Wadati-Benioff Zone

Was named after two seismologists **Hugo Benioff and Kiyoo Wadati.**

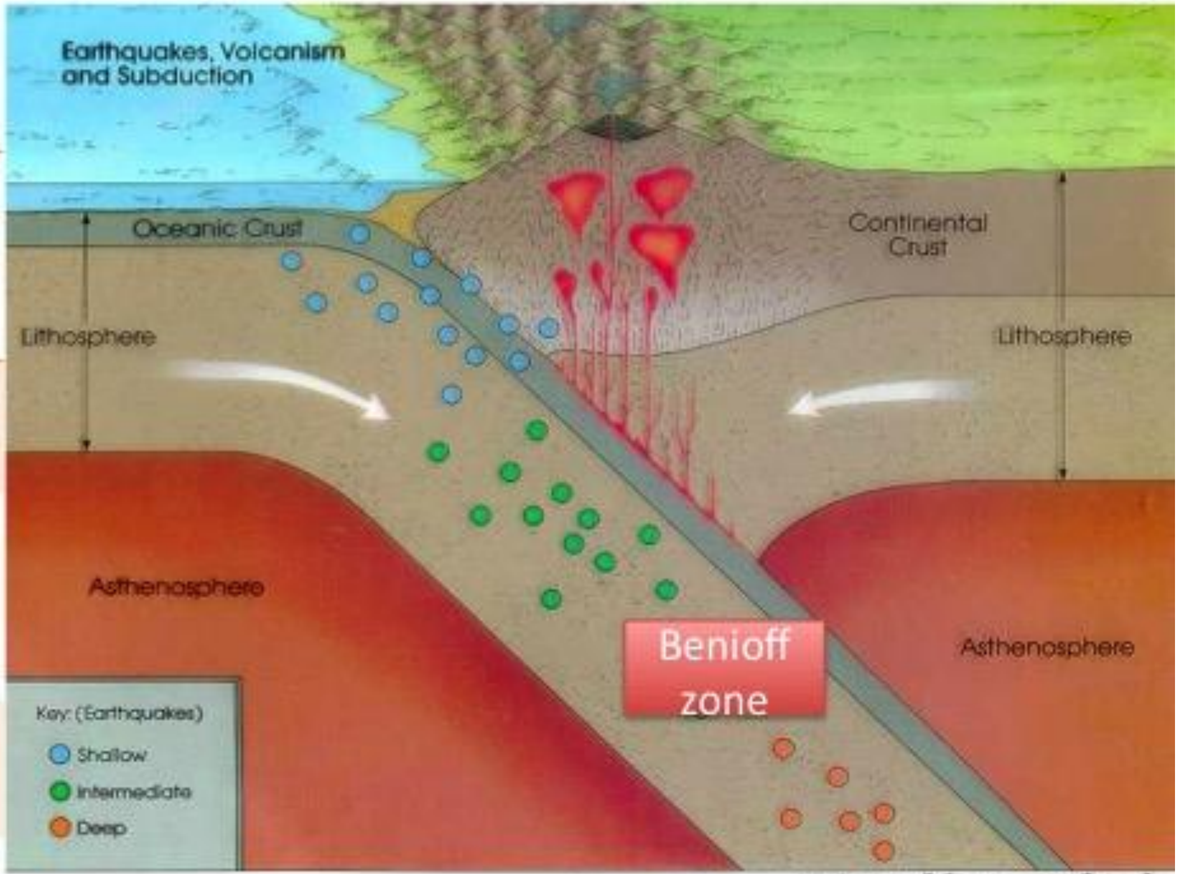
Known for deep-focus earthquake.

The zone of Seismicity corresponds to the down-going slab in a subduction zone.

The dip can be between 30° to 60°

The Benioff zone may extends from near surface to depths of up to 650-700 km.

Most of the earthquakes occur within 1000°C isotherm due to internal deformation and dehydration embrittlement of the subducting slab.



