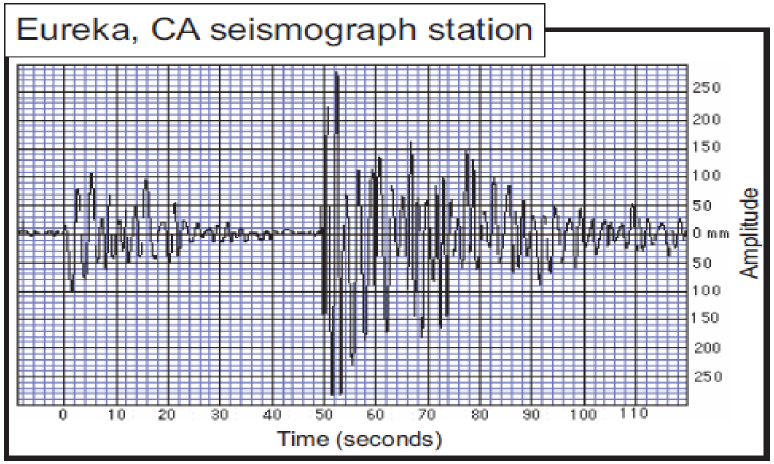
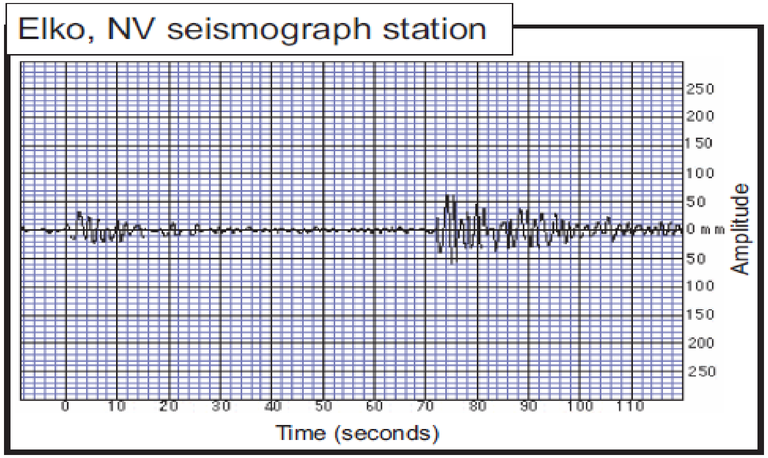
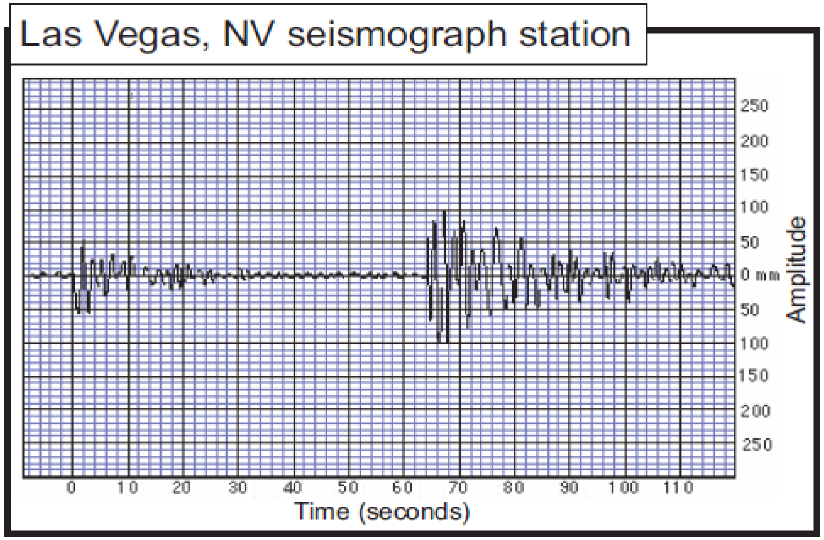
Seismology (G317)
Lab.NO.1

Locating Earthquake Epicenter

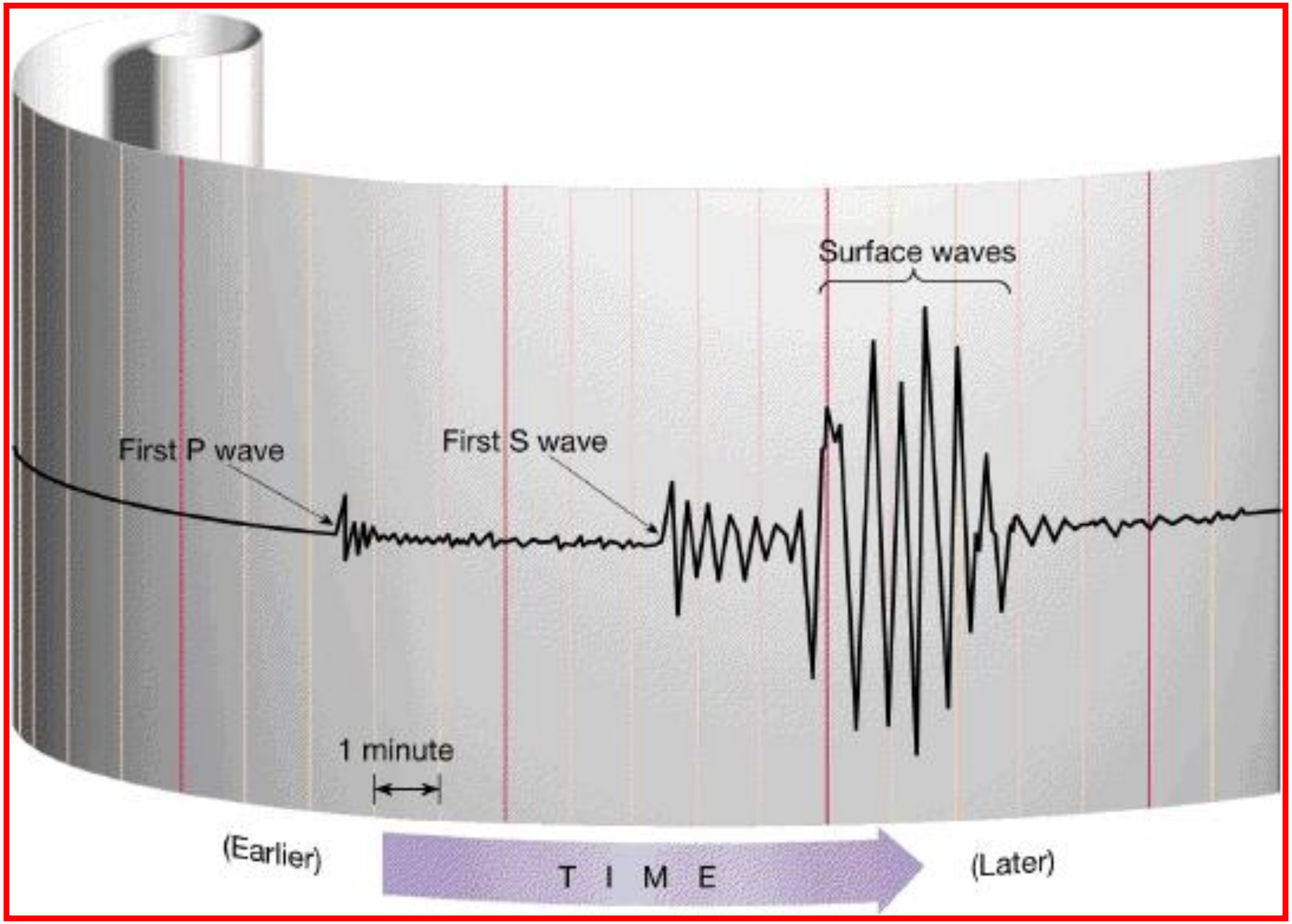
Q/ Determine the location of the earthquake that was recorded in the three seismograms below.







