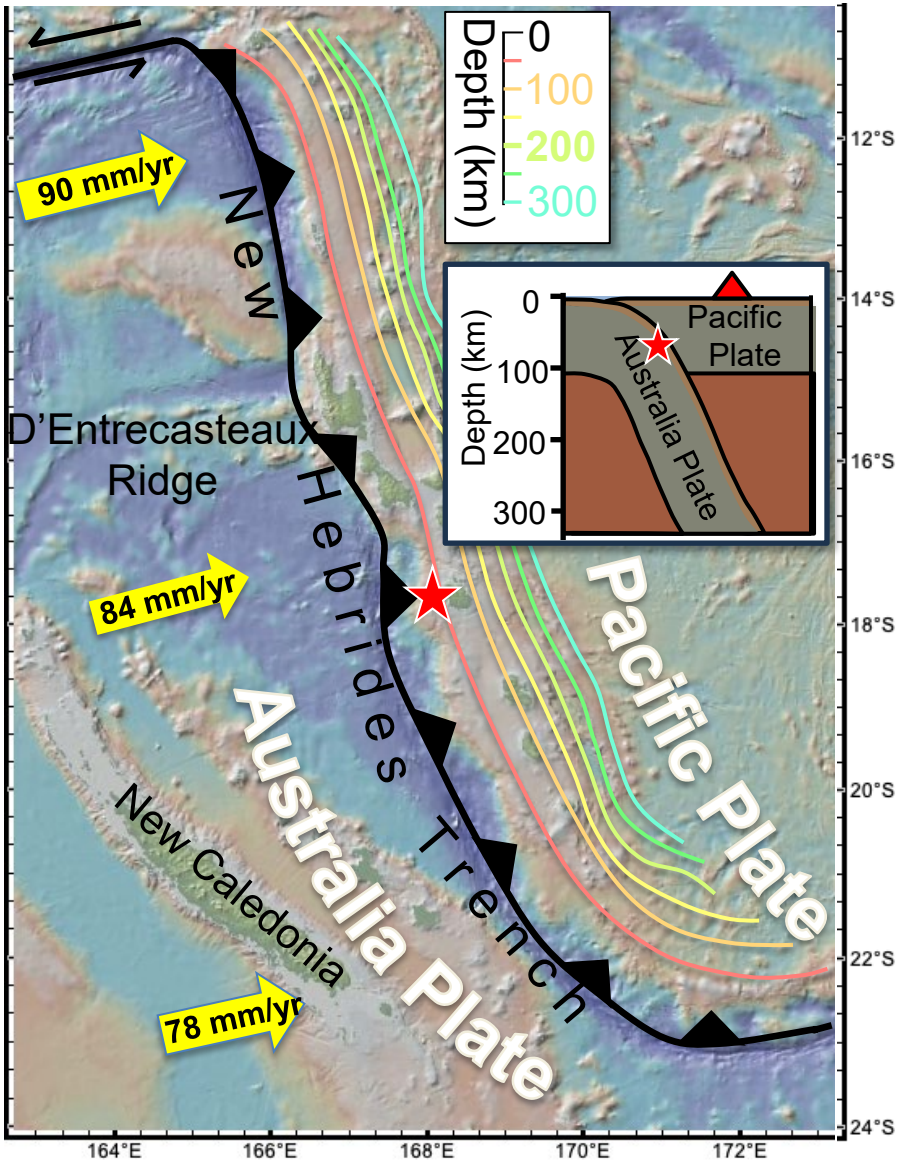
How Do Earthquakes Help Us Understand Plate Boundaries?

- Using earthquake locations and depths, we can map the boundary between the Australia and Pacific plates (called the megathrust).
- The map shows depth contours (lines) for the top of the subducting Australia Plate.
- The December 17 earthquake (red star) happened west of the 50-km depth contour and at a depth of 57 km.
- This means it was an **"intraplate" earthquake**—it occurred within the subducting Australia Plate itself.

Why Did It Happen?

