

ERSC 1P92

Assignment 4. Interpretation of Earthquakes and Volcanoes on Trafalmdore.

This tutorial is based on a Powerpoint presentation so the pages are referred to as “slides”.

The aim of this assignment is to identify plate boundaries and the location of various geological features on the basis of the spatial distribution of earthquakes and the location of volcanoes and the type of magma that they are made from.

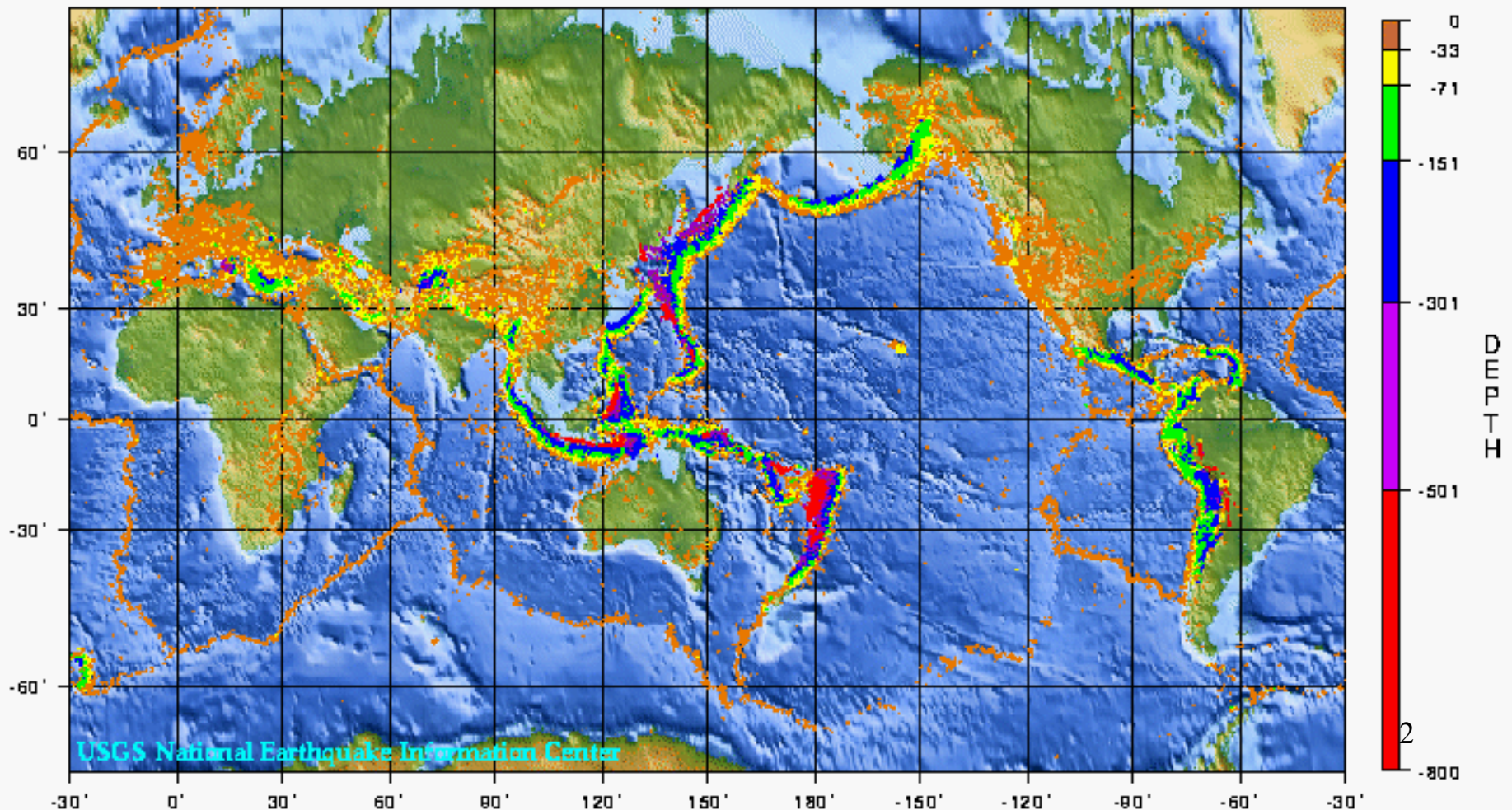
Detailed instructions are given in the assignment itself which can be downloaded from the course Sakai page.

The following slides were used to give several detailed hints as to how to successfully complete the assignment.

Note that the final slide in this set provides useful information about the distribution of volcanoes that will help you complete the assignment.

Tectonic plate boundaries on Earth are delineated by the distribution of earthquakes. In this assignment you will look for patterns of earthquakes on the fictitious planet of Trafalmadore in order to identify plate boundaries and volcanic islands and to predict where mountain would be found.