The Seismogram

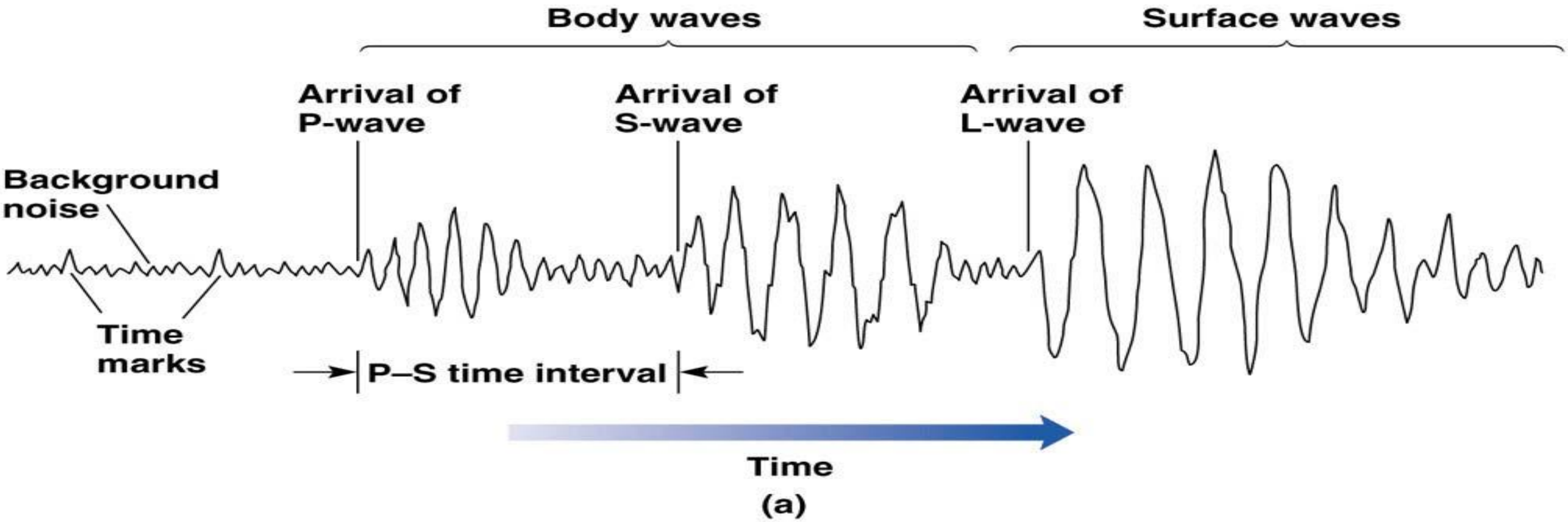


Seismic wave behavior:

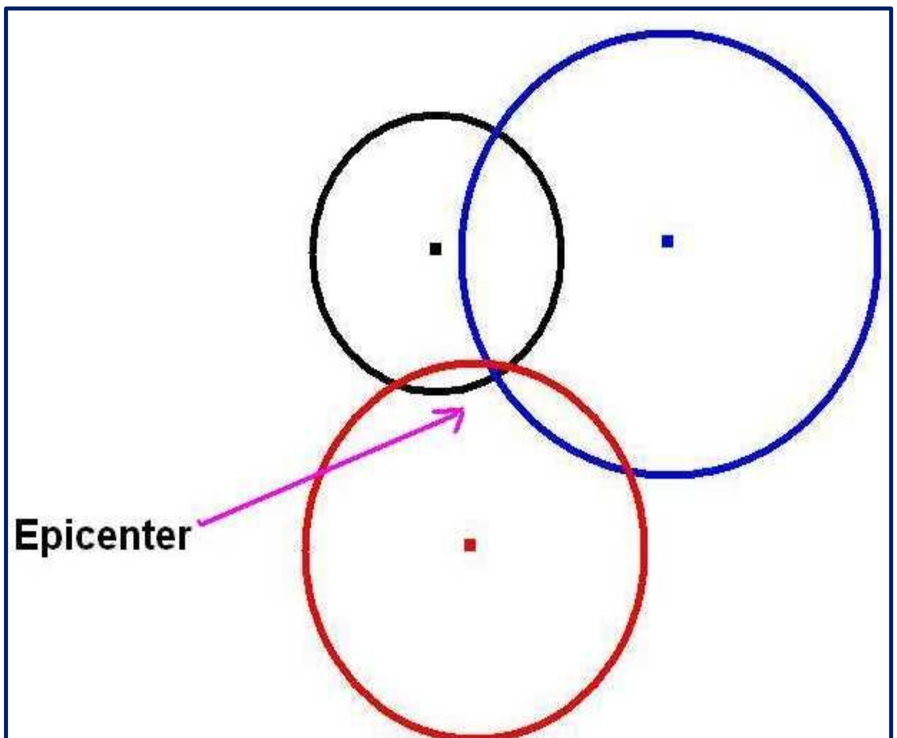
1- P waves arrive first, then S waves, then L and R.