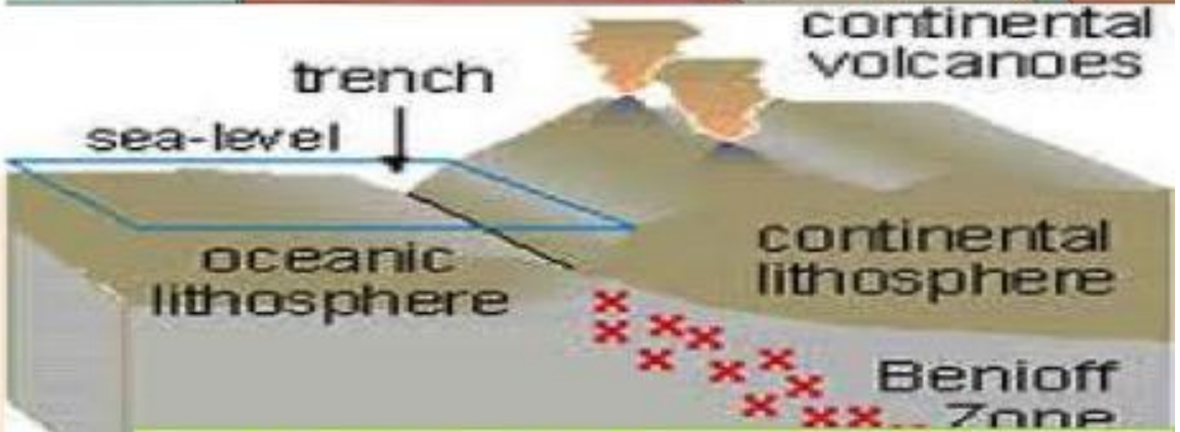
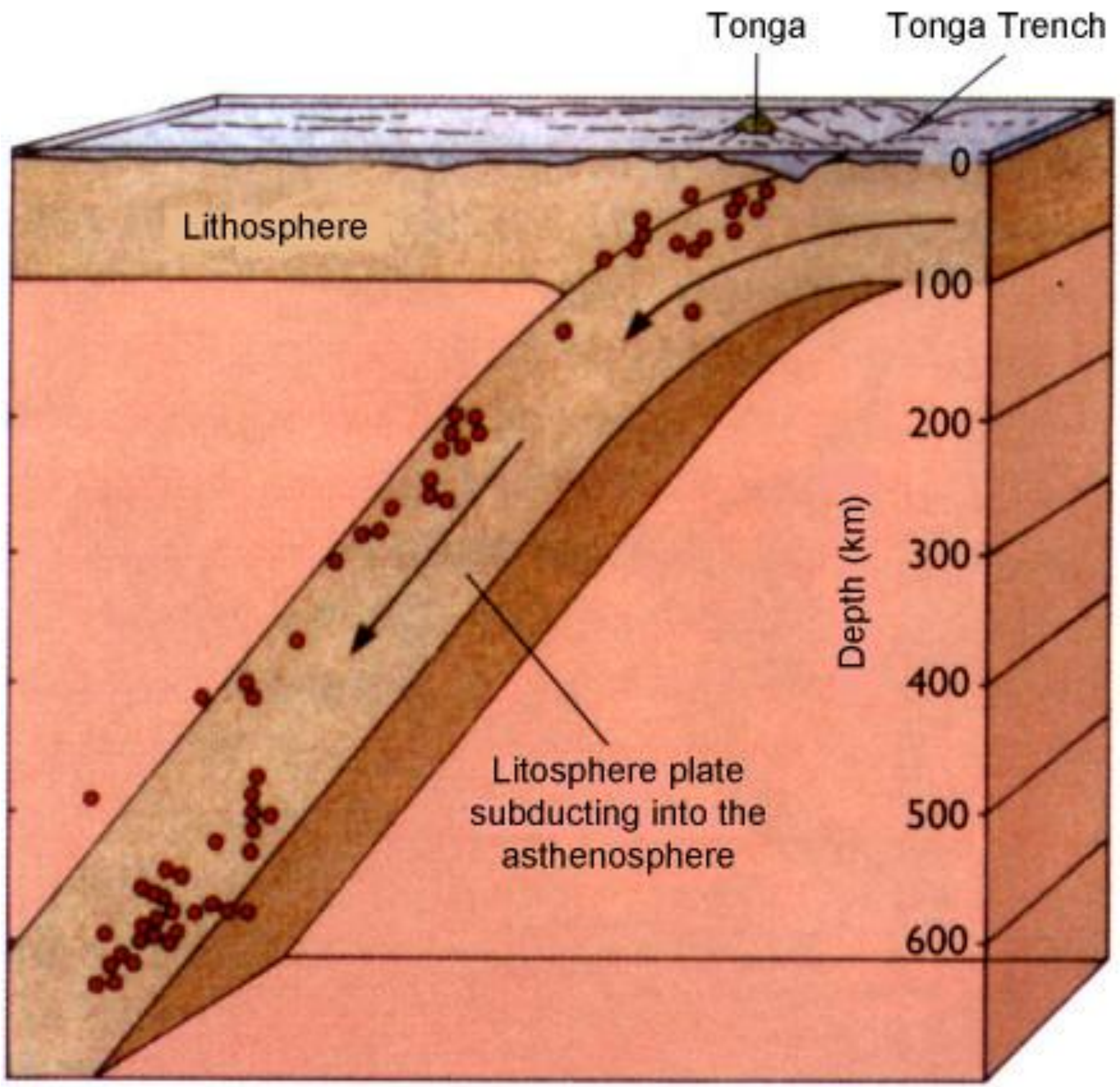
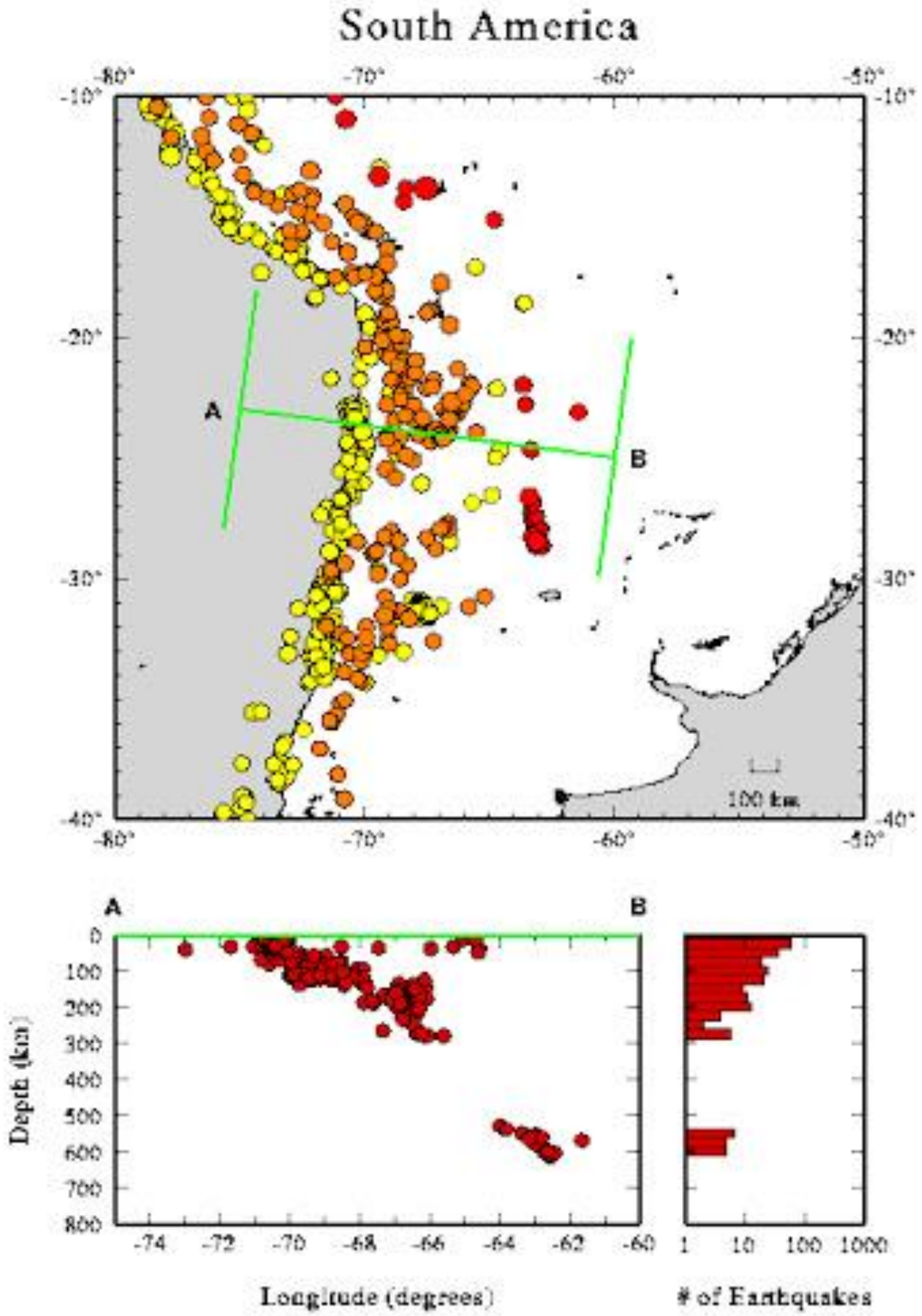
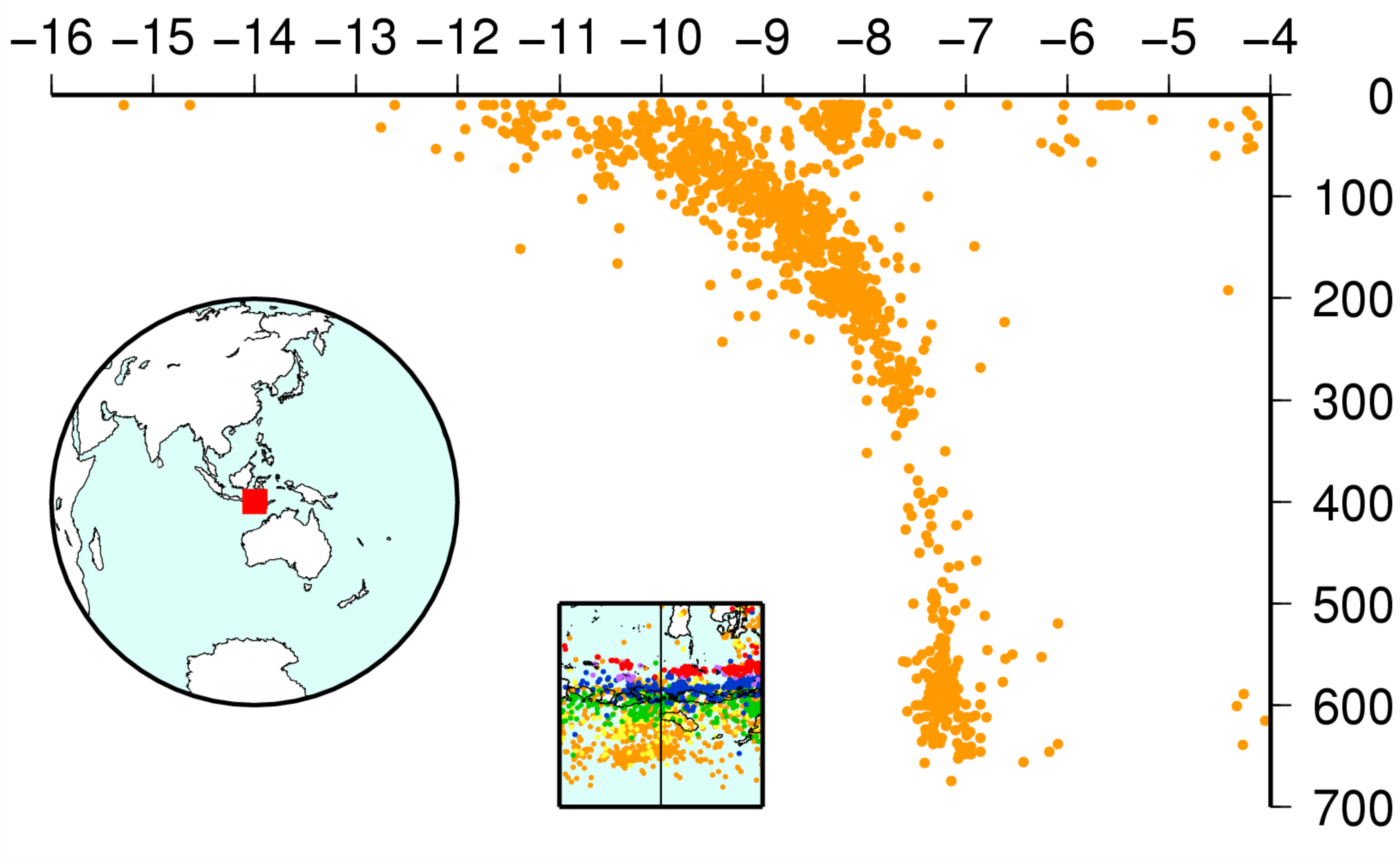