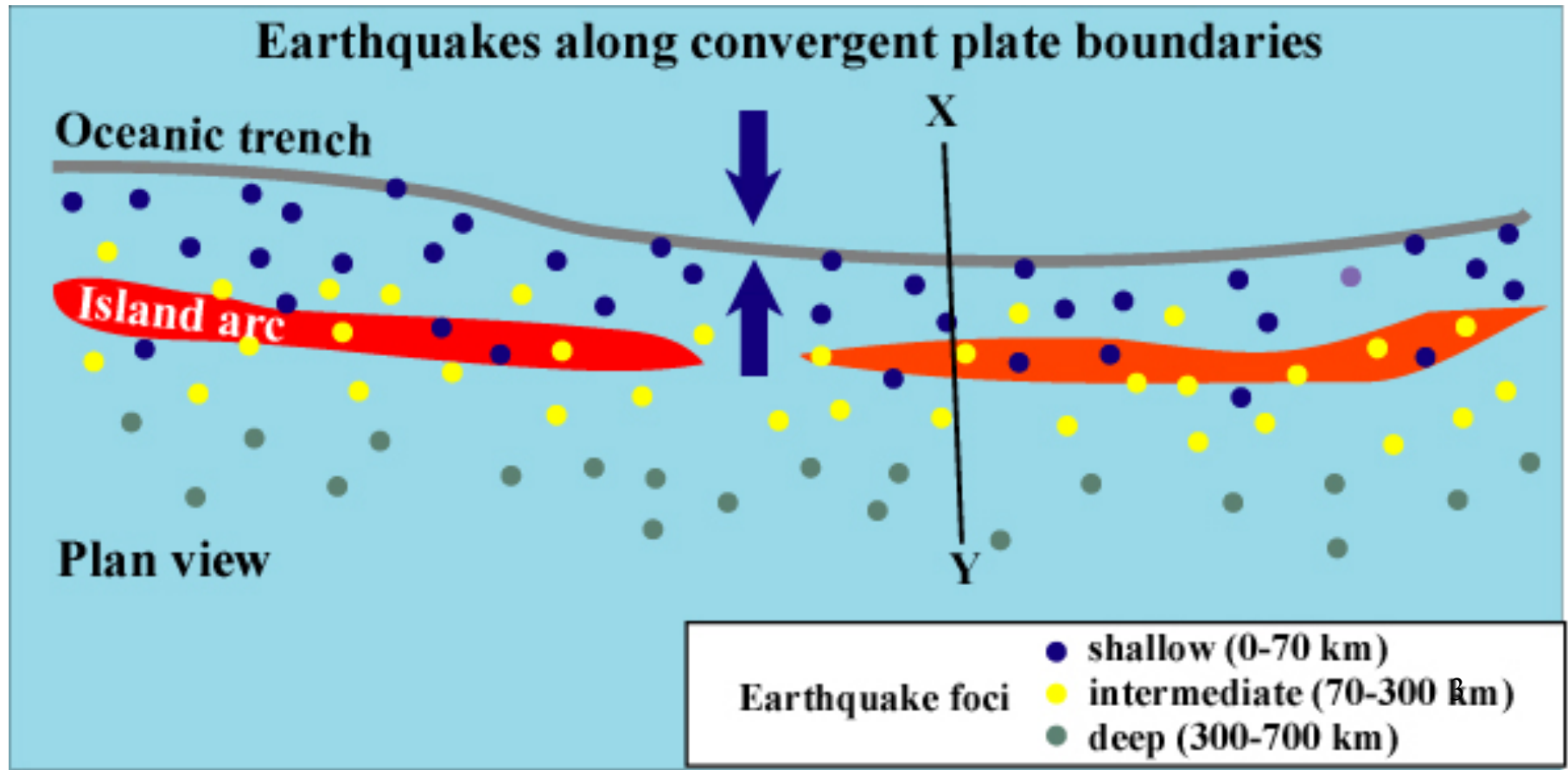
World Seismicity: 1975 - 1995



1. Oceanic trenches

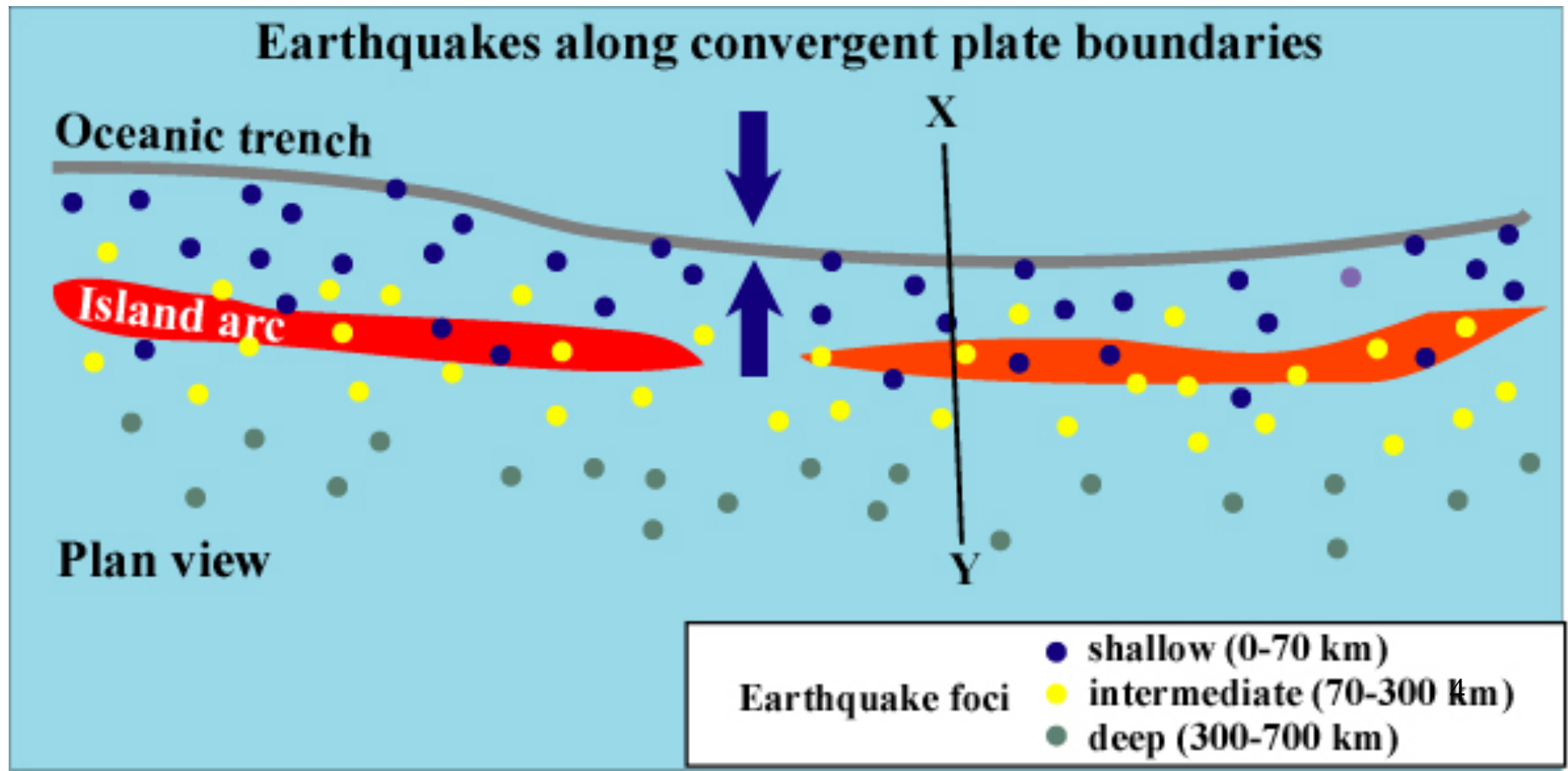
Subducting crust gets “stuck” as it descends, storing energy that is released to cause an earthquake.

Earthquakes occur beneath and within the obducting (over-riding) plate.



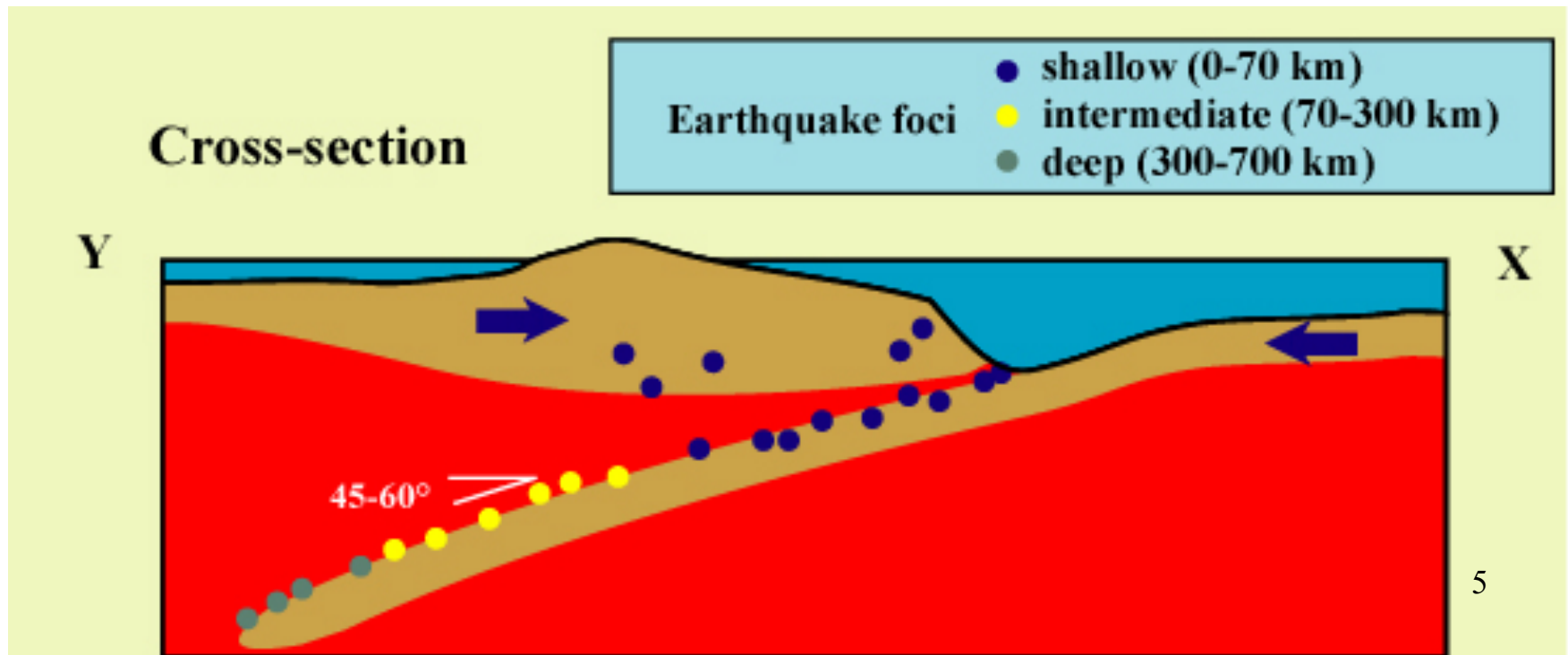
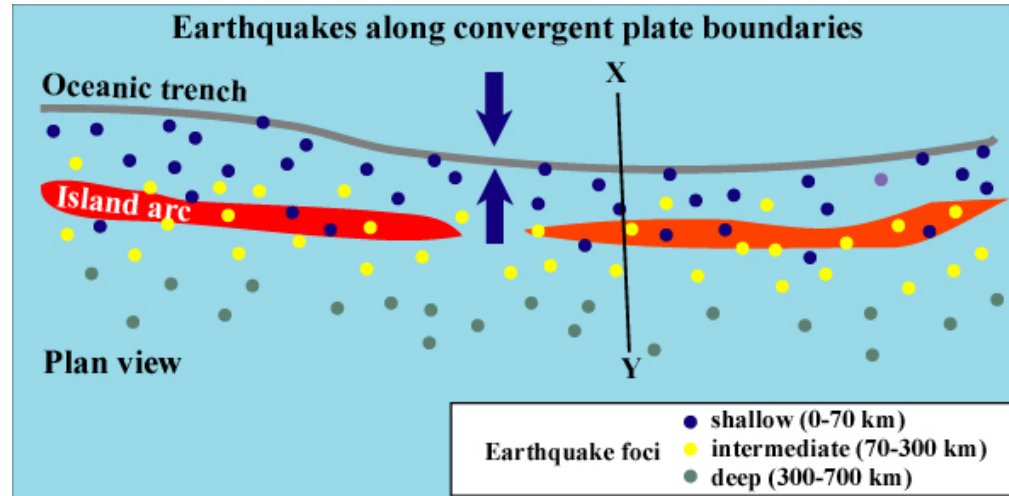
Foci become deeper in the direction of subduction; to a maximum depth of 700 km.

Foci delineate the path of the subducting crust.



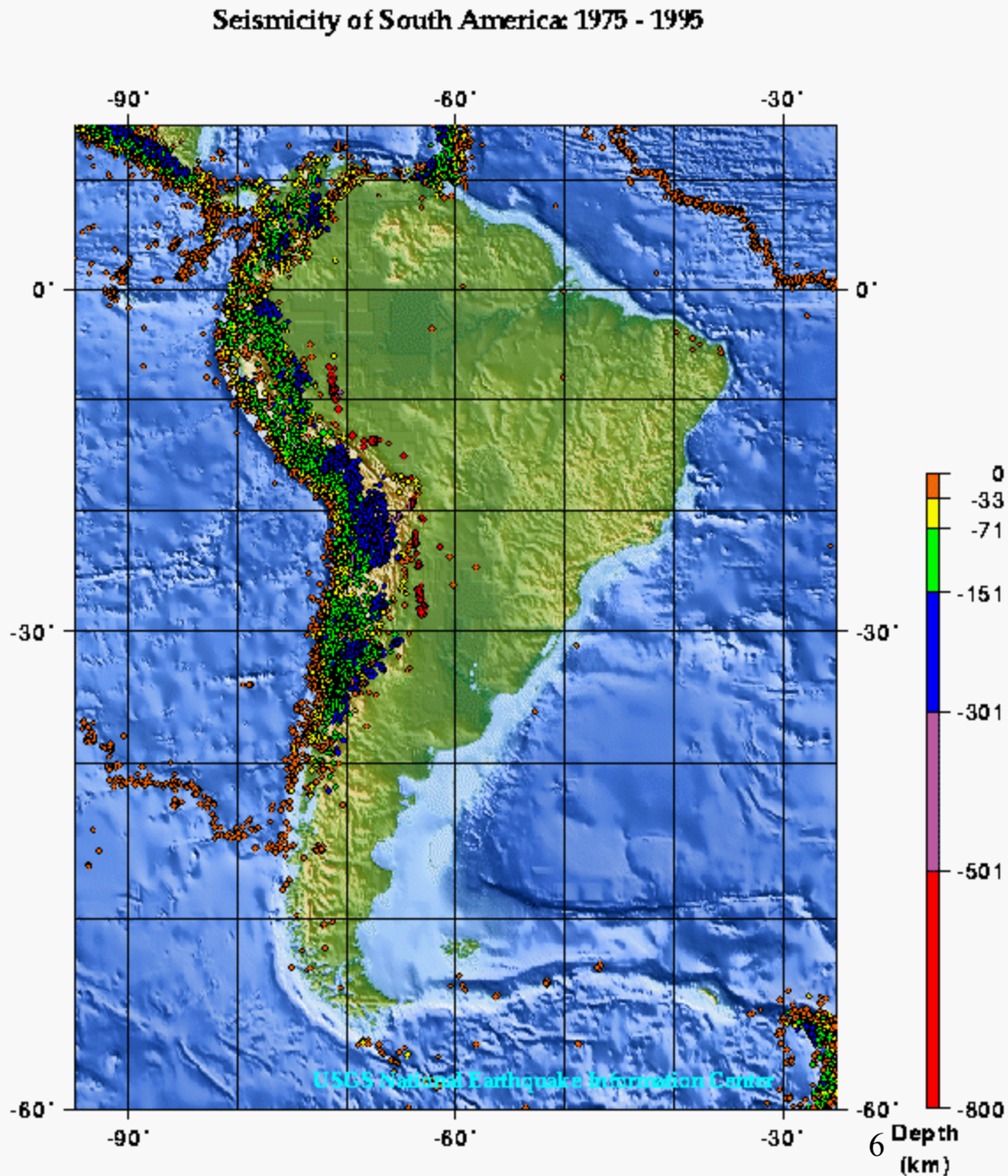
Most foci occur along the top of or within the subducting plate with some associated with the island arc.