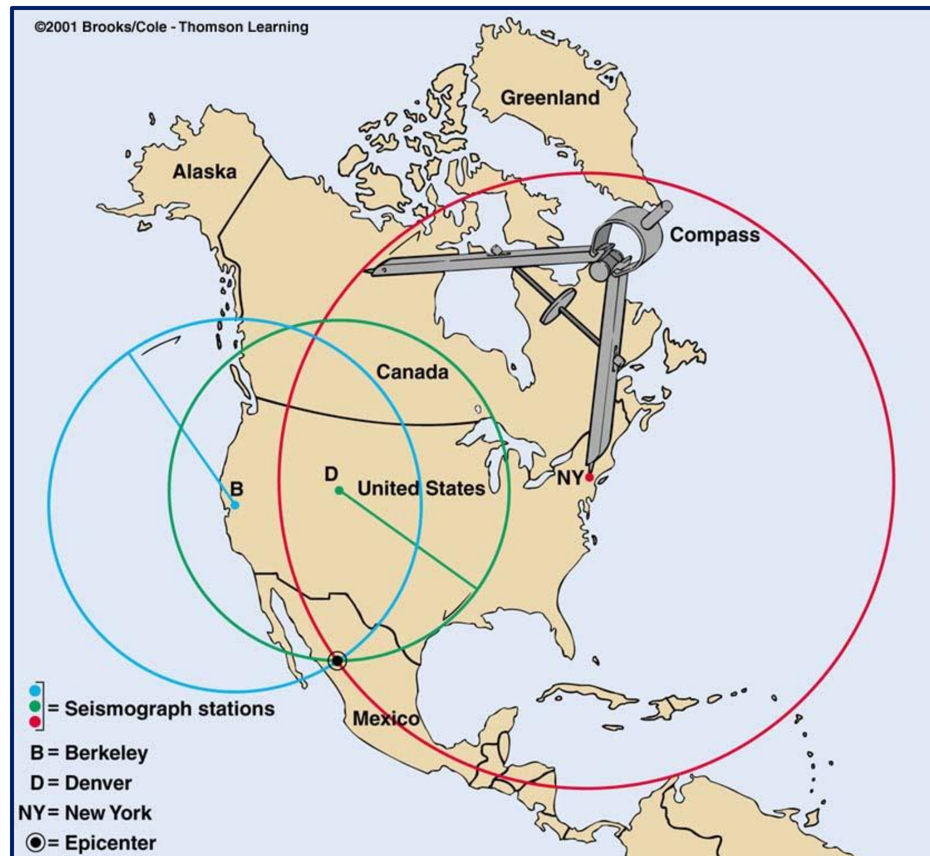
2- Average speeds for all these waves is known

3- After an earthquake, the difference in arrival times at a seismograph station can be used to calculate the distance from the seismograph to epicenter.



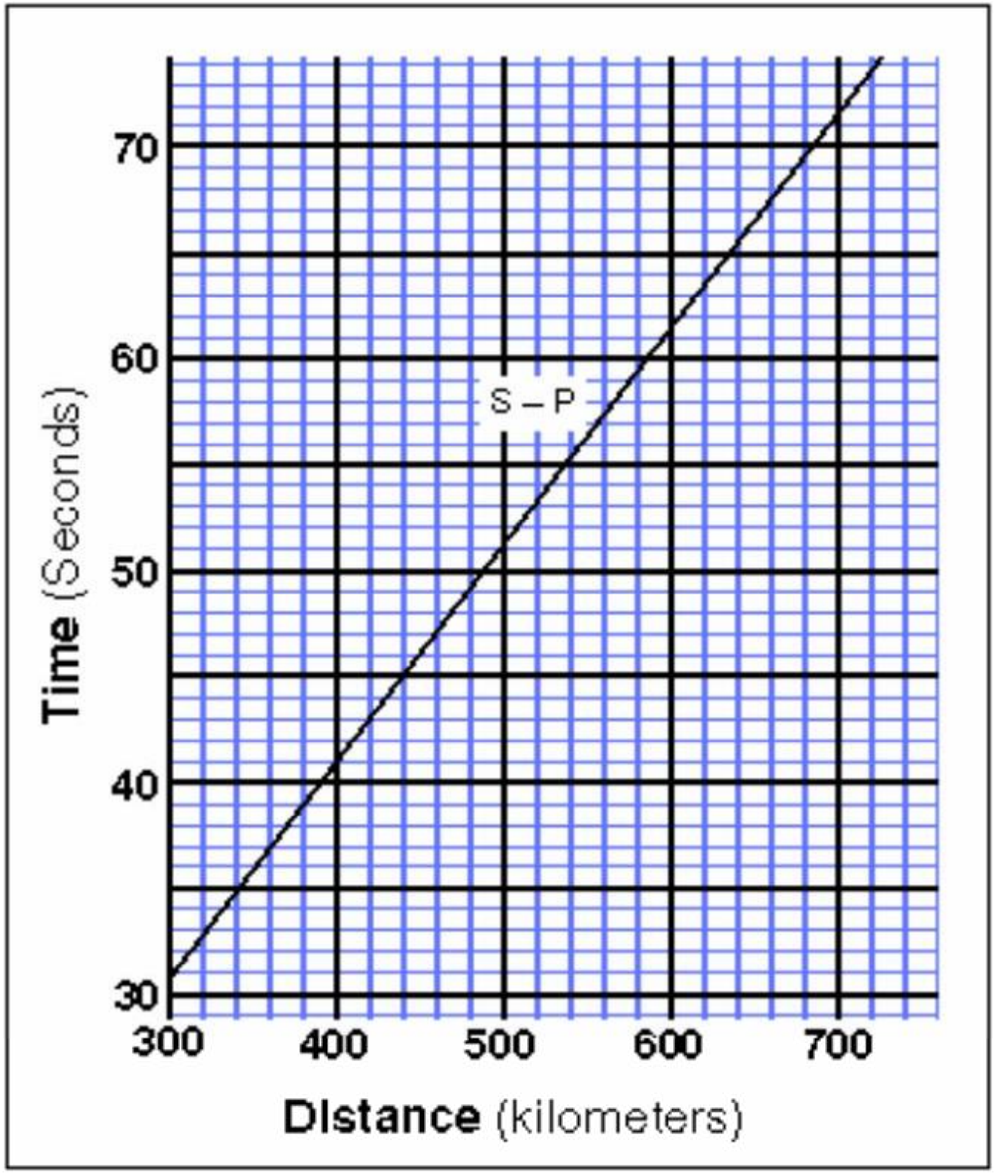
Triangulate or Triangulation : is the process of determining three location of a point **angles** to identify the epicenter. Where, the location of an earthquake's epicenter is found by plotting circles on a map from the records of three seismograph stations and finding the point where the three circles **intersect** (that means to use three positions to determine an exact location).