Diagram of Wadati-Benioff zone, from the United States Geological Survey

WADATI-BENIOFF ZONE



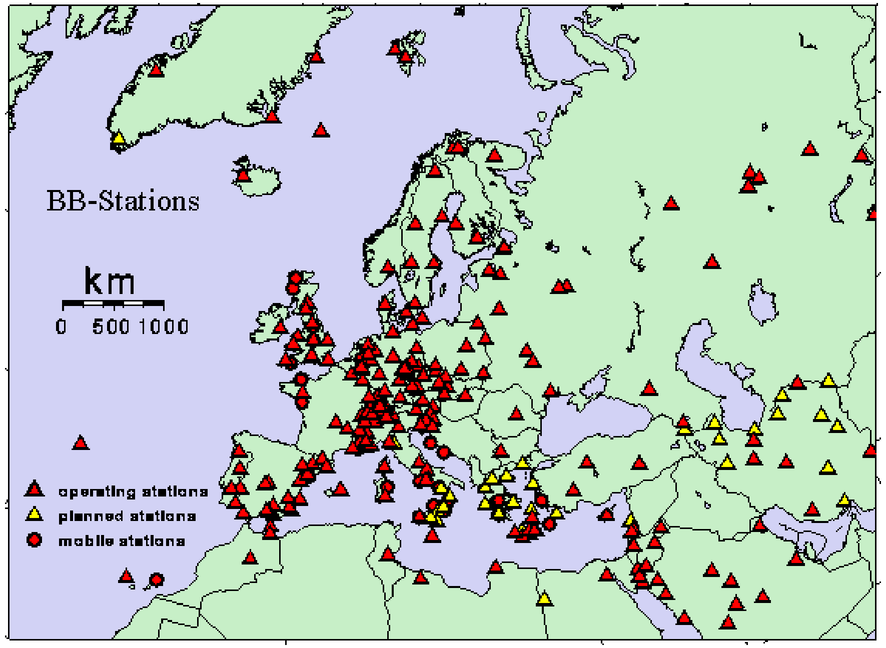




−16 −15 −14 −13 −12 −11 −10 −9 −8 −7 −6 −5 −4
0
100
200
300
400
500
600
700

Observational Seismology

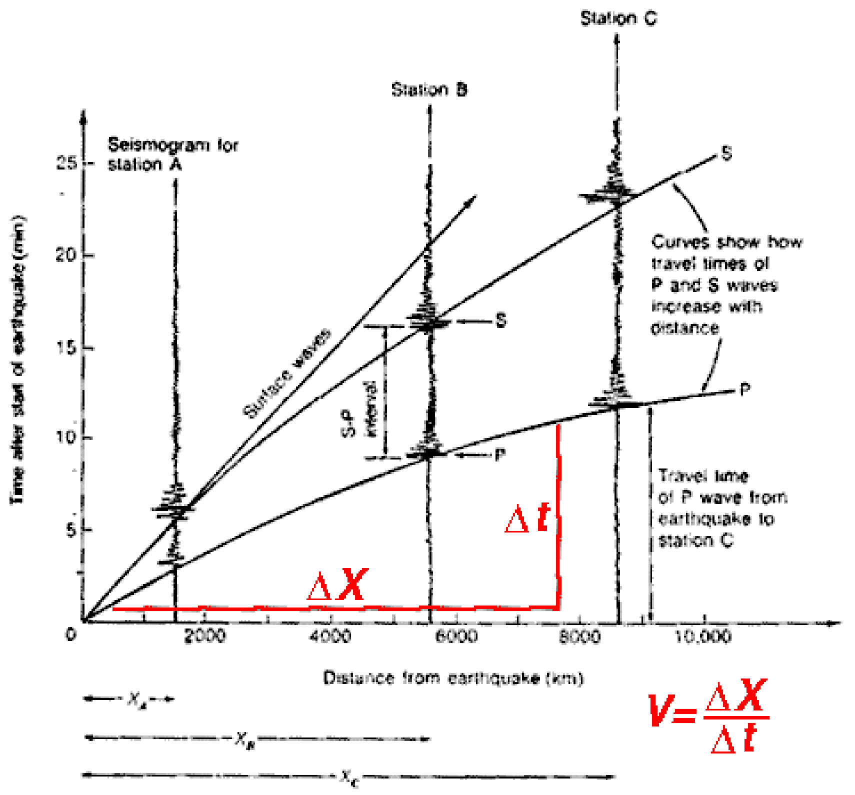
- We are now equipped to start recording and locating earthquakes. For that we need a seismic network of as many stations as possible.
- Minimal number of stations needed to locate the position of an earthquake epicentre is three.