The top of the subducting crust is cooler than the bottom and generates more friction.



A similar pattern of earthquakes occurs where oceanic crust subducts beneath continental crust.

Earthquakes also occur within the obducting continental crust due to compressive forces that cause movement along thrust faults.



Important Points

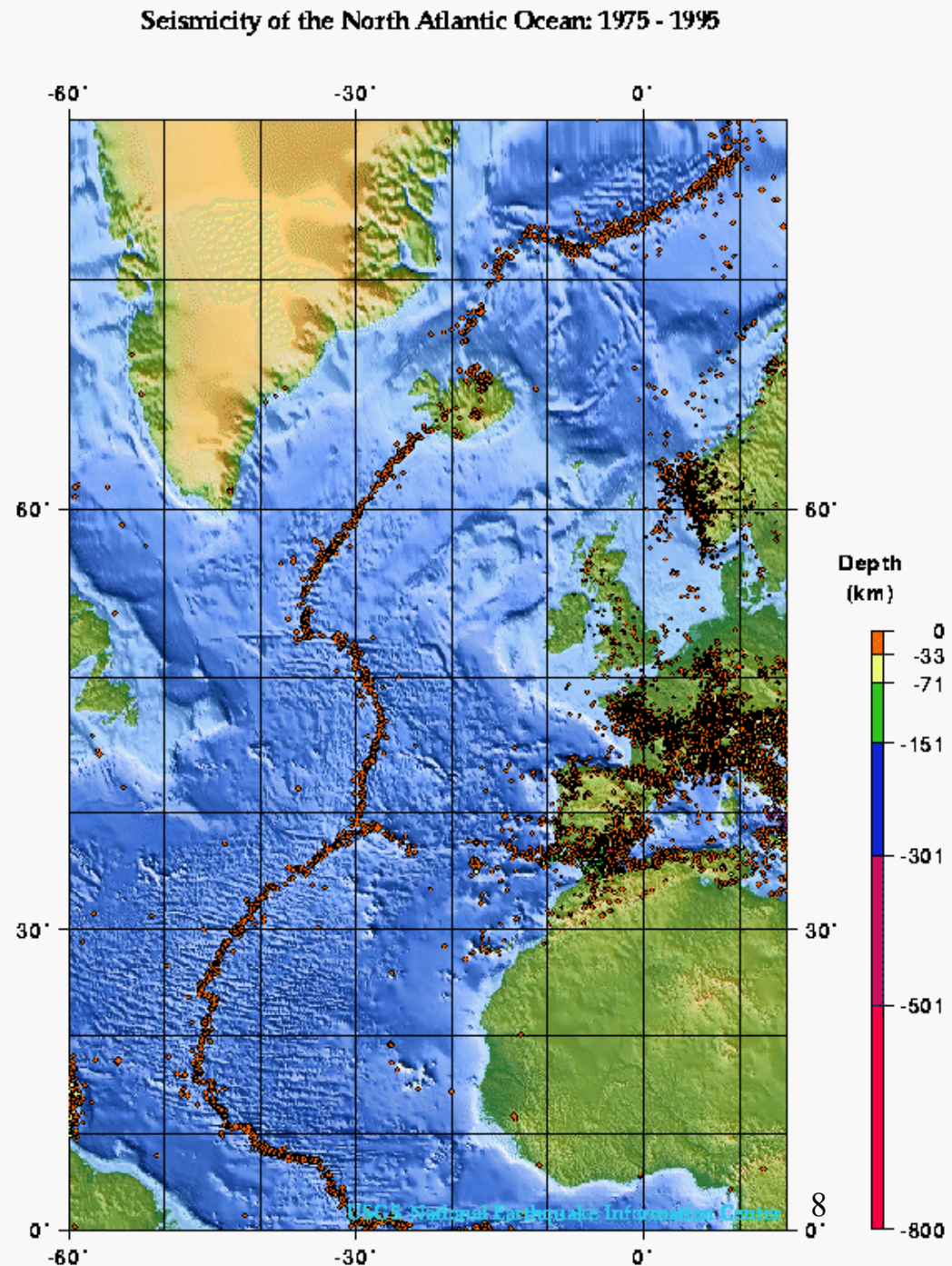
1. Oceanic trenches

- Deep earthquakes **only** occur in association with oceanic trenches.
- They are associated with BOTH shallow and intermediate earthquake.
- Shallow, intermediate and deep earthquakes occur in linear distributions that are parallel to each other and parallel to the trench.
- The trench is parallel to and ALWAYS on the side of the line or band of shallow earthquakes where earthquakes are absent.
- This pattern from shallower to deeper earthquakes may extend beneath continents (a major land mass) or island arc (linear islands that parallel the trench).
- Earthquake foci become progressively deeper in the direction of subduction.

Oceanic Ridges

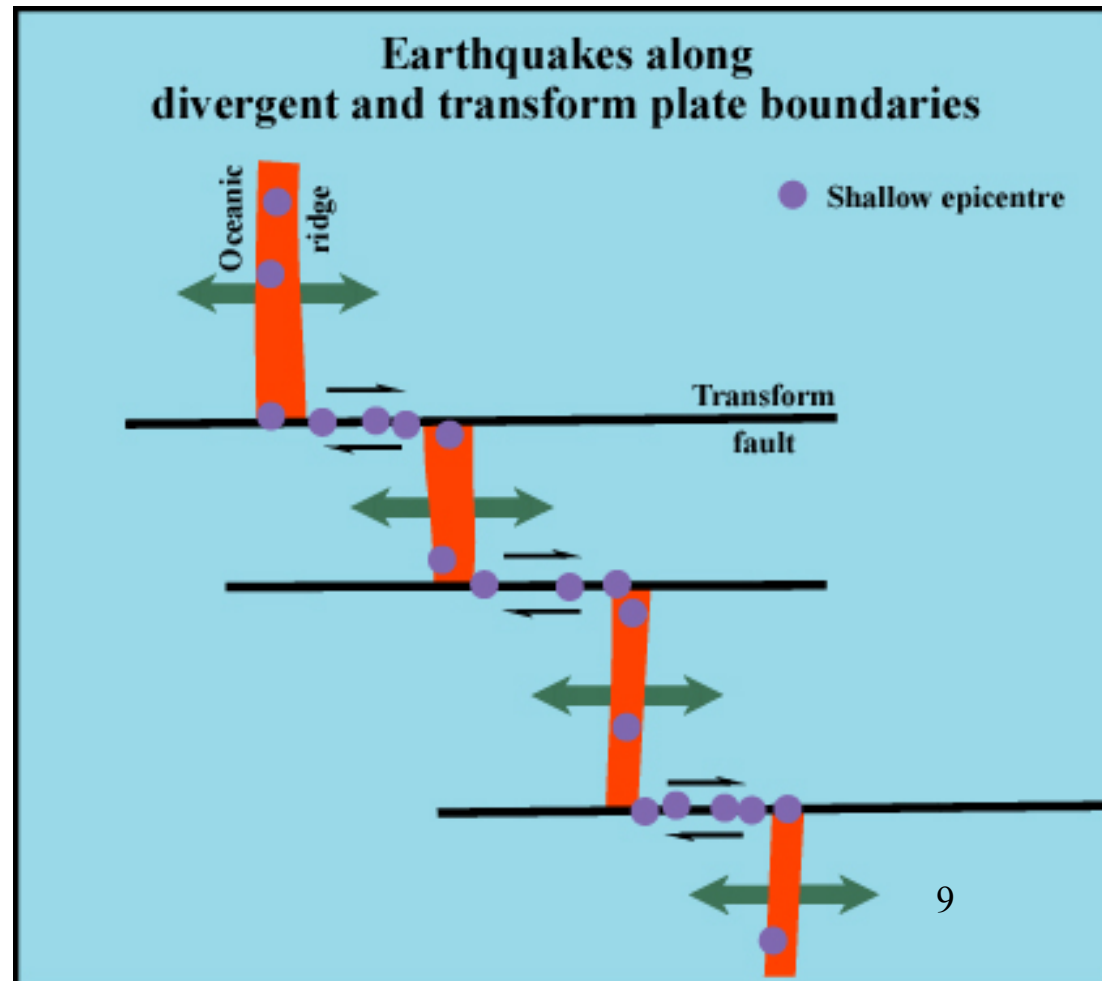
Largely shallow earthquakes (foci above 70 km depth) along the length of the ridge.