Solution Steps:

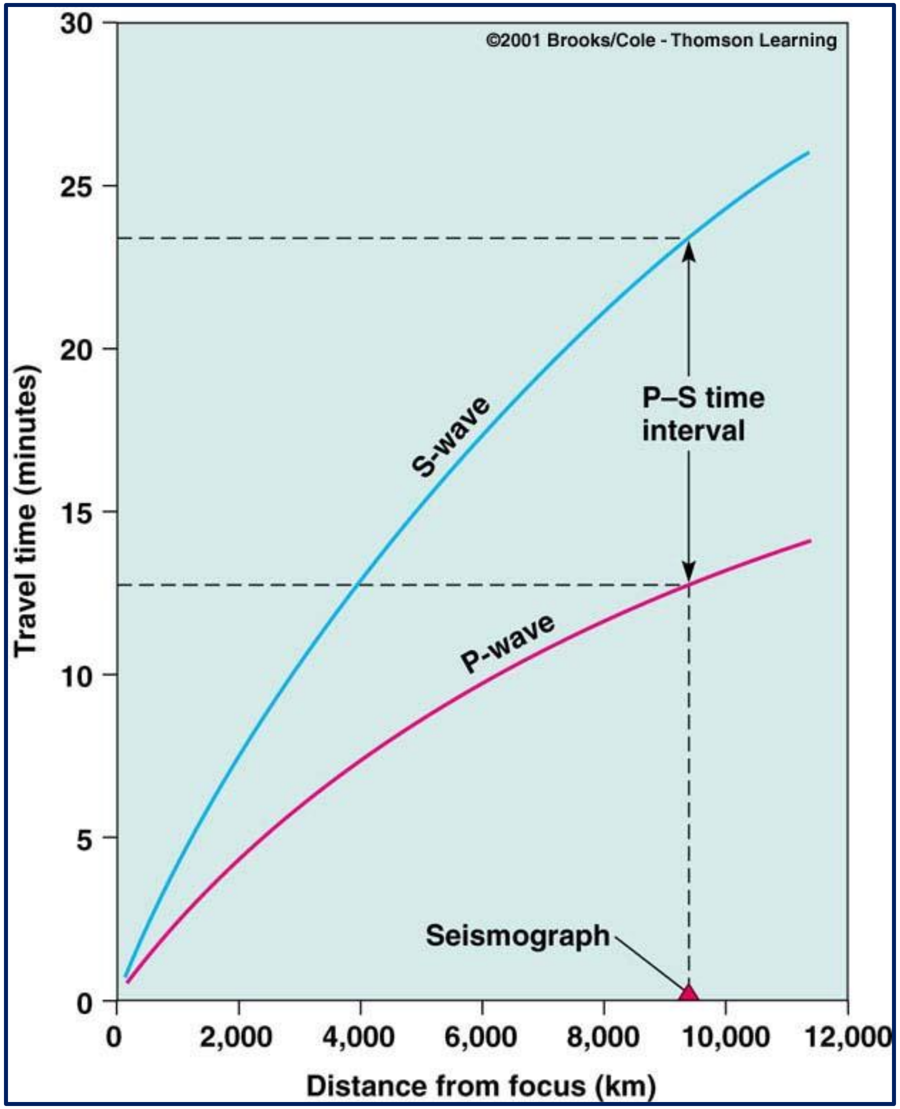
1. *Seismographs* record seismic waves.
2. From seismograph record called the ***seismogram***, measure **time** delay between P & S wave arrival.
3. Use **travel time curve** to determine **distance** to earthquake as function of P-S time delay .
4. Plot a circle around seismograph location; radius of circle is the distance to the earthquake.
5. Do the same thing for **at least 3 seismograph** stations; circles **intersect** at epicenter. Thus, point is triangulated and epicenter is located.


70
60
50
40
30
S – P
Time (Seconds)
300
400
500
600
700
Distance (kilometers)


OREGON
Klamath Falls
Boise
IDAHO
Eureka
Elko
Ogden
Reno
Sacramento
Salt Lake City
San Francisco
NEVADA
Provo
CALIFORNIA
Tonopah
UTAH
Fresno
Las Vegas
Bakersfield
ARIZONA
Los Angeles
San Bernardino
San Diego
Phoenix
Yuma
Miles
0 100 200 400 600
0 100 200 300 400 500 600 700
Kilometers

Station Name	Arrival Time P-wave (sec)	Arrival Time S-wave (sec)	Travel Time (sec)	Distance (km)
Eureka				
Elko				
Las Vegas				

Time-distance graph



Note:

If there is not any type of time-distance graph, you can calculate the distance from the following equation:

Velocity or Speeds =Distance / Time

(The speed is known in the question, for example, 100 km/sec)

Distance= Velocity * Time

Seismology (G317)
Lab.NO.2

Determine the Size and Strength of an Earthquake (The Magnitude)

First Method

Determining the magnitude of an earthquake:

Magnitude : is the measure of total amount of energy released by an earthquake.

There are several different ways to measure magnitude.

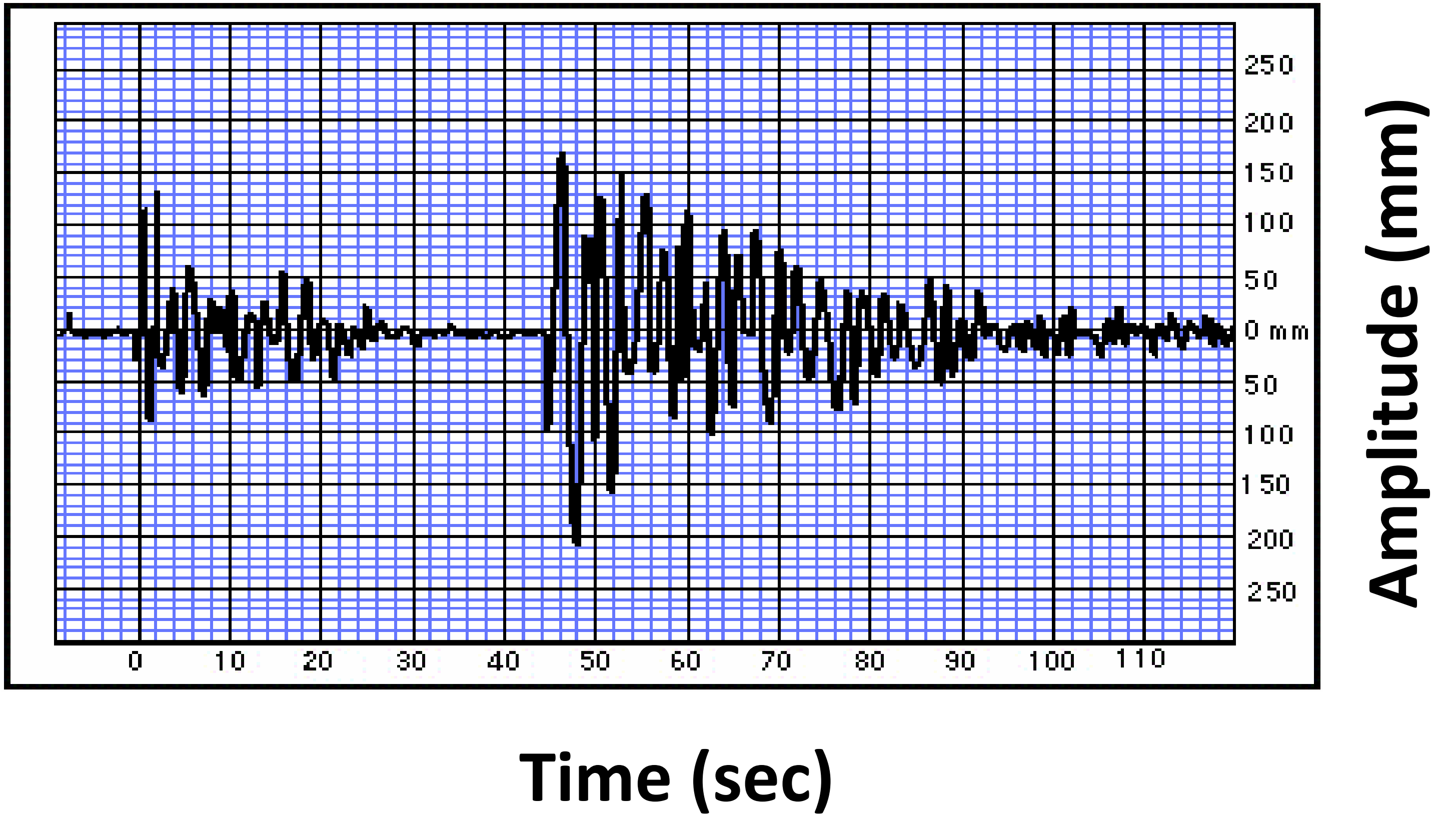
Most common magnitude measure is **Richter Scale**, named for the renowned seismologist, Charles Richter.