- At the New Hebrides Trench, the Australia Plate bends as it dives under the Pacific Plate.
- Near the surface, it descends at a shallow angle, but deeper down it bends steeply.
- This bending creates tension in the plate, causing it to crack and produce **"bending stress" earthquakes**, like the December 17 event.
- These types of earthquakes are common in subduction zones around the world.



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Earthquakes that occurr **within** the downgoing (subducting) slab are often referred to as **intraslab earthquakes**.

Intraslab earthquakes are seen commonly in subduction zones around the world. They are caused by the stresses that accumulate in the subducting slab as it bends under the overriding plate. These **bending stresses** often result in normal faulting earthquakes, which accommodate extension.

Intraslab earthquakes can be damaging, depending on how deep they occur, with shallower events producing more intense shaking at the surface.

A good analogy for intraslab earthquakes is cracking your knuckles! When you stretch your knuckles beyond a certain point, the stresses you impose cause your knuckles to crack (similar to generating an intraslab earthquake.

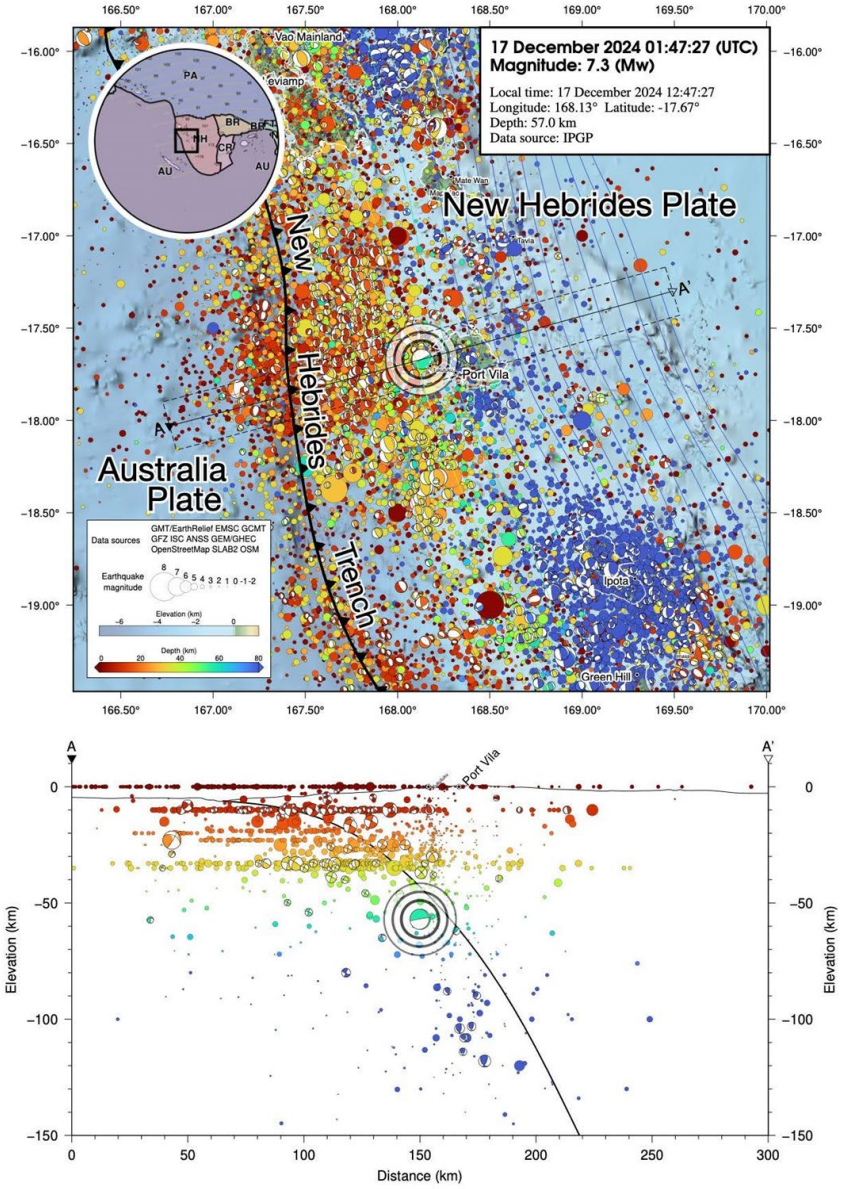

Image: [Earthquake Insights](#) (12/17/24)