**Motion is periodic;
rocks stick,
accumulate energy and
release it when they
break.**



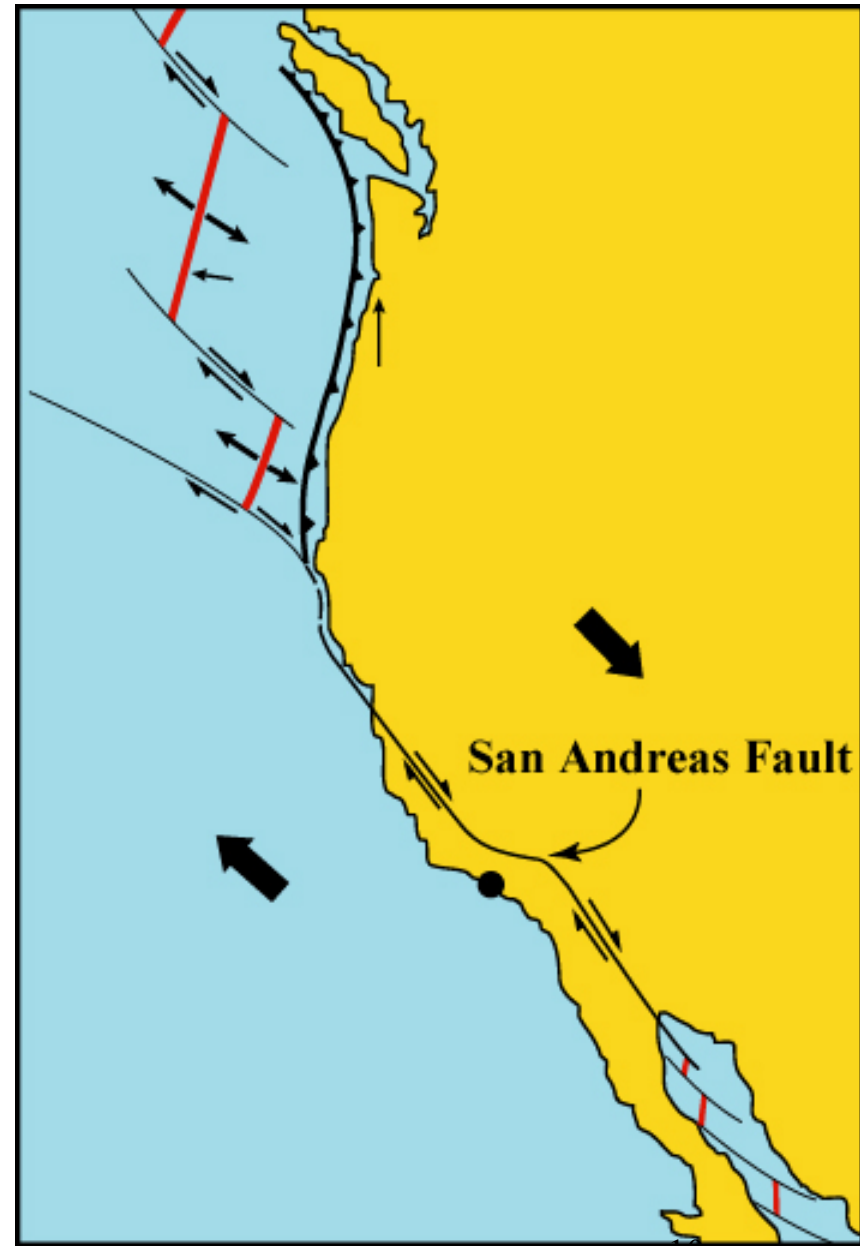
Earthquakes are generated:

1. Along the ridge axis due to sea-floor spreading.
2. Along transform faults due to lateral slipping between plates.



The San Andreas Fault is a transform fault that has been over-ridden by the North American Plate.

The fault experiences over 15,000 earthquakes per year.



Important Points

2. Oceanic ridges and transform faults

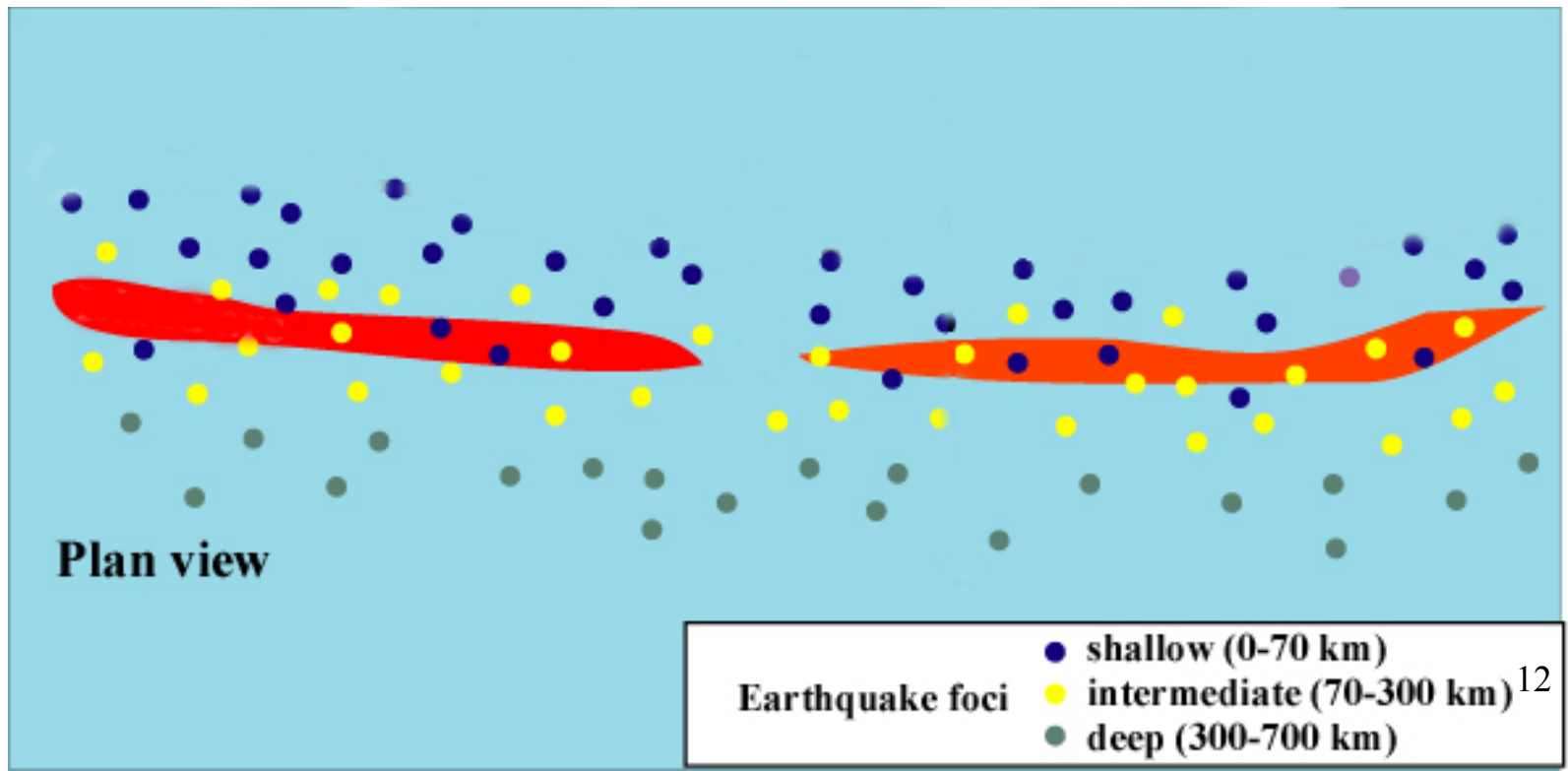
- Oceanic ridges display a linear pattern of earthquakes, all of which have relatively shallow foci.
- If deep or intermediate earthquakes lie parallel to the band of shallow earthquakes, it is not a ridge, it is a trench.
- Transform faults displace the oceanic ridge and these faults are also characterized by a linear pattern of shallow earthquakes.
- Combined the ridge and transform faults form two approximately perpendicular trending linear patterns of shallow earthquakes.
- Plate movement is away from the ridge axis, in opposite directions on either side of the ridge.
- If you know the direction of plate movement based on the location of the trenches and the direction of subduction you can distinguish ridges from transform faults.

For this assignment you should identify the trenches first.

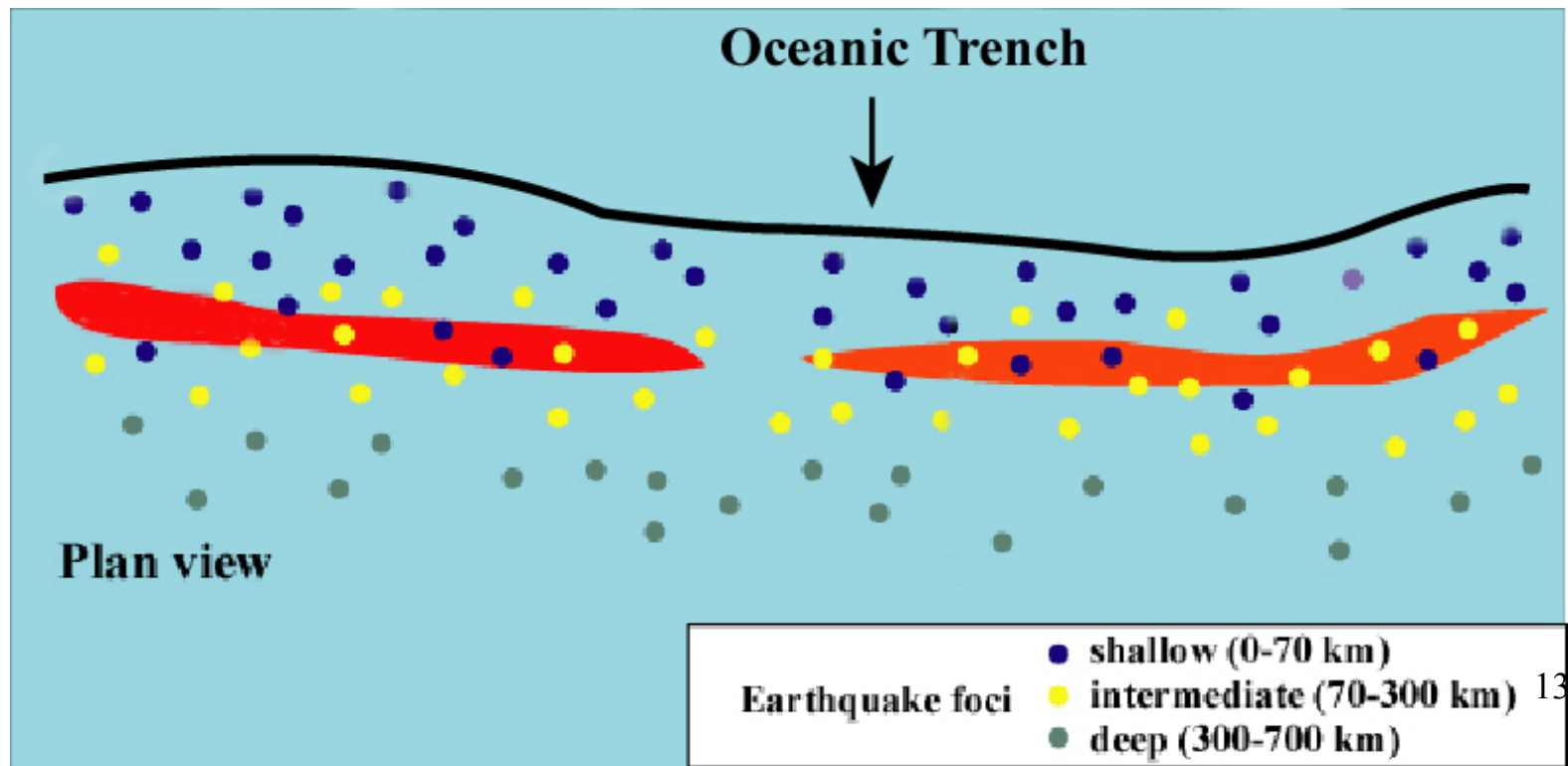
Deep earthquakes only occur in association with oceanic trenches.