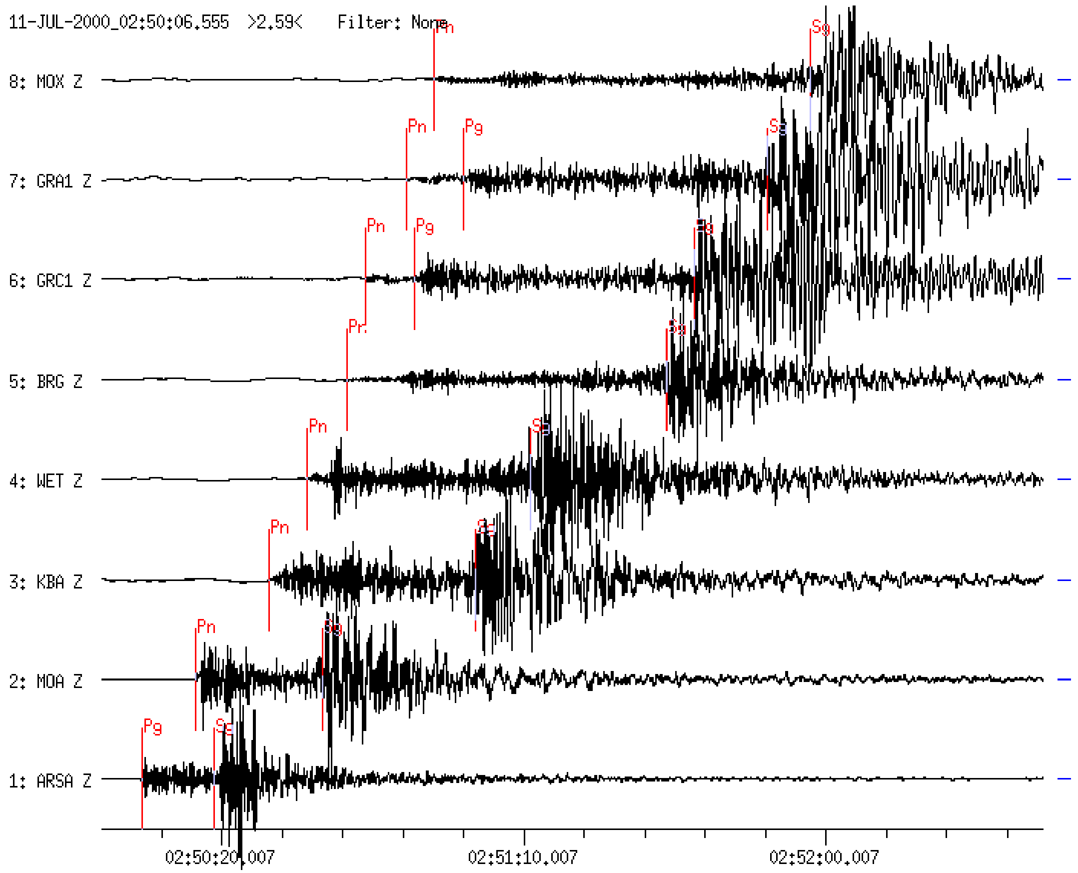
Broad-band seismological stations in Europe

Observational Seismology
Locating Earthquakes

- **Knowing the difference in arrival times of the two waves, and knowing their velocity, we may calculate the distance of the epicentre.**
- **This is done using the travel-time curves which show how long does it take for P- and S-waves to reach some epicentral distance.**



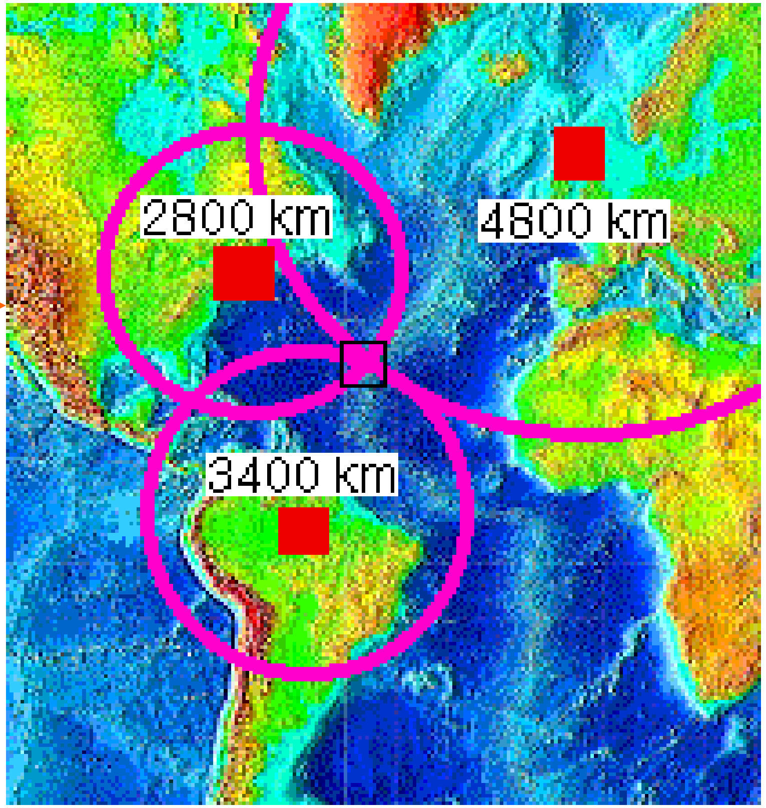
Observational Seismology
Locating Earthquakes



Another example of picking arrival times

Observational Seismology
Locating Earthquakes

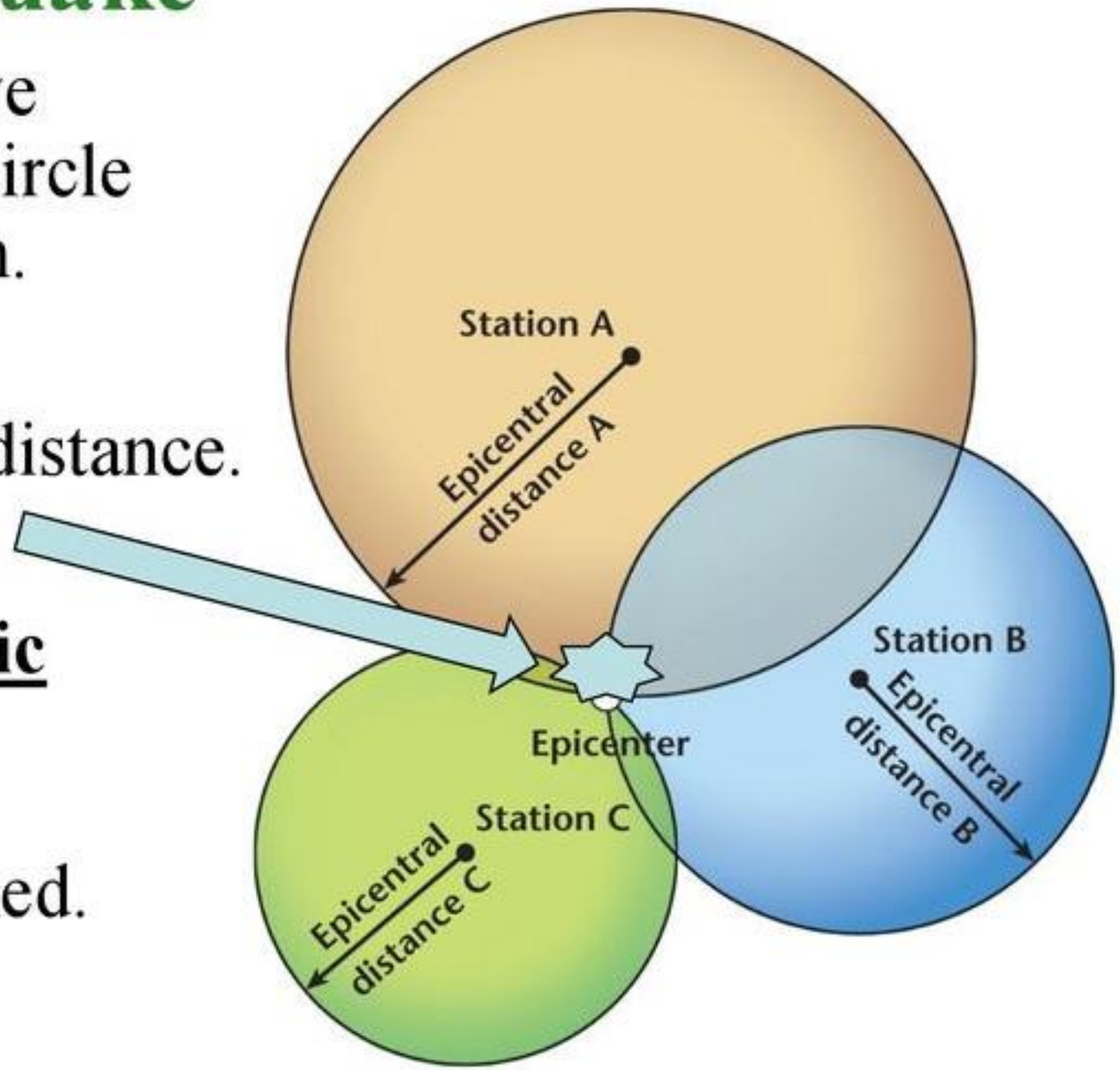
- After we know the distance of epicentre from at least three stations we may find the epicentre like this
- There are more sofisticated methods of locating positions of earthquake foci. This is a classic example of an *inverse problem.*