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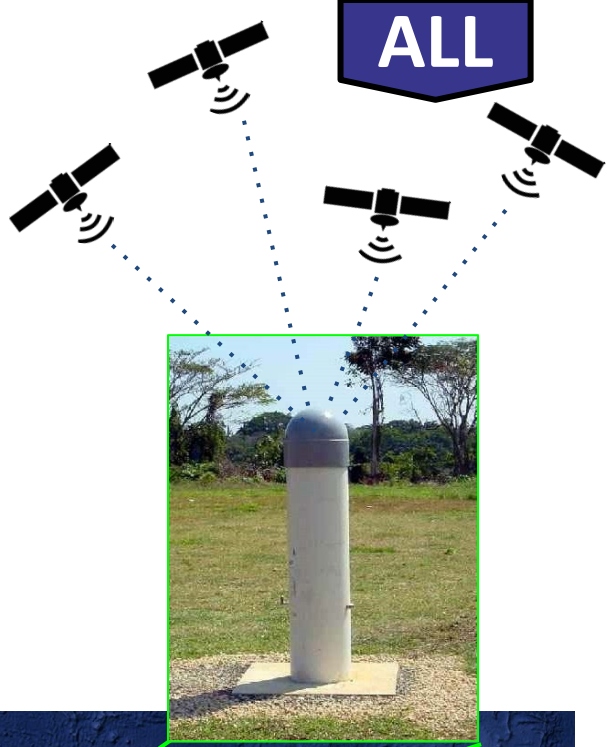
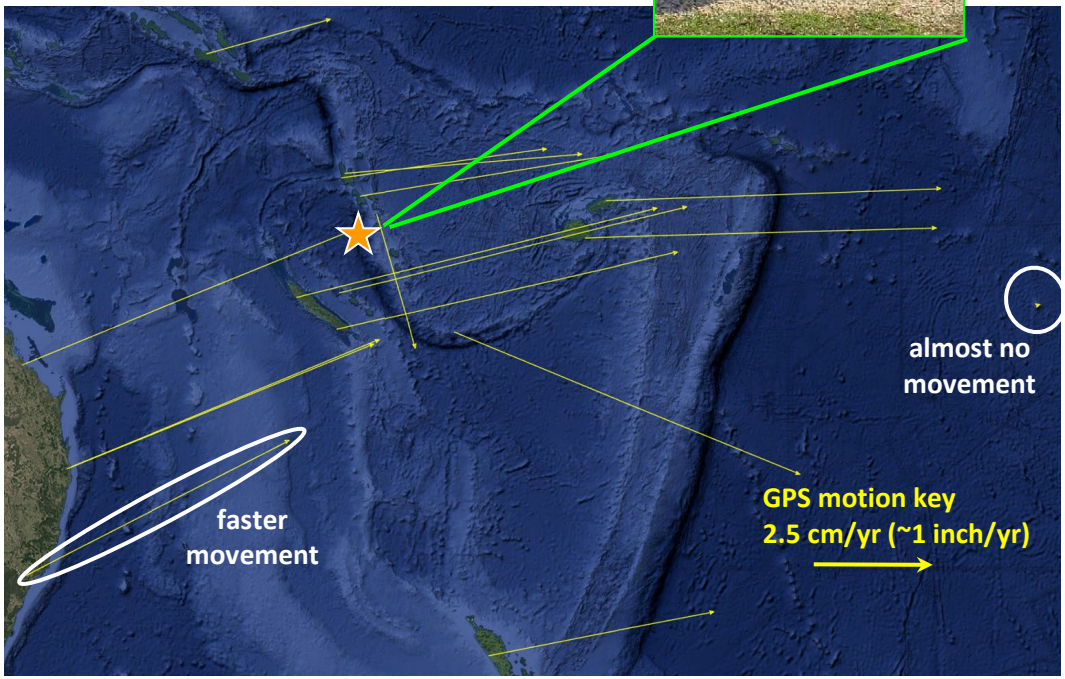
One of the ways we know the rates of plate motion is from GPS stations.