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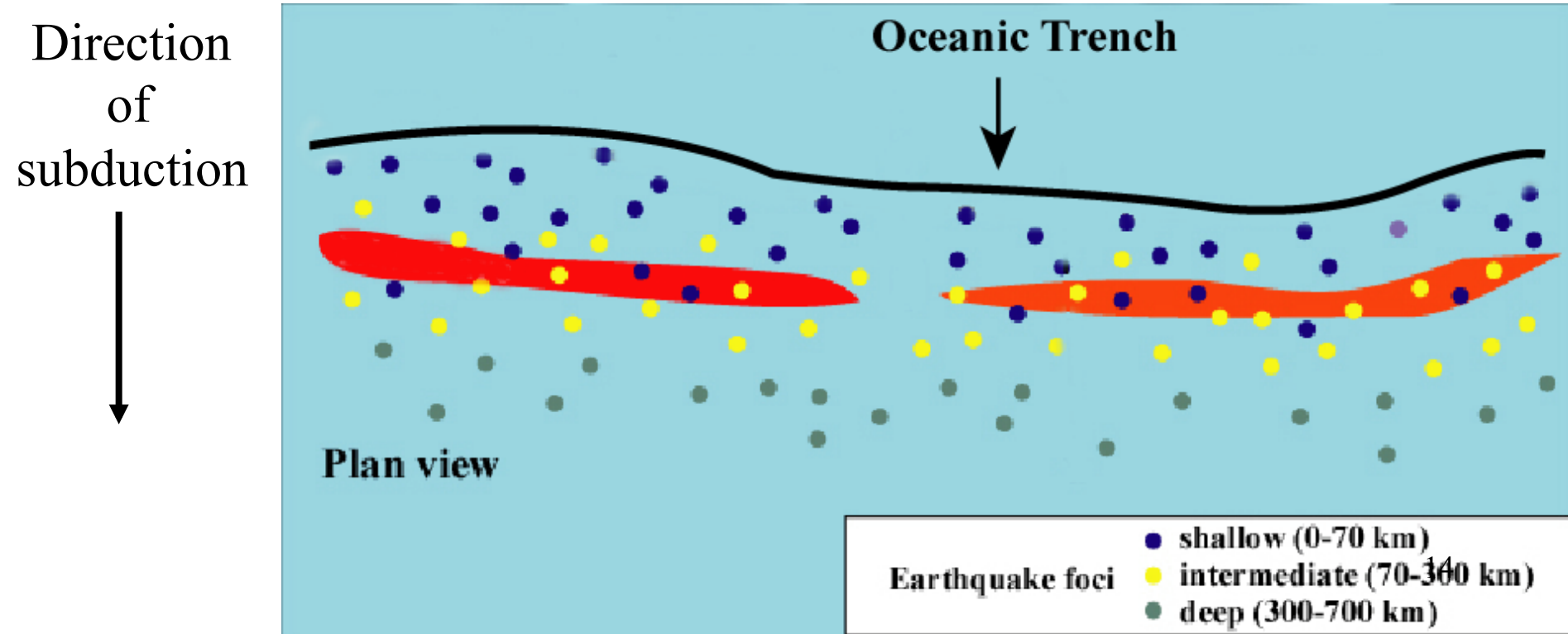


The trench is parallel to and ALWAYS on the side of the line or band of shallow earthquakes where earthquakes are absent.

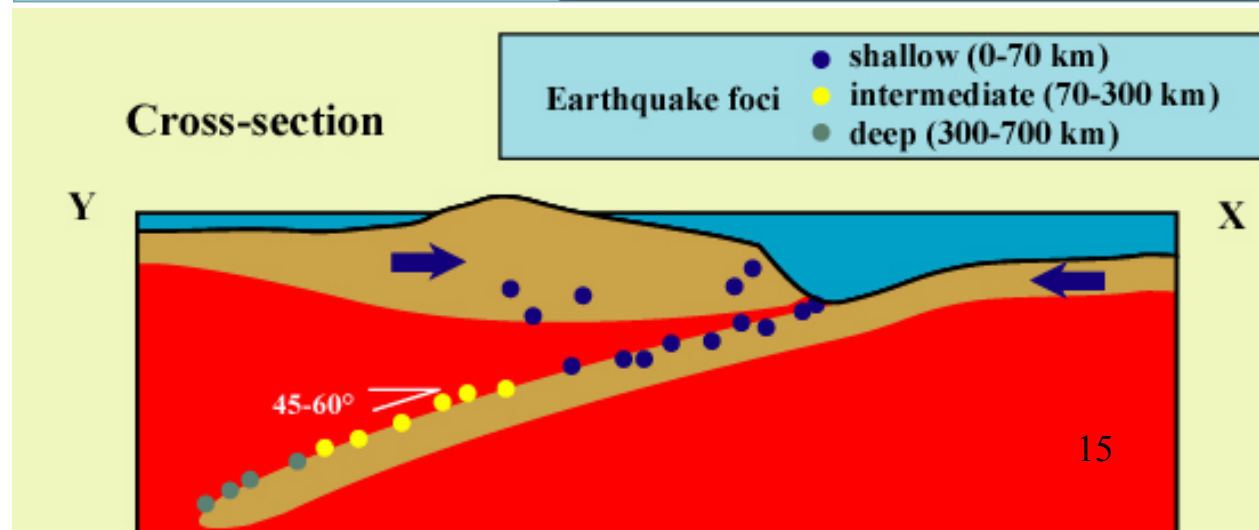
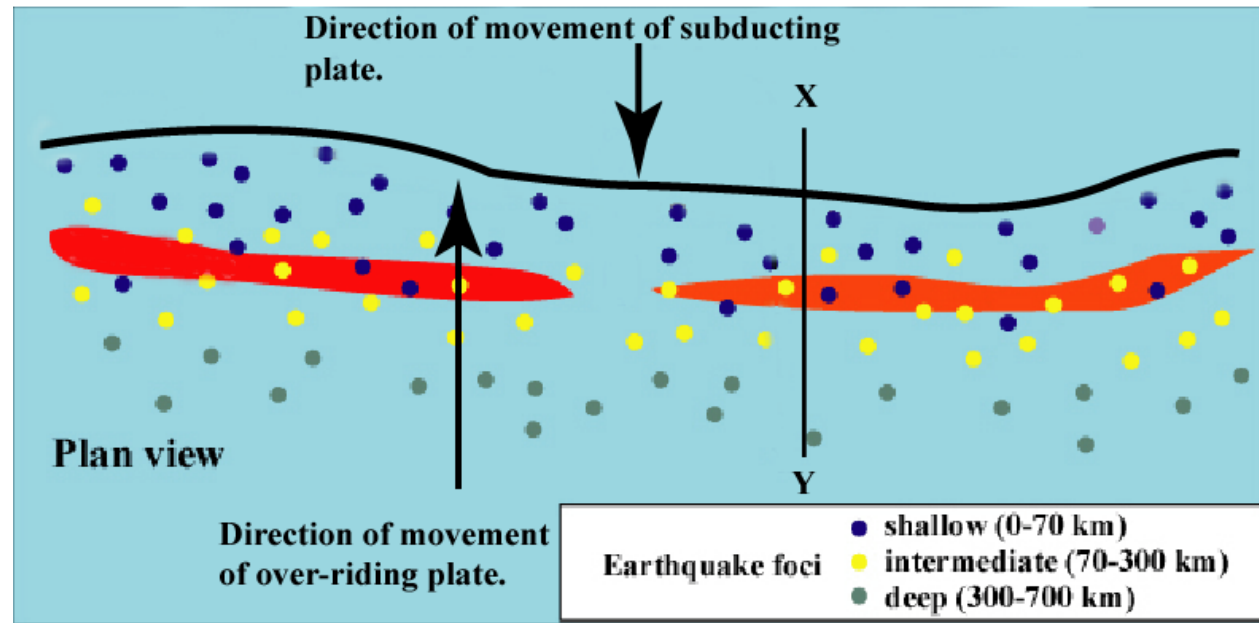


Earthquake foci become progressively deeper in the direction of subduction.

Important point: if, along a line that is perpendicular to what you believe to be there trench, the pattern is not one of shallow, to intermediate to deep earthquakes along that line (e.g., if it is shallow to deep or only shallow to intermediate) you are not observing a simple trench but possibly a more complex situation where two plate boundaries are in close proximity to each other.