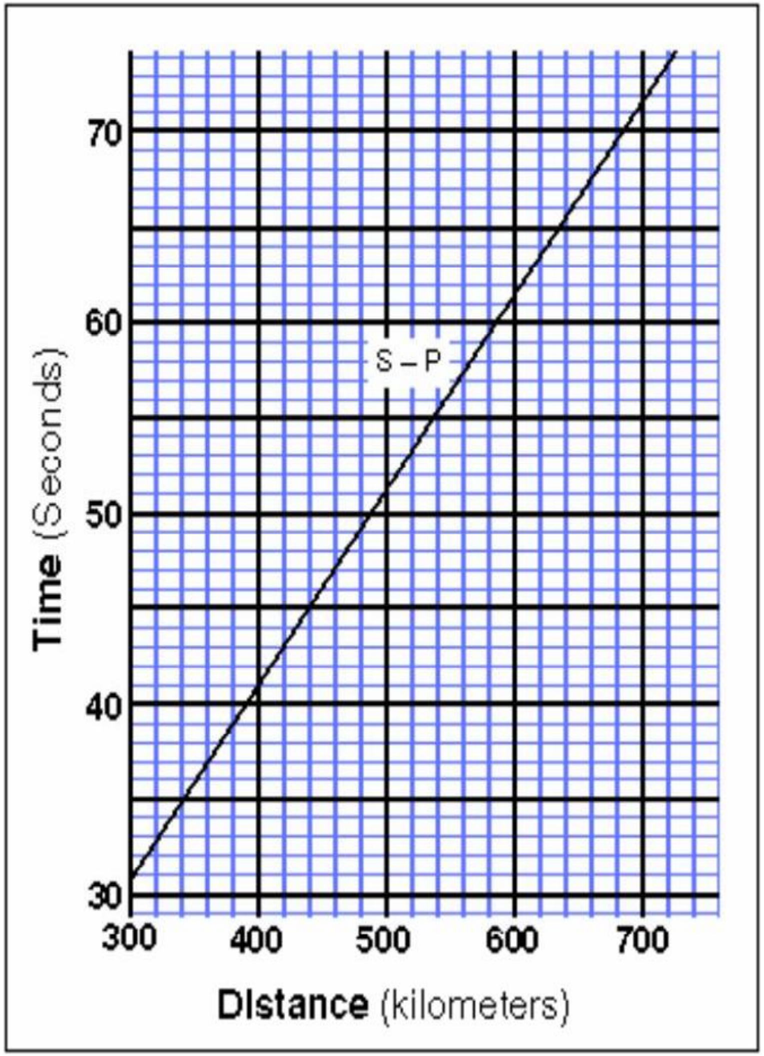
Richter Magnitude

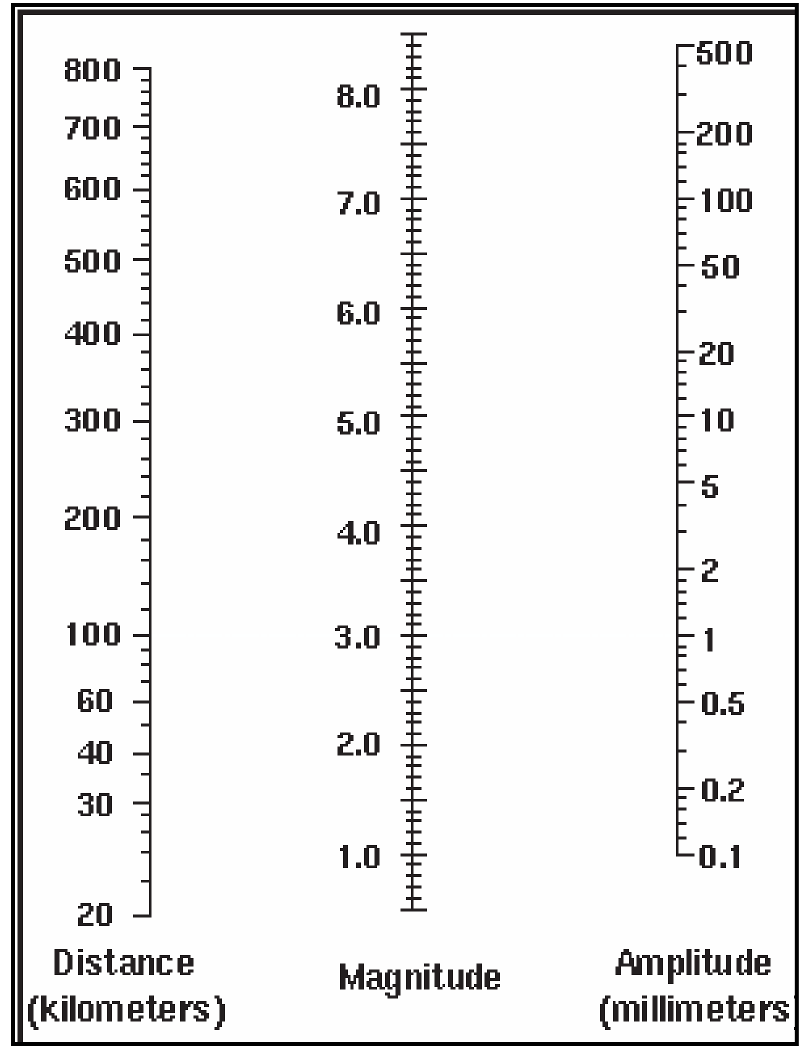
*Measure **amplitude** of largest S wave on seismograph record.