Locating an Earthquake

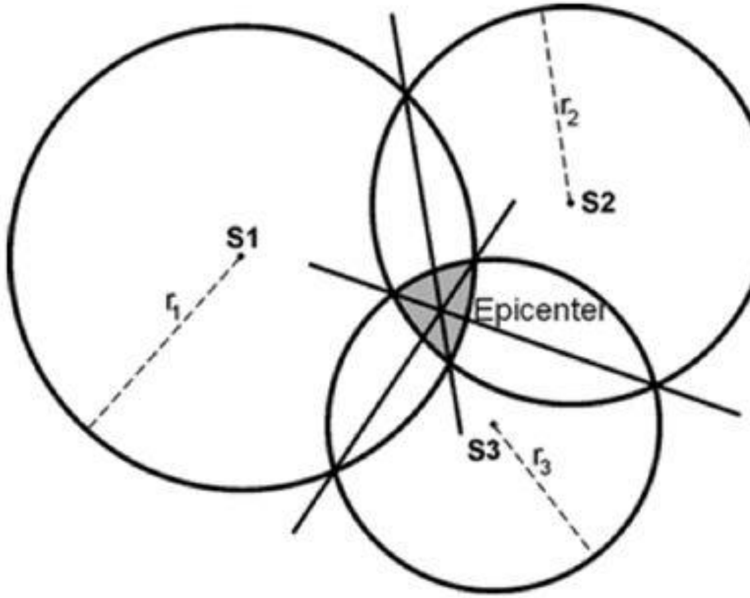
Distance to an Earthquake

- The earthquake could have occurred anywhere on a circle around the seismic station.
- The radius of the circle is equal to the epicentral distance.
- If the epicentral distances **<u>for three or more seismic stations</u>** are known, the exact location of the epicenter can be determined.



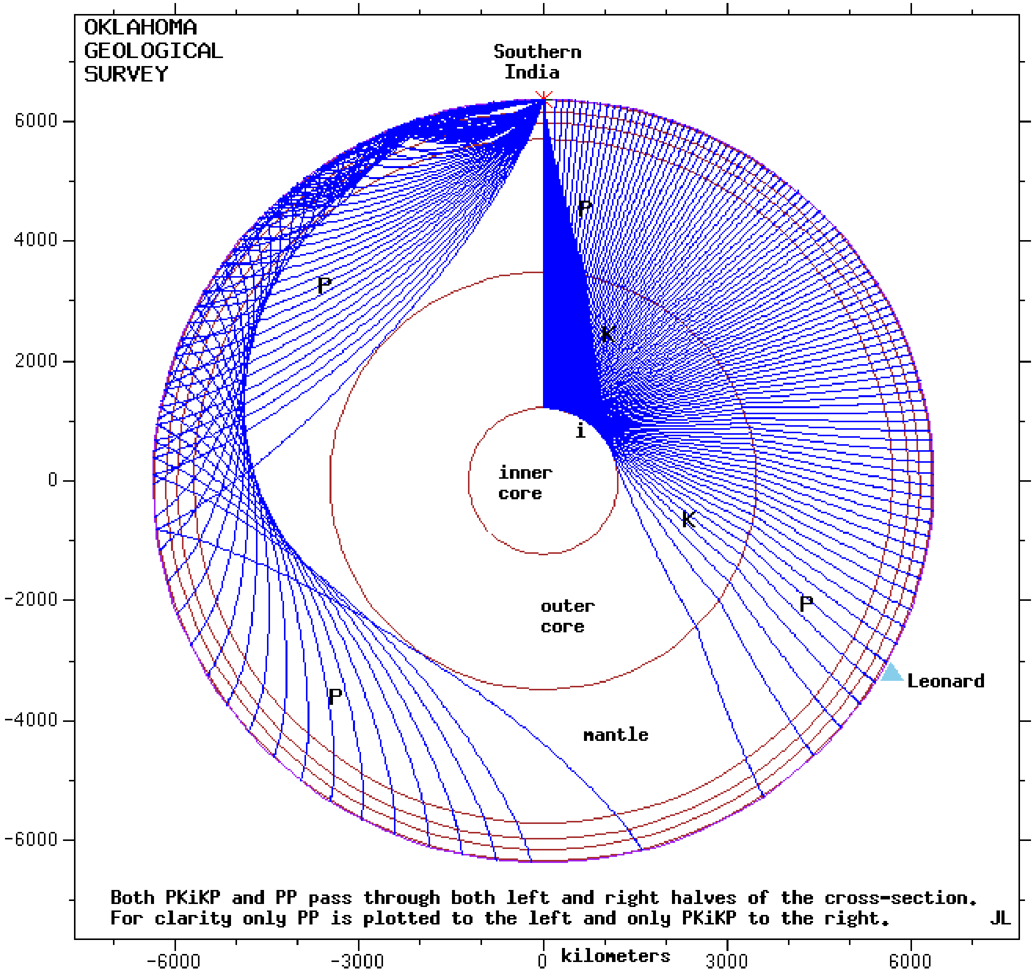
Location: Multiple station

With readings from at least 3 stations, a simple manual location can be from circle drawing, with the center of each station at the station location and the radii equal to the epicentral distances calculated from the S-P times