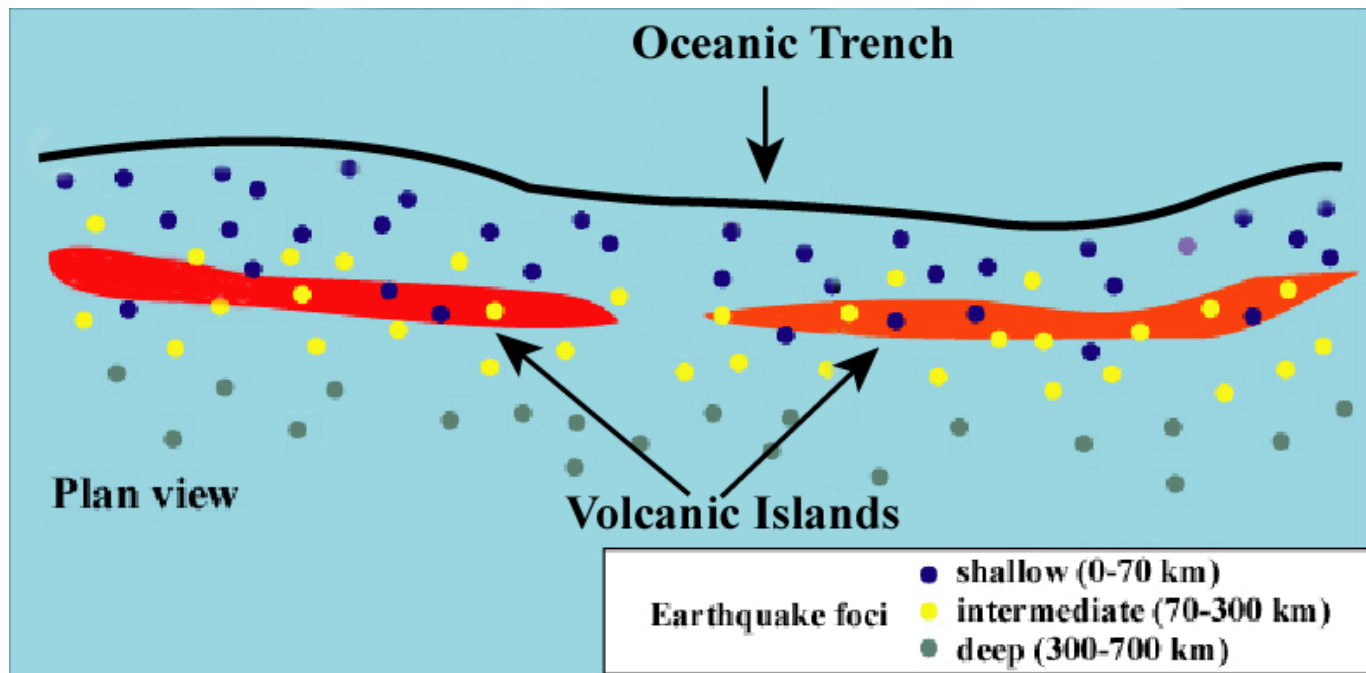


You can use the direction of subduction to distinguish the subducting plate from the over-riding plate.



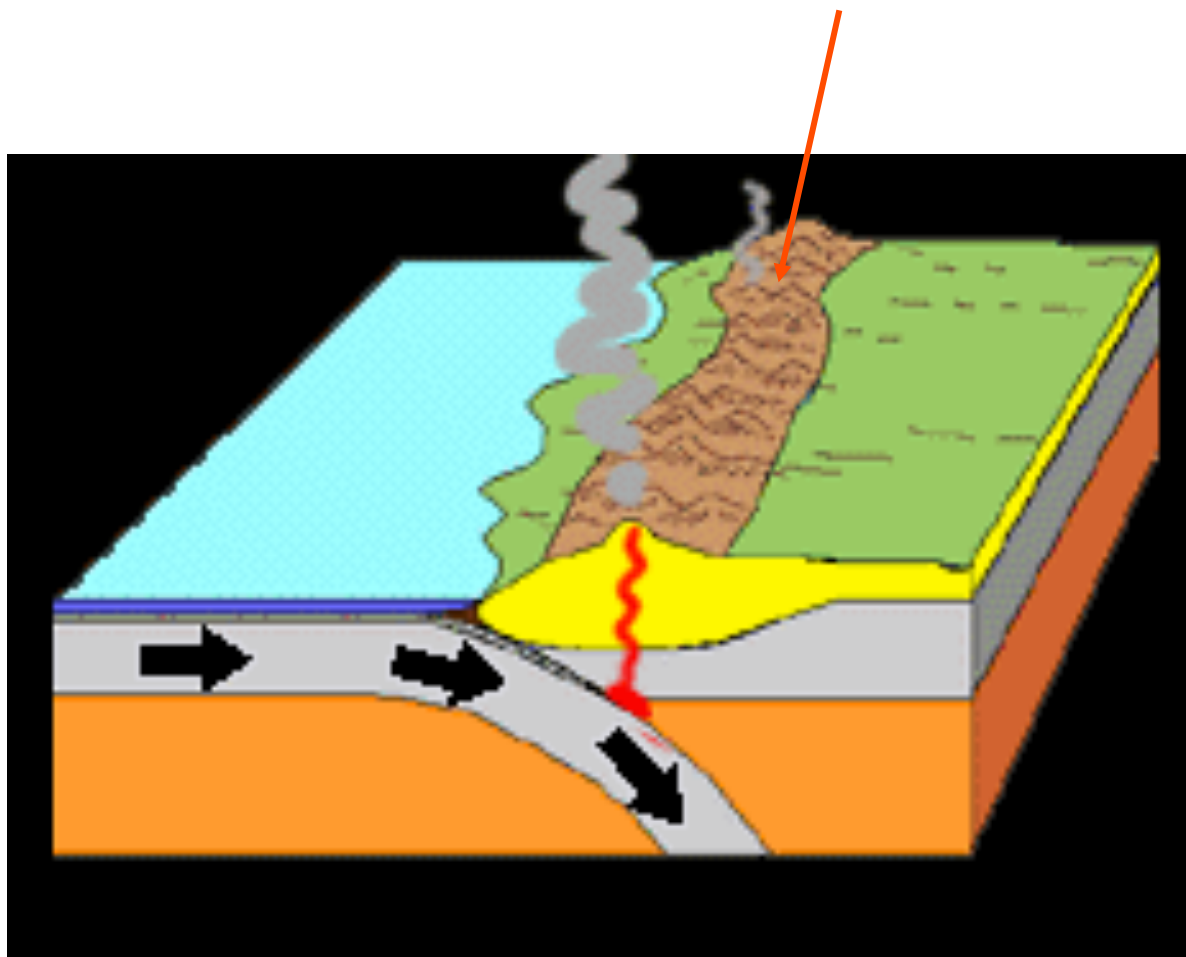
This pattern from shallower to deeper earthquakes away from the trench may extend beneath continents (a major land mass) or island arcs (linear islands that parallel the trench).

In this example there are long, narrow islands parallel to the trench and on the over-riding plate. Therefore, these are volcanic islands of an Island Arc Complex.

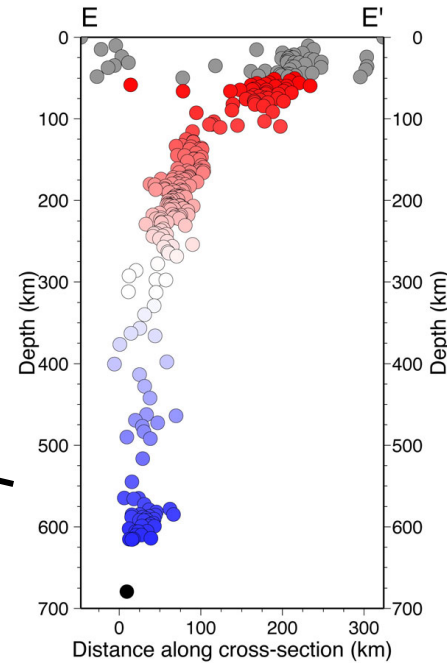
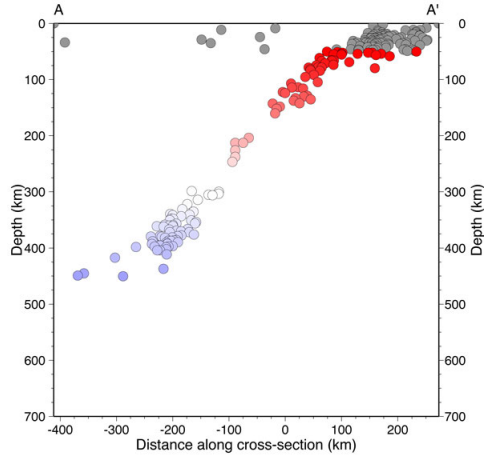
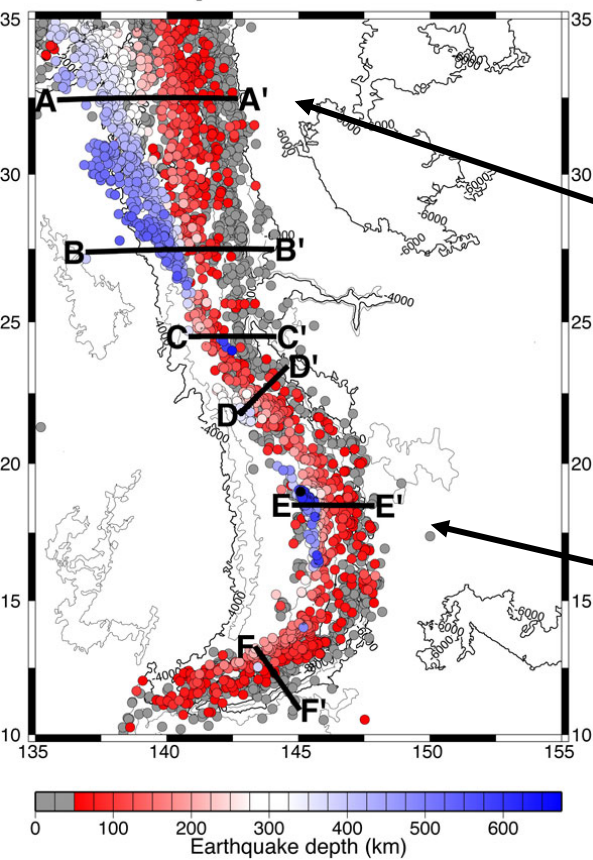


When trenches lie parallel to continental masses, the compressive forces and volcanic activity form linear mountain belts, on the continent, that parallel the trench like the Andes along the western side of North America.