Intensity: refers to the amount of damage done in an earthquake.

Q/ Determine the magnitude of an earthquake that was recorded in seismogram below.

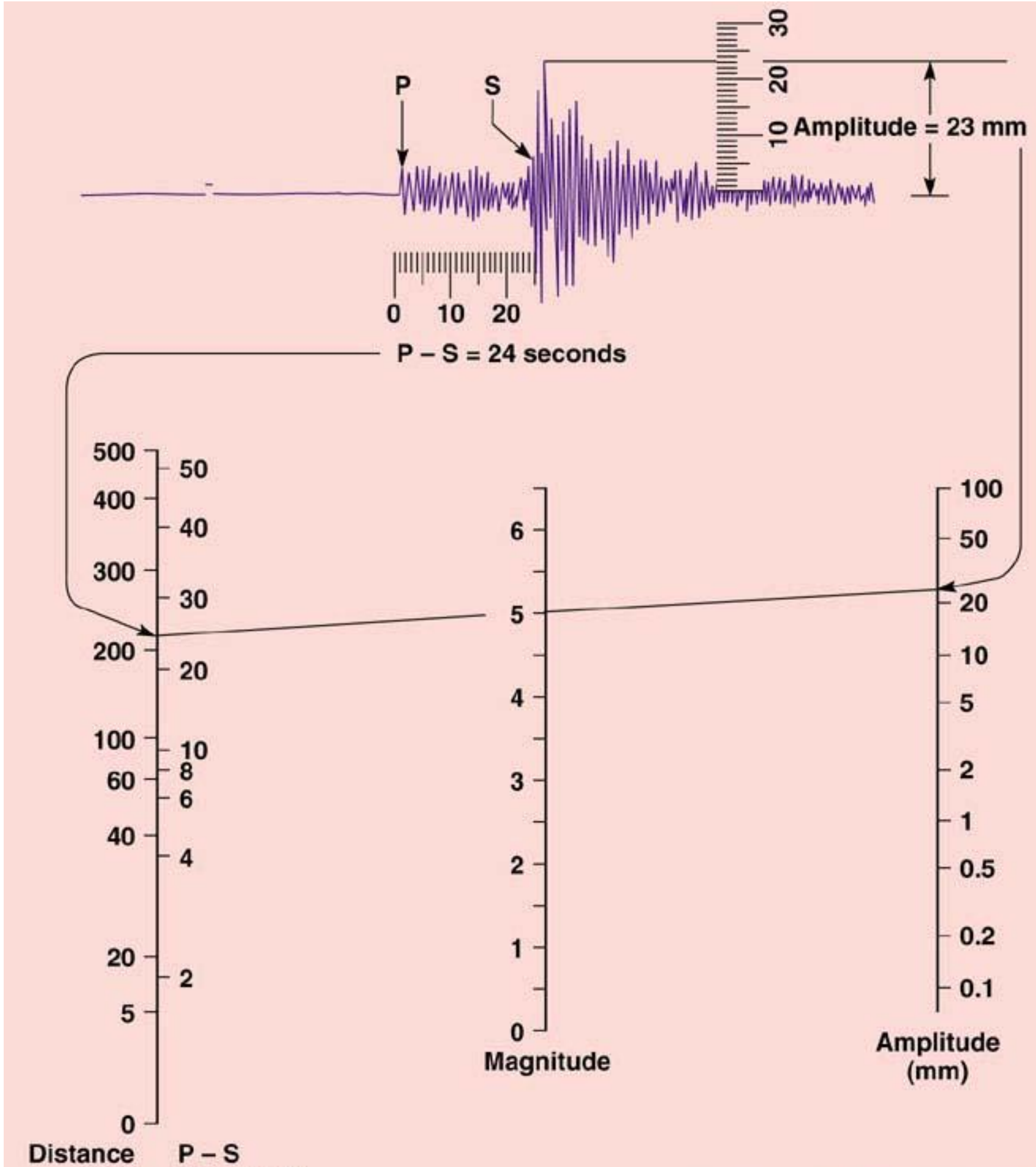



Time (Seconds)
70
60
50
40
30
S – P
300
400
500
600
700
Distance (kilometers)


800
700
600
500
400
300
200
100
60
40
30
20
Distance (kilometers)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
Magnitude
500
200
100
50
20
10
5
2
1
0.5
0.2
0.1
Amplitude (millimeters)

Q/ Determine the Richter magnitude of the following earthquakes by using the Nomogram scale

NO.	S-P (sec)	Amplitude(mm)	Magnitude
1	1	20	
2	10	20	
3	50	20	
4	20	0.2	
5	20	2.0	
6	20	20.0	


P
S
Amplitude = 23 mm
30
20
10
0
10
20
P – S = 24 seconds
500
400
300
200
100
60
40
20
5
0
50
40
30
20
10
8
6
4
2
Distance (km)
P – S (seconds)
6
5
4
3
2
1
0
Magnitude
100
50
20
10
5
2
1
0.5
0.2
0.1
Amplitude (mm)

Seismology (G317)
Lab.NO.3

Determine the Size and Strength of an Earthquake (The Magnitude)

Second Method

Calculating the magnitude of earthquake using equations.

For a set of earthquakes, the following information data are given below in table (1).
Calculate the magnitude & intensity of these earthquakes.

Important Relations:

$M = \text{Log } A + 3 \text{ Log } \Delta - 3.37$

$M = 1.3 + 0.6\, I_{max} \rightarrow \qquad I_{max} = \frac{M - 1.3}{0.6}$

M= Magnitude of earthquake.

A = Maximum trace amplitude of body waves.

Δ = Epicenter distance.