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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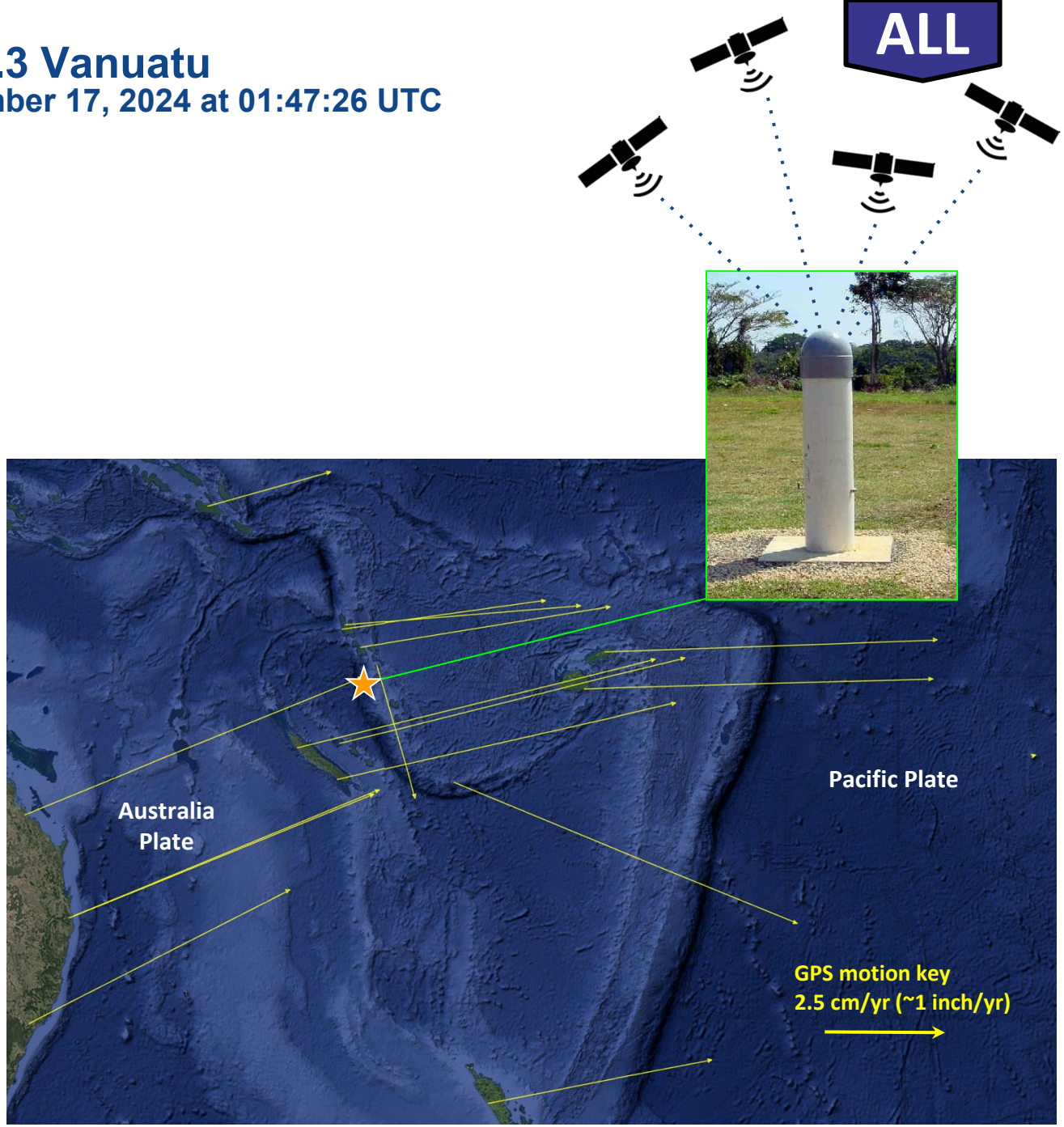
Vanuatu, neighboring Pacific islands, and Australia have GPS stations that record the long term motion from plate tectonics.