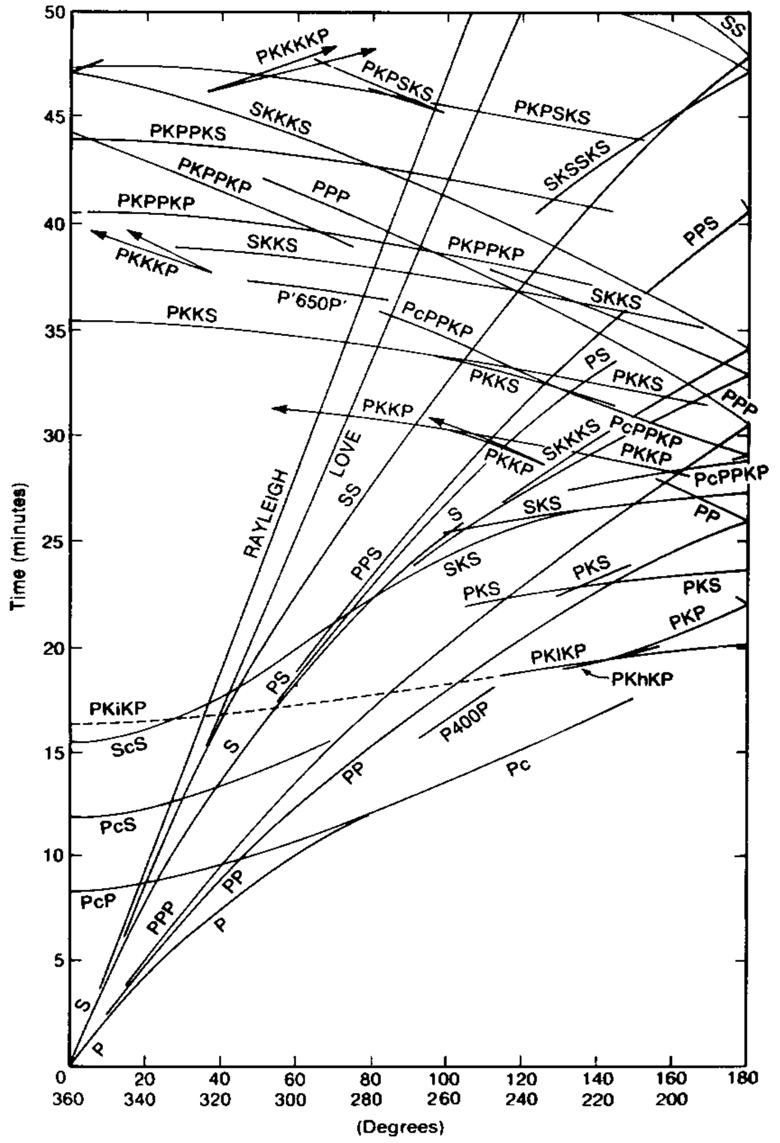


The circles drawn around the stations with radius that is set according to t_s-t_p will normally not be crossing at a single point, but rather “overshoot”.

‘Physical’ Seismology



Seismic waves get reflected, refracted and converted on many discontinuities within the earth thus forming numerous seismic phases. The rays also bend because the velocity of elsastic waves changes with depth.



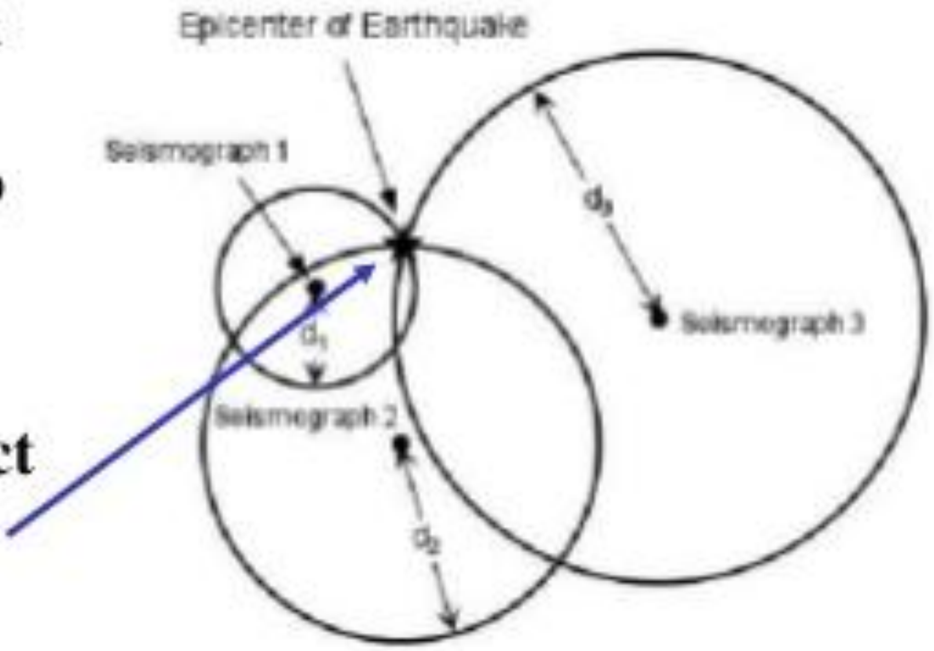
Locating the Epicenter

Step 4: Use Triangulation to Pin Point the Epicenter:

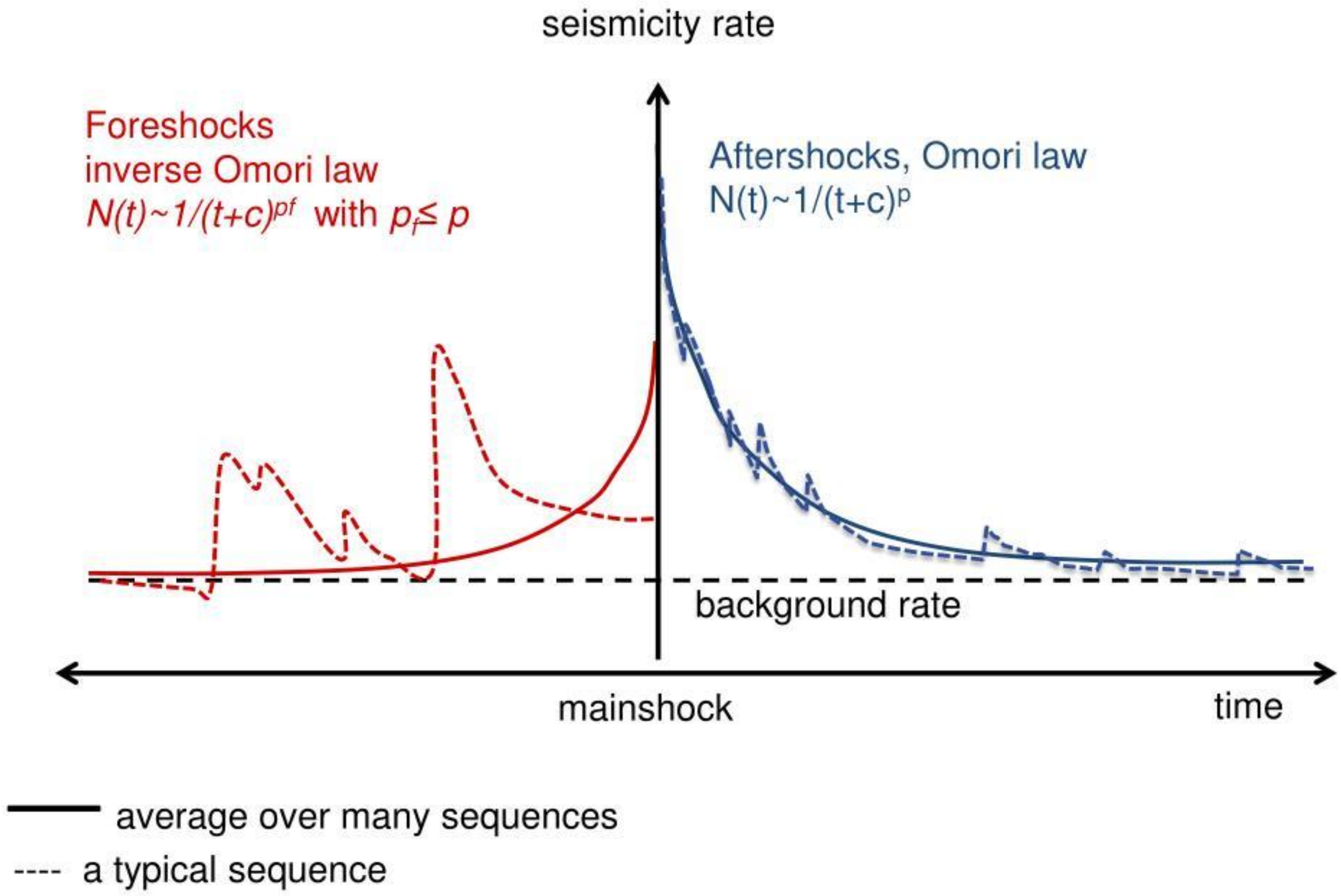
- **The distance to the epicenter from each seismograph station is;**
  Station #1 -- d_1 = 2500km
  Station #2 -- d_2 = 3500km
  Station #3 -- d_3 = 4500km