Mountain Belt

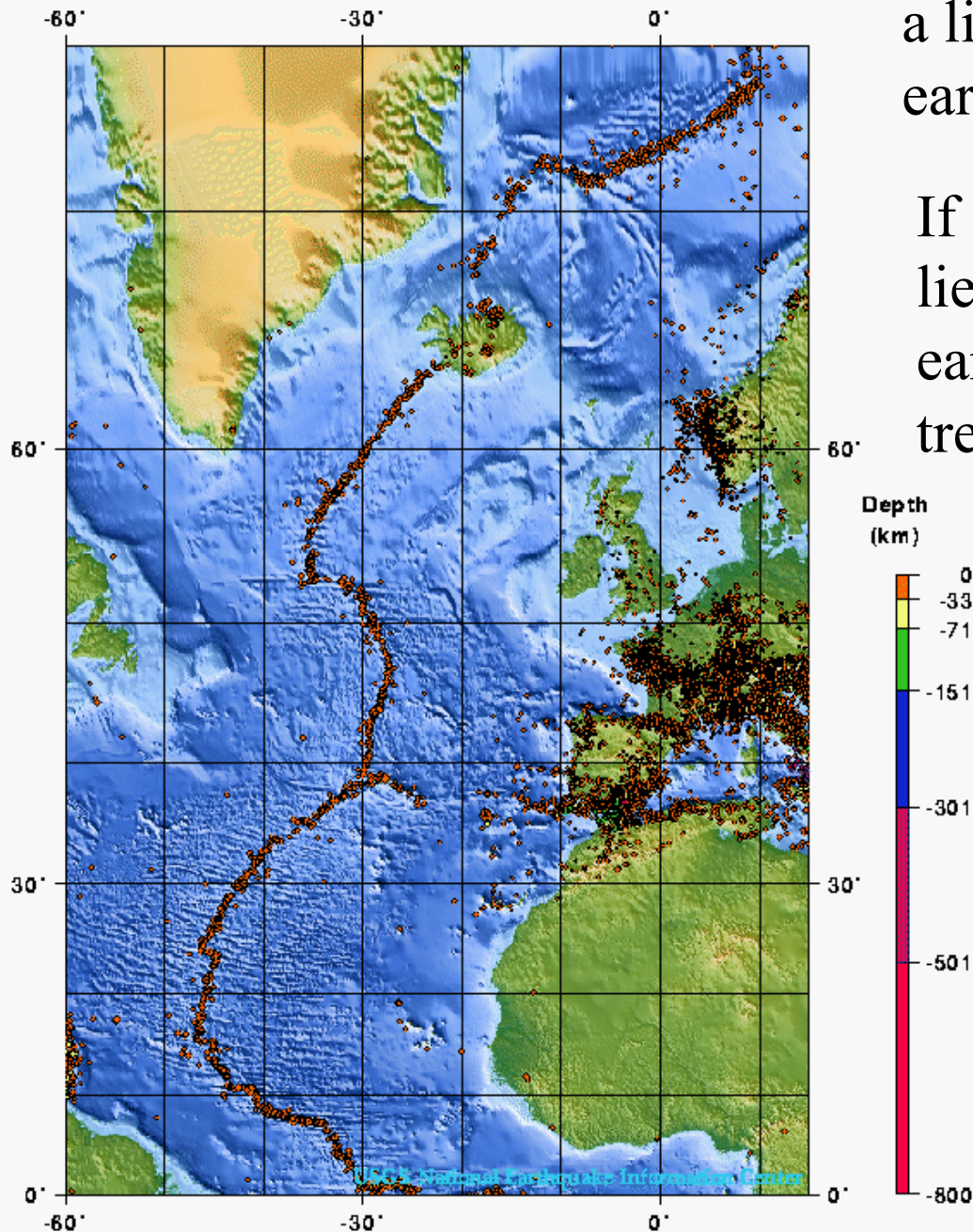


Earthquakes: 1964-1999



How steep is Subduction?

As seen on a map, the narrower the band of earthquakes on the map, the steeper the angle of subduction.

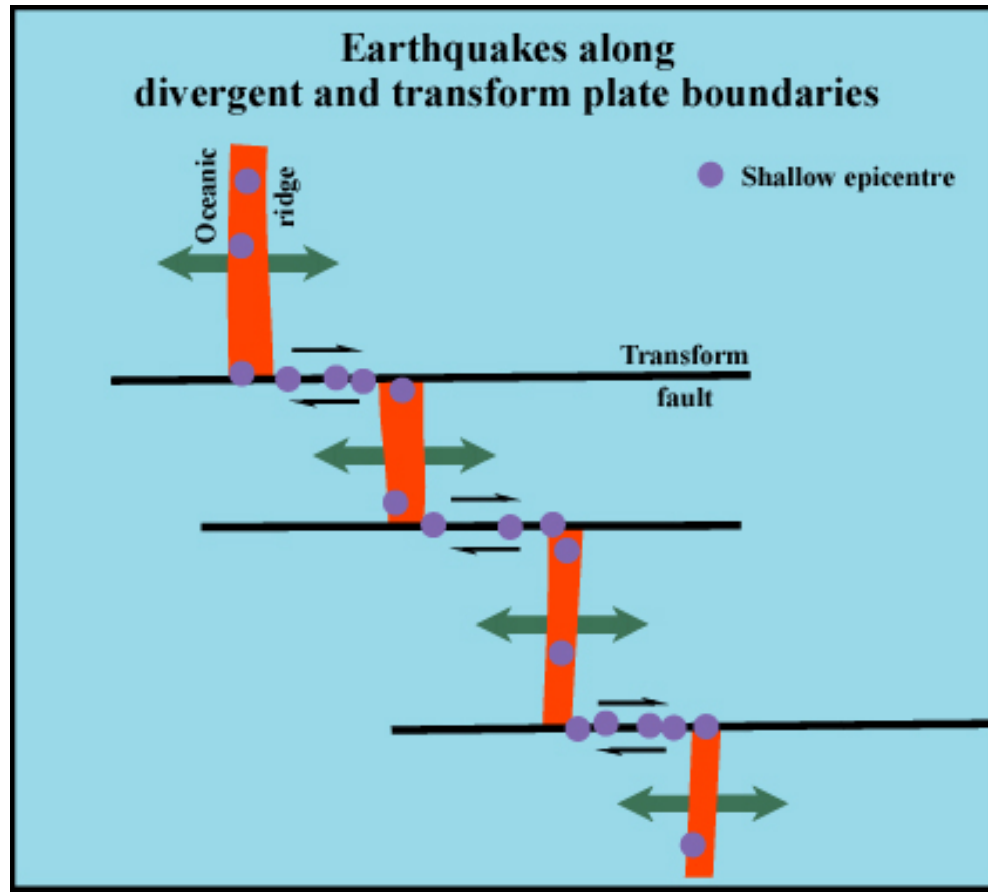


Oceanic ridges are delineated by a linear pattern of shallow earthquakes.

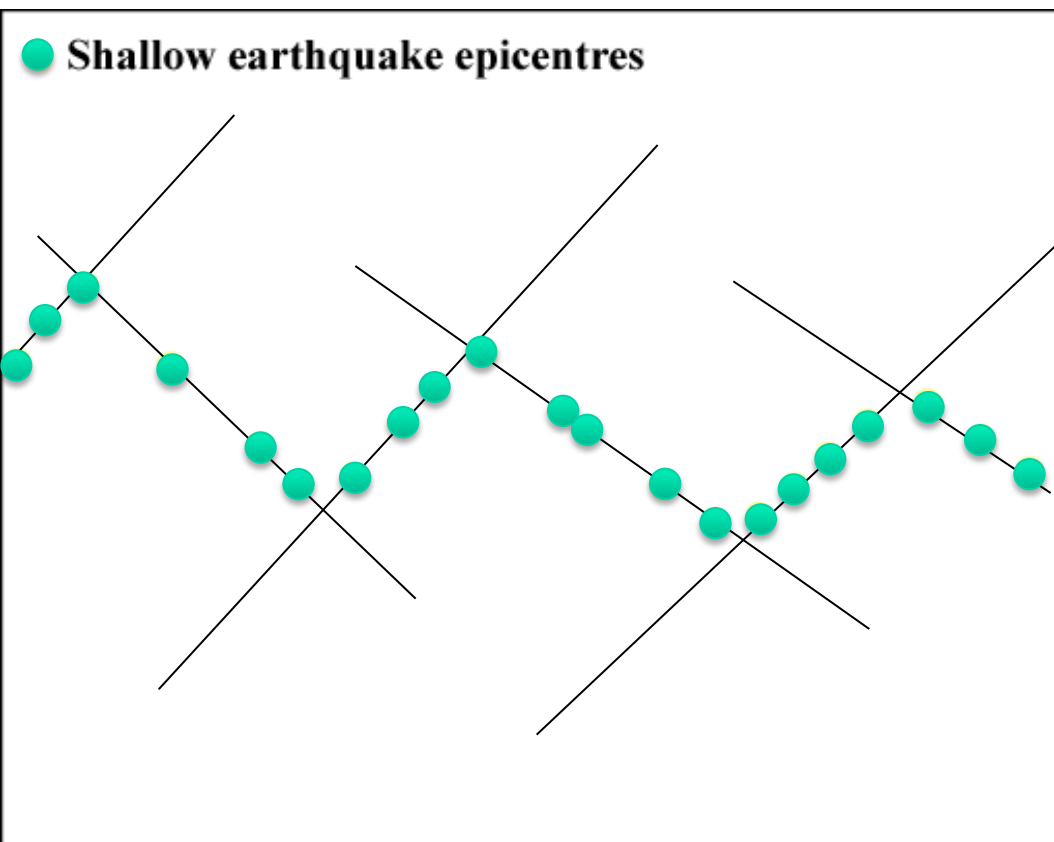
If deep or intermediate earthquakes lie parallel to the band of shallow earthquake, it is not a ridge, it is a trench.

Note that Iceland is a volcanic island that is a part of the North Atlantic Ridge.

Transform faults displace the oceanic ridge and these faults are also characterized by a linear pattern of shallow earthquakes.



Combined the ridge and transform faults form two approximately perpendicular trending linear patterns of shallow earthquakes.



The question is: which of the linear trends of shallow earthquakes is along the ridge and which is along transform faults?