Compared to the main Pacific plate, stations in Vanuatu are moving as much as 7.5 cm/yr (~3 inch/yr) towards the east and northeast as the Australia Plate pushes into the Pacific Plate.

Over decades and centuries this compression accumulates and is occasionally released in earthquakes such as the magnitude 7.3 quake on Dec 17, 2024.



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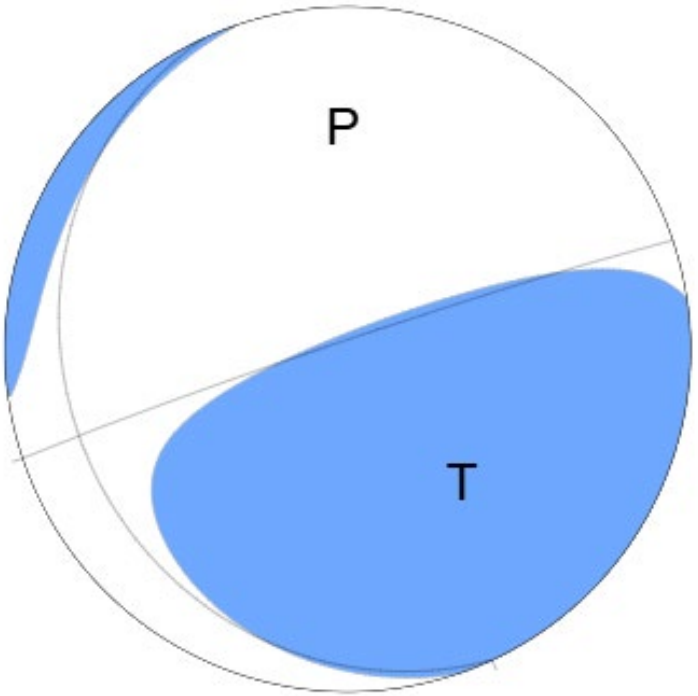
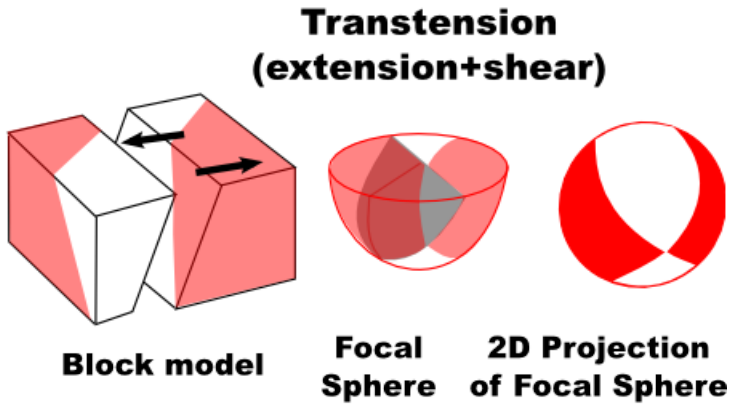
According to the USGS, the preliminary location, depth and focal mechanism of the event indicate rupture occurred as the result of oblique normal faulting. The earthquake's depth places it beneath the boundary of the Australia and Pacific plates in the Coral Sea region, within the subducting Australia Plate. Earthquakes that occur within a subducted plate, as opposed to at the interface of the plate, are termed intraslab earthquakes.



USGS WPhase Centroid Moment Tensor Solution



Shaded areas show quadrants of the focal sphere in which the P-wave first-motions are away from the source, and unshaded areas show quadrants in which the P-wave first-motions are toward the source. The letters represent the axis of maximum compressional strain (P) and the axis of maximum extensional strain (T) resulting from the earthquake.