- **At each station we can draw a circle on a map that has a radius equal to the distance to the epicenter from each seismograph station.**

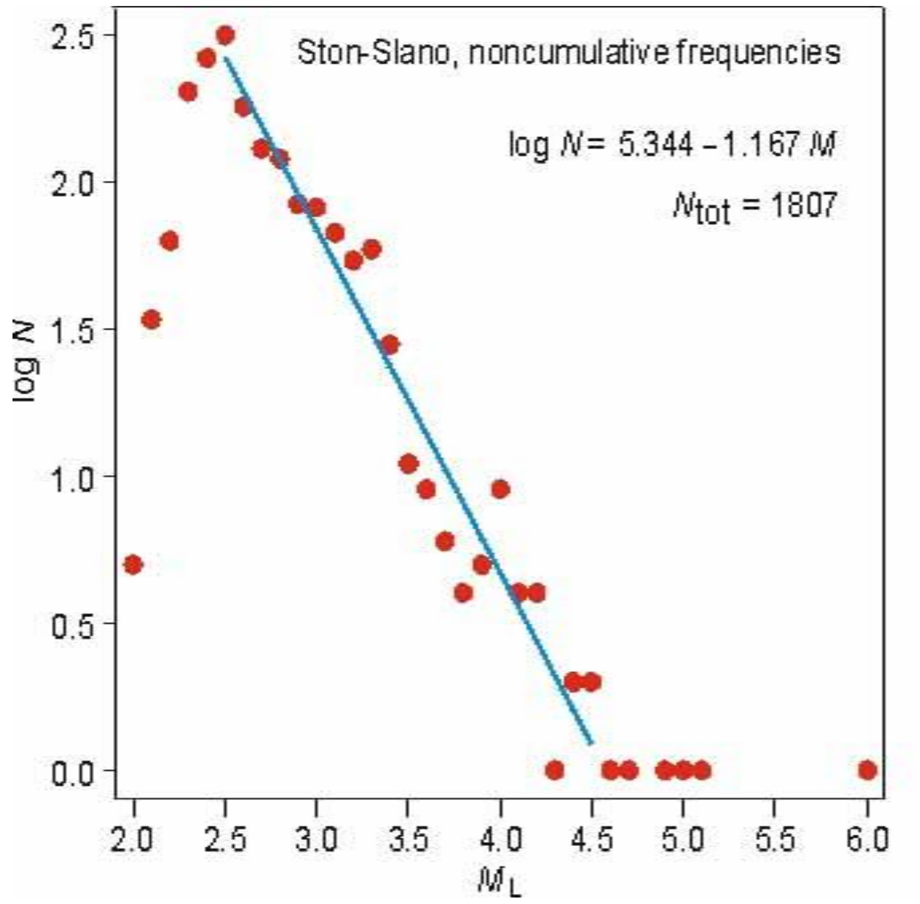
- **Three such circles will intersect in a point that locates the epicenter of the earthquake.**



“Foreshocks”, “mainshocks”, “aftershocks”