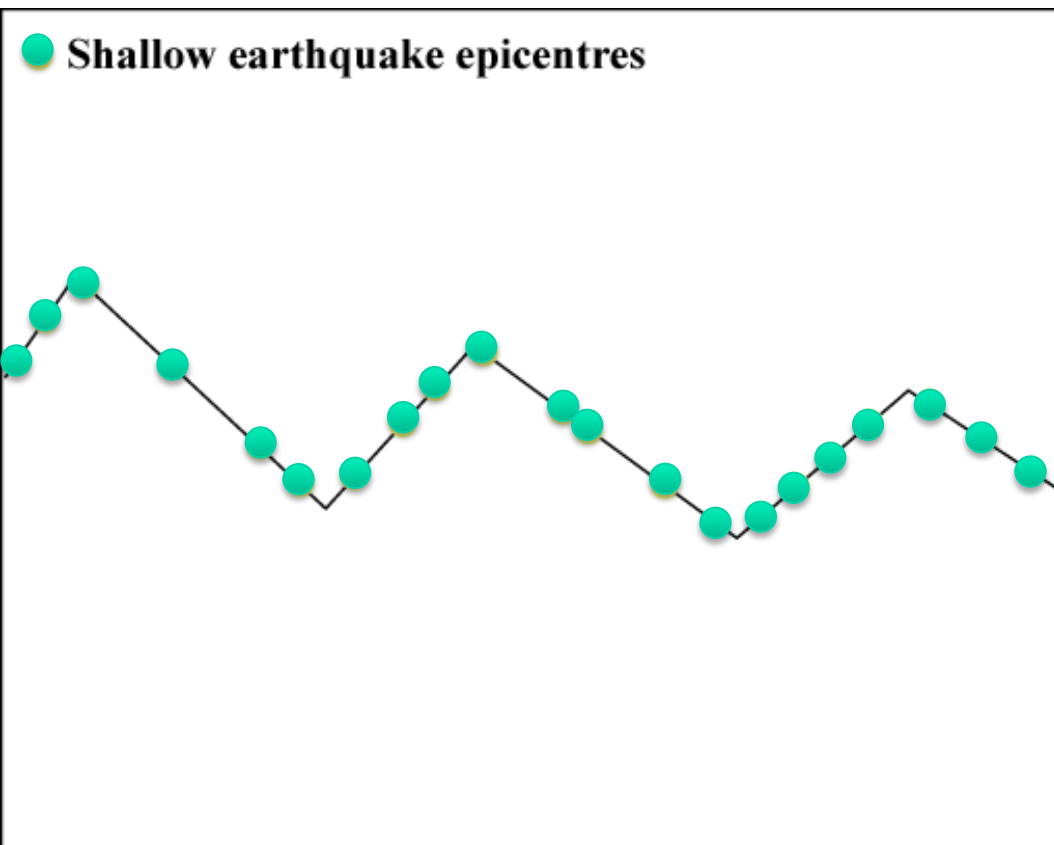
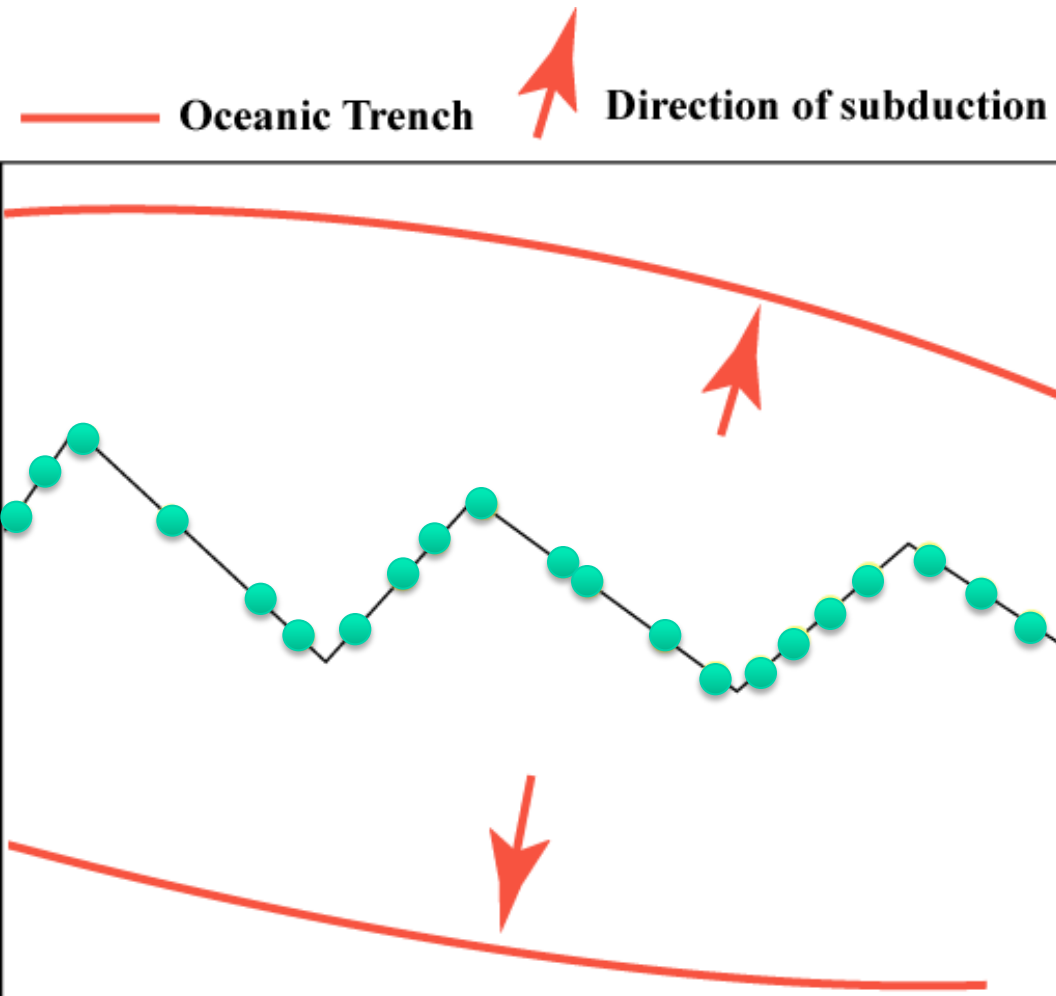
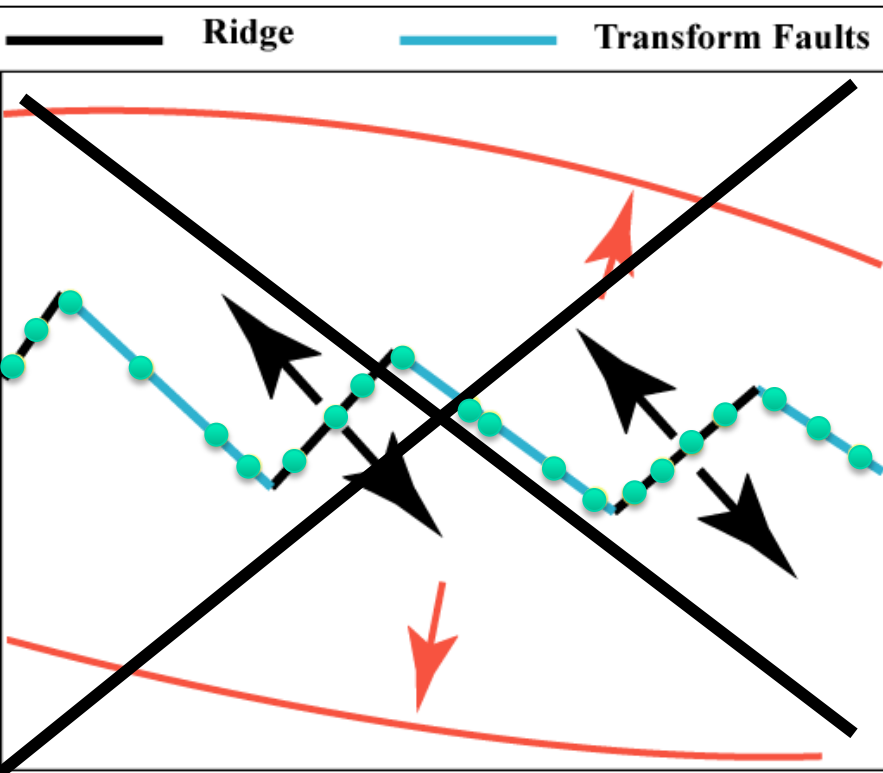


Plate movement is away from the ridge axis, in opposite directions on either side of the ridge.

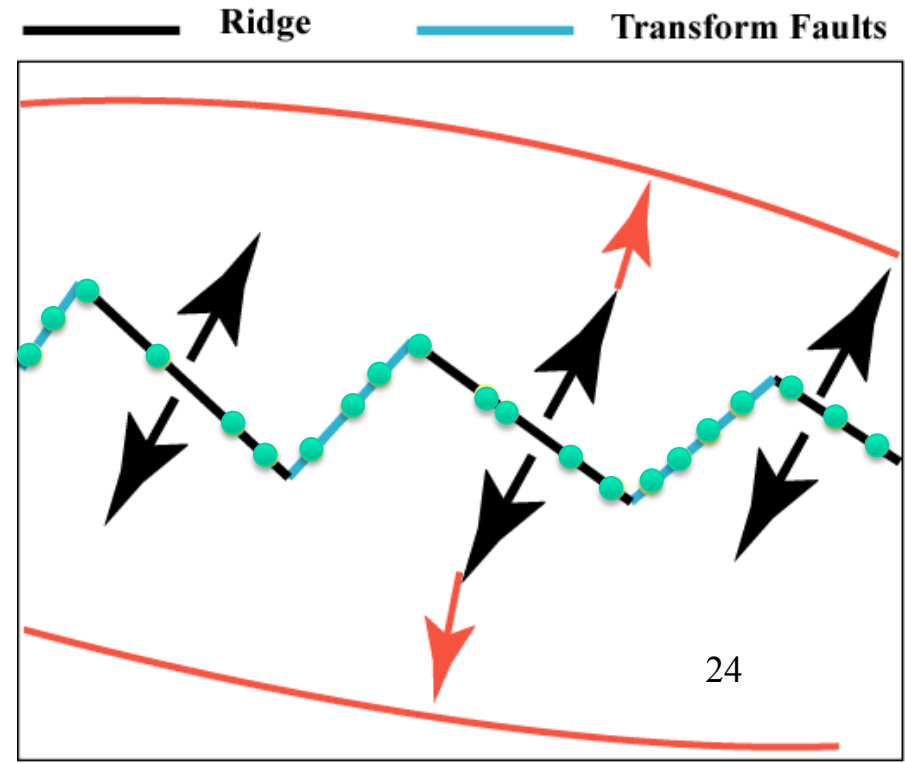
You know the direction of plate movement based on the location of the trenches so you can determine which linear trending shallow earthquakes represent the oceanic ridge.



Decide for yourself which of the following figures are correct based on the direction of plate movement.



OR



Remember:

Transform faults can pass through continents to connect ridges... where they form a linear pattern of shallow earthquakes.

Ridges do not pass through continents to connect transform faults.



The following information is broadly true of volcanoes:

Basaltic volcanoes: occur along oceanic ridges and away from plate boundaries as hot spot volcanoes on basaltic oceanic crust (e.g., Hawaiian Islands)

Andesitic volcanoes: found on parallel to oceanic trenches on the over-riding plate.

Granitic volcanoes: occur over hot spot volcanoes on continental crust.