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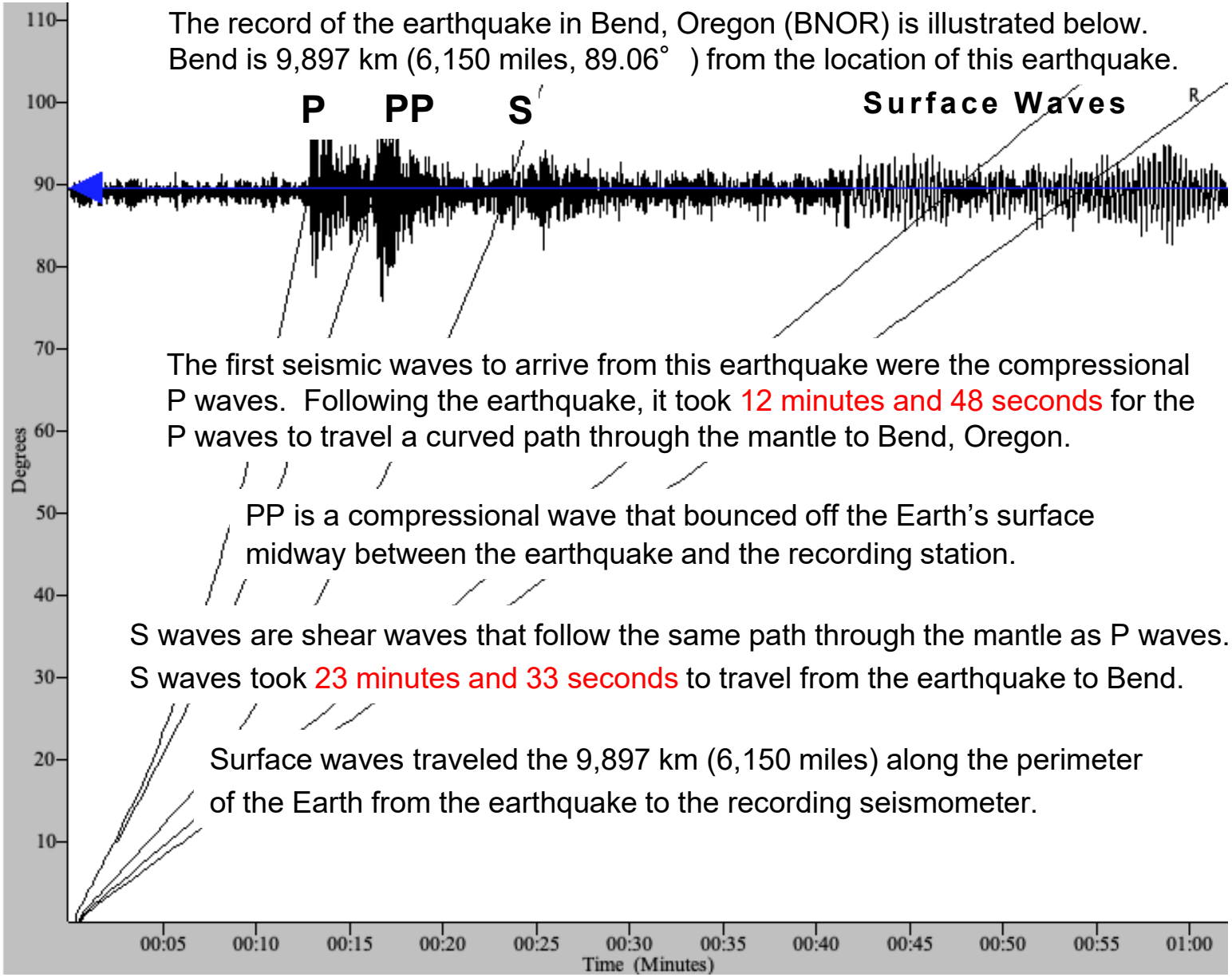
The record of the earthquake in Bend, Oregon (BNOR) is illustrated below. Bend is 9,897 km (6,150 miles, 89.06°) from the location of this earthquake.



The first seismic waves to arrive from this earthquake were the compressional P waves. Following the earthquake, it took 12 minutes and 48 seconds for the P waves to travel a curved path through the mantle to Bend, Oregon.

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

S waves are shear waves that follow the same path through the mantle as P waves. S waves took 23 minutes and 33 seconds to travel from the earthquake to Bend.

Surface waves traveled the 9,897 km (6,150 miles) along the perimeter of the Earth from the earthquake to the recording seismometer.

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

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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?

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These resources have been developed as part of the SAGE facility operated by the EarthScope Consortium via support from the National Science Foundation.