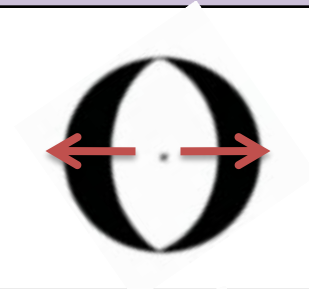
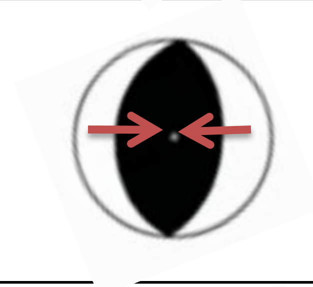
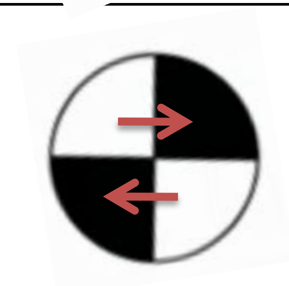
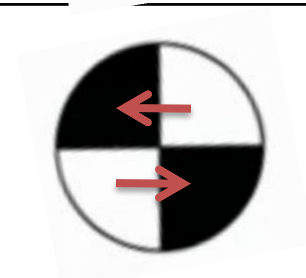
Δ (km)	A (microns)	M	I
200	0.55		
420	0.68		
615	0.85		
815	1.35		
980	1.50		
1200	5.0		
1450	7.5		
1630	10.8		
1800	15.0		
1950	20.3		

Seismology (G317)
Lab.NO.4

Earthquake Focal Mechanisms Solution (F.M.S)
(Fault Plane Solution)

The aim of the laboratory:

To know the type of fault responsible for the occurrence of the earthquake, as well as to know the type of forces that cause the occurrence of the fault and the depth of the focus.

Type of force	Type of fault	Beach ball	Focal depth
Tension (Divergent)	Normal (Rifting zone)		0 – 70 km Shallow focus
Compression (Convergent)	Reverse or Thrust (Subduction zone)		70– 300 km Intermediate focus
Transform	Strike slip 1-Right-lateral (Dextral) 2-Left-lateral (Sinistral)		300 – 700 km Deep focus
			

Important notes:

1- The movement is always from white towards black.

2- The black part is **C**, and it expresses Compression or (Shortening), while white part is **D**, and it expresses Dilatation or (Tension).

3- For waves, there is a **polarity**, which is the movement of the wave up or down. Upward (+), downward movement is Compressive (C) or movement is tensile (D) or (-).

4- The auxiliary axis is the axis perpendicular to the fault plane.

Methods of F.M.S:

1- Moment tensor (software):

The fault drawing and the location of the earthquake are given, and we fall directly on the sphere and determine the type of fault and the type of forces causing it, as in the example given of two faults in the middle of the ocean ridge.

Methodology:

1- Draw **fault plane** which is a line parallel to the first fault on the first circle (which represents the projection of forces or the first movement). This line must pass through the center of the circle.

2- Draw a line perpendicular to the first line and it passes through the center of the circle, which represents **Axial plane (Auxiliary plane)**.

3- Isolate compressive forces (Black circle) from tensile forces (White circle) by drawing a great circle.

4- Define the movement from the white area to the black area and draw the direction of motion on the fault to know its type.

5- Repeat the same procedure for the second fault on the second circle.

2- First motion (graphic):

Methodology:

1- A map of the area is given, including earthquakes, stations, and a scale drawing.

2- Organize a table as in the next slide.

3- Used stereoscopic projection to fall Strike or (Azimuth) as a linear element (point), the dip from the outside to the inside.

4- Draw the boundary between the white circle and the black circle and extract the type of fault and the forces that cause it.

Q/ Drawing Nodal Planes

The outline map below labeled Figure 1.a shows the positions of two earthquakes recorded on the Mid-Atlantic ridge system. Lower hemispheres of focal spheres of earthquakes 1 and 2 are also shown in Figures 1.b and 1.c.

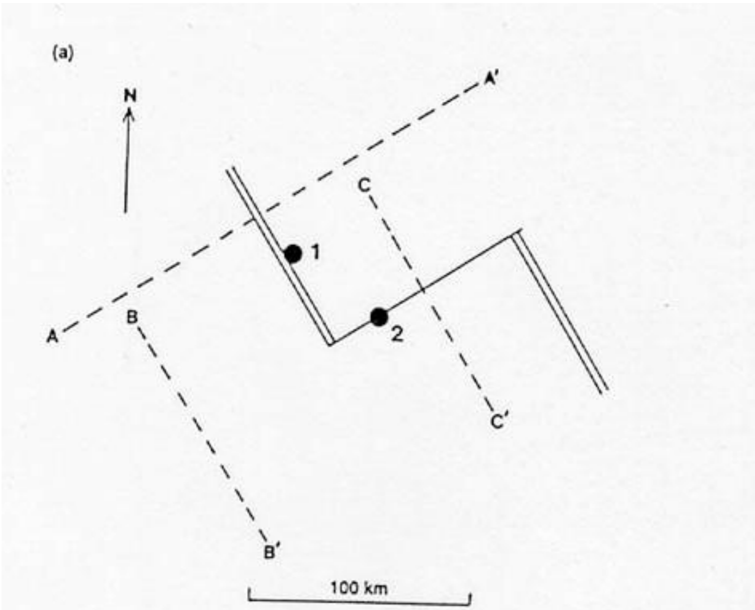
a. Draw the nodal planes on Figures 1.b and 1c.

Remember that the nodal planes must be perpendicular to each other. You can't do this very accurately but you can draw the nodal planes with sufficient care to indicate that the nodal planes are perpendicular to each other and do divide the focal sphere into four sectors of equal

size.

b. Identify the fault types that generated earthquakes 1 and 2.

c. From the tectonic setting, what are the depth ranges you would expect for earthquakes 1 and 2 ?