Observational Seismology
Some statistics

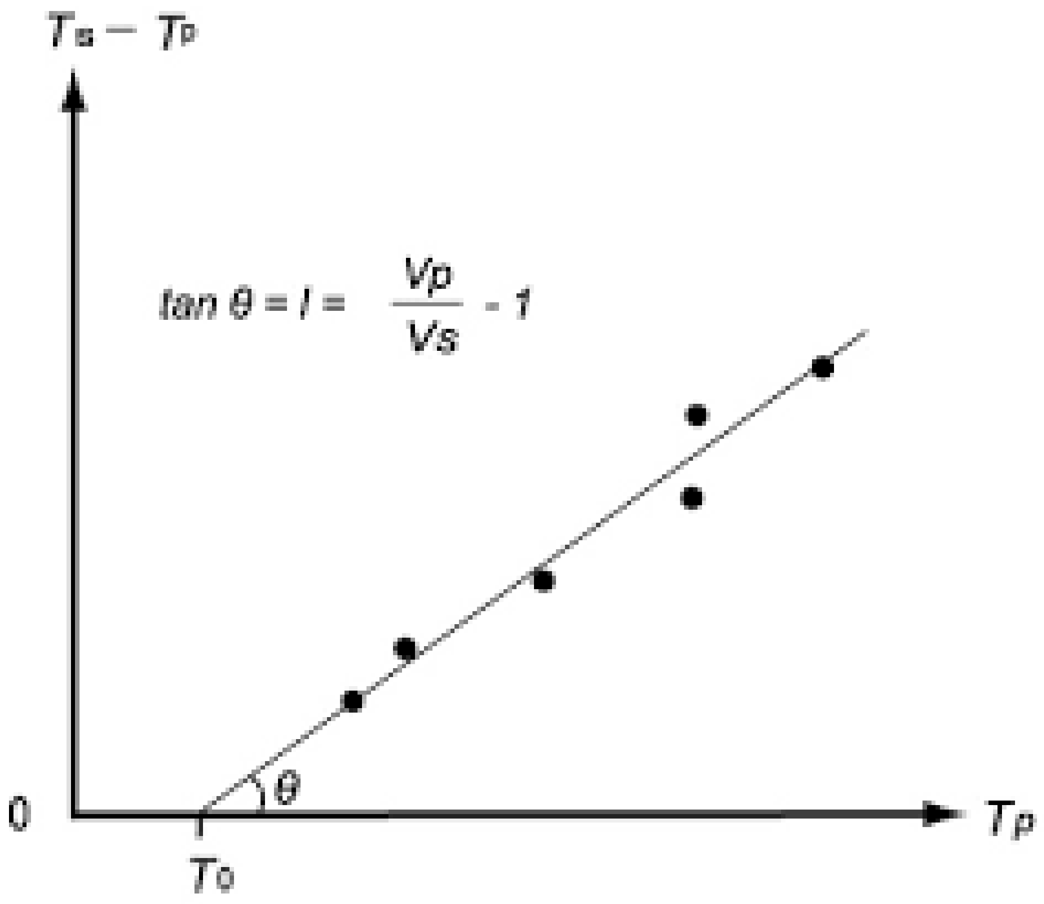


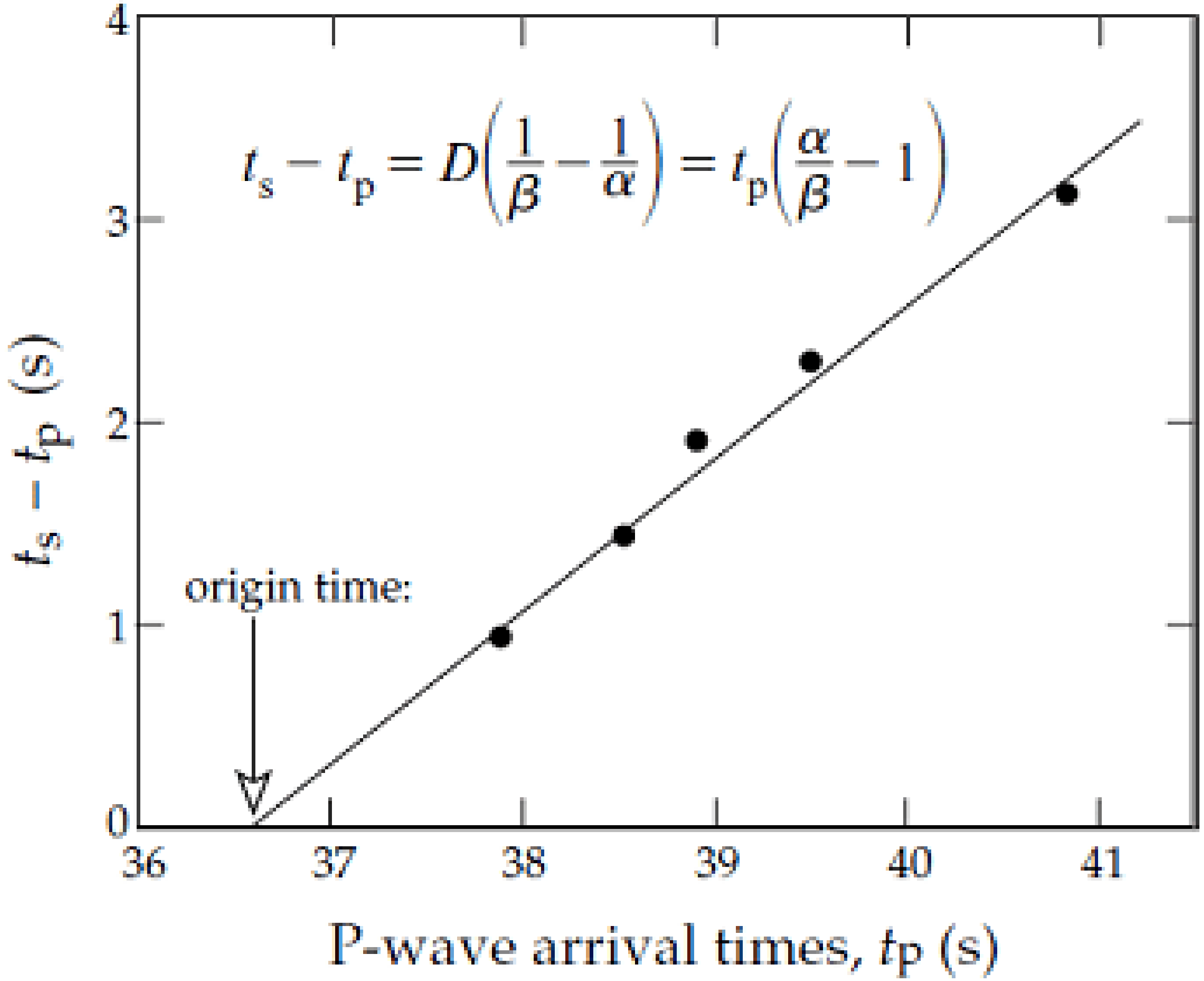
- **Gutenberg-Richter frequency-magnitude relation:**

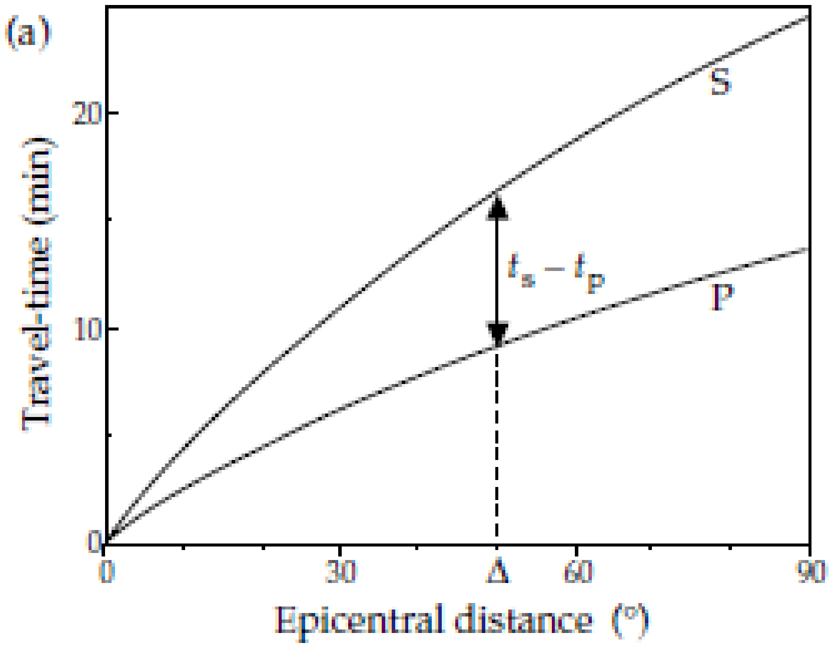
  $\log N = a - bM$

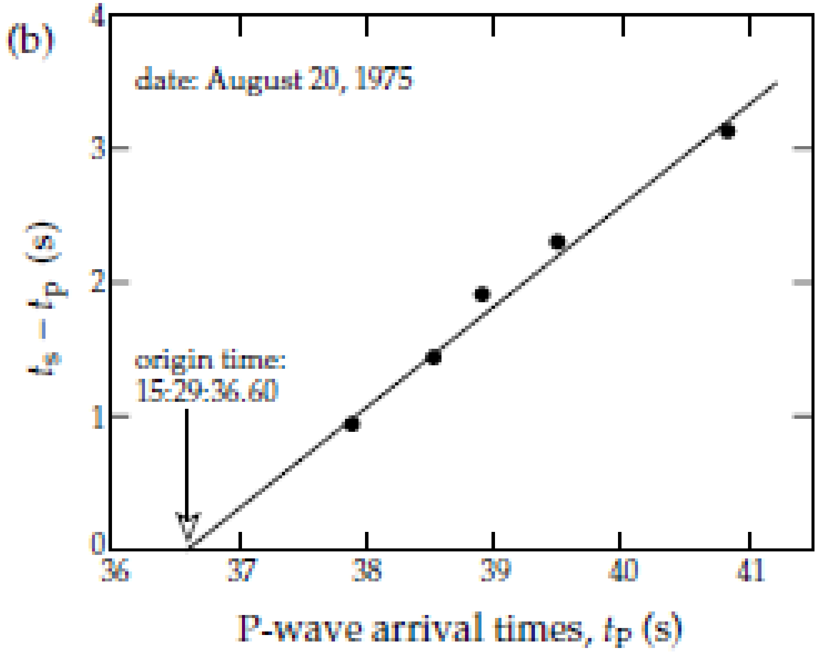
- b is approximately constant, $b = 1$ world-wide $\rightarrow$ there are ~10 more times M=5 than M=6 earthquakes
- **This shows selfsimilarity and fractal nature of earthquakes.**

WADATI DIAGRAM FOR COMPUTATION OF ORIGIN TIME









(a) Travel-times of P- and S-waves from an earthquake through the body of the Earth to an observer at epicentral distances up to 90°. The epicentral distance (Δ) of the earthquake is found from the difference in travel times ($\tau_s - \tau_p$).

(b) Wadati diagram for determining the time of occurrence of an earthquake.