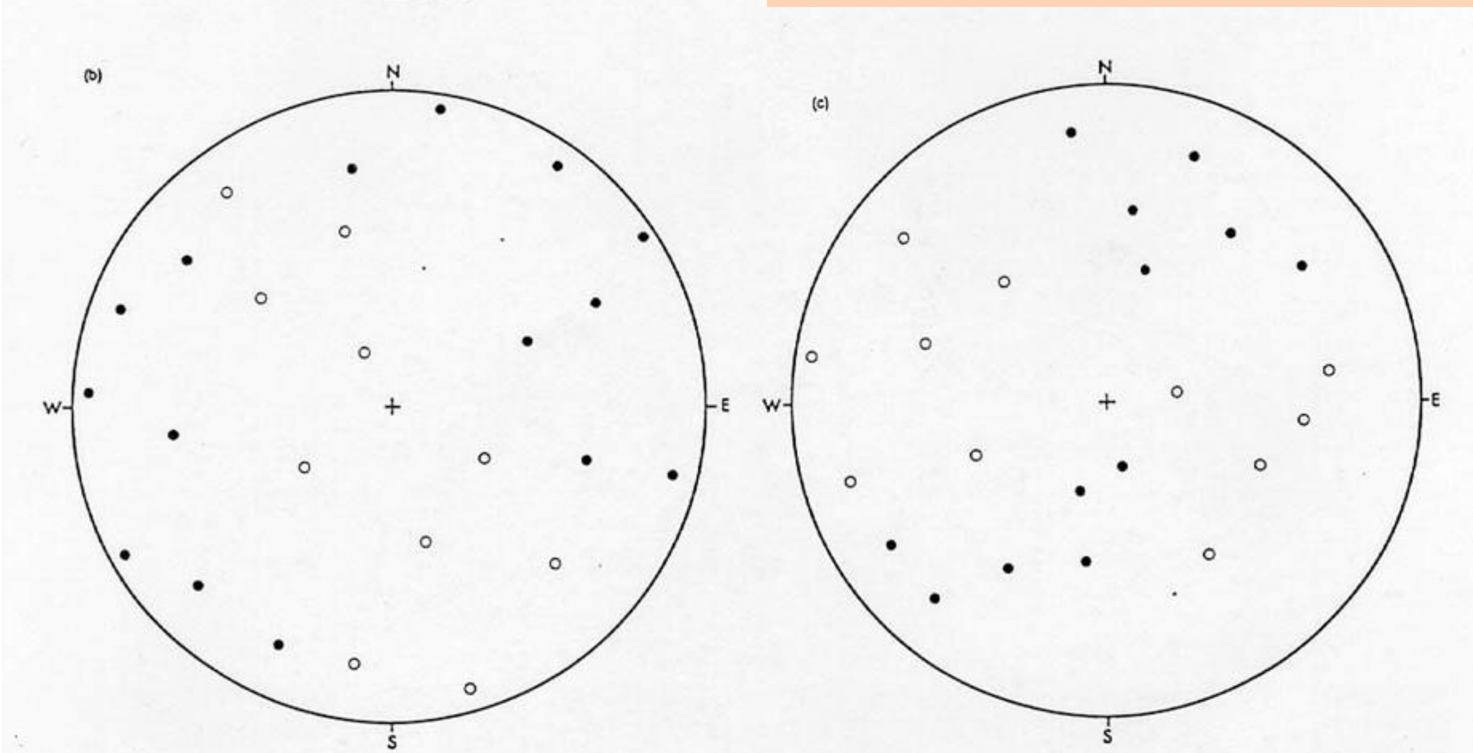
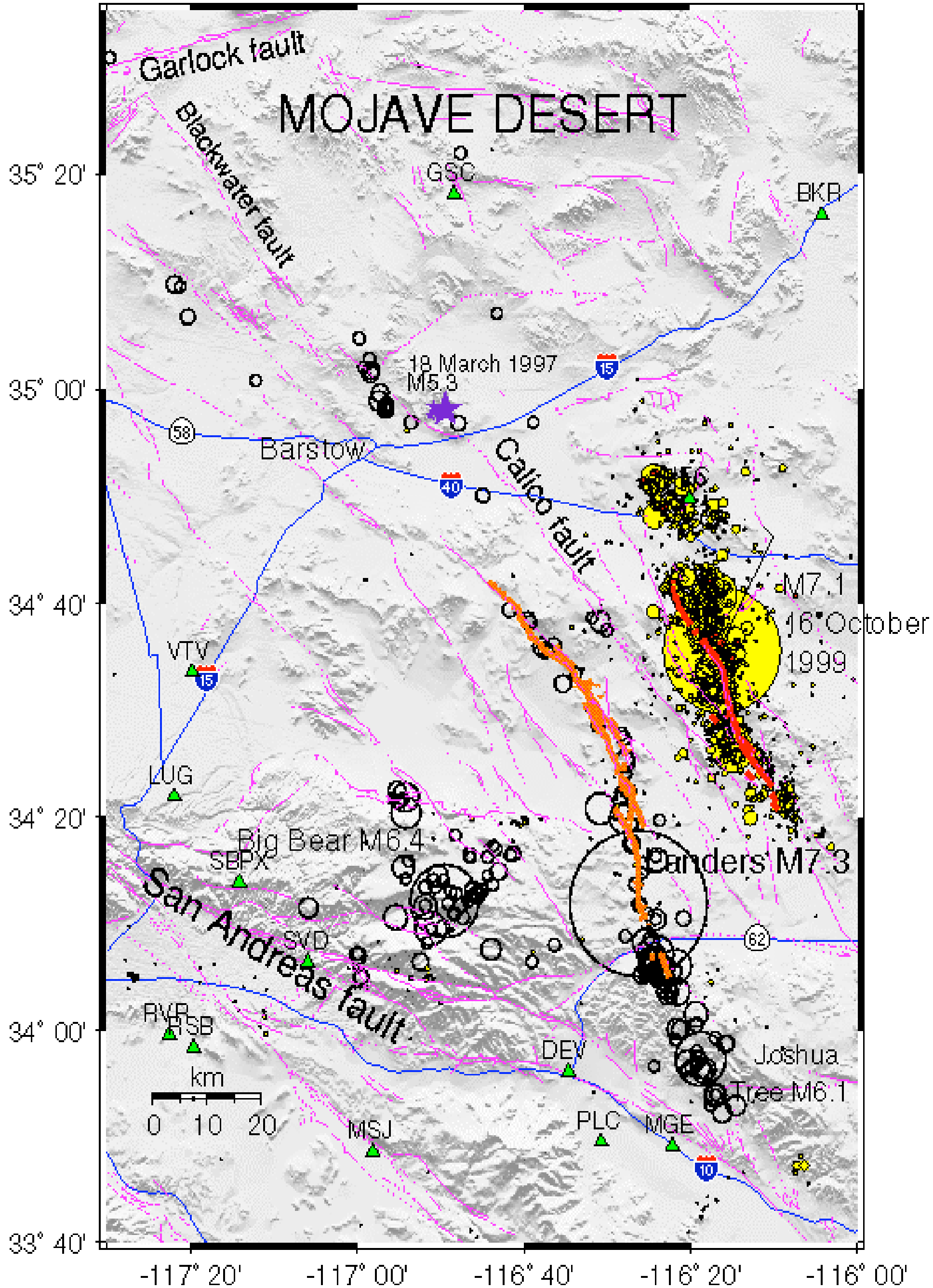


Figure 1. (a) Location of earthquakes 1 and 2 on the Mid-Atlantic Ridge. (b) Direction of first motion for earthquake 1. (c) Direction of first motion for earthquake 2.

M7.1 Hector Mine Earthquake of 16-26 October 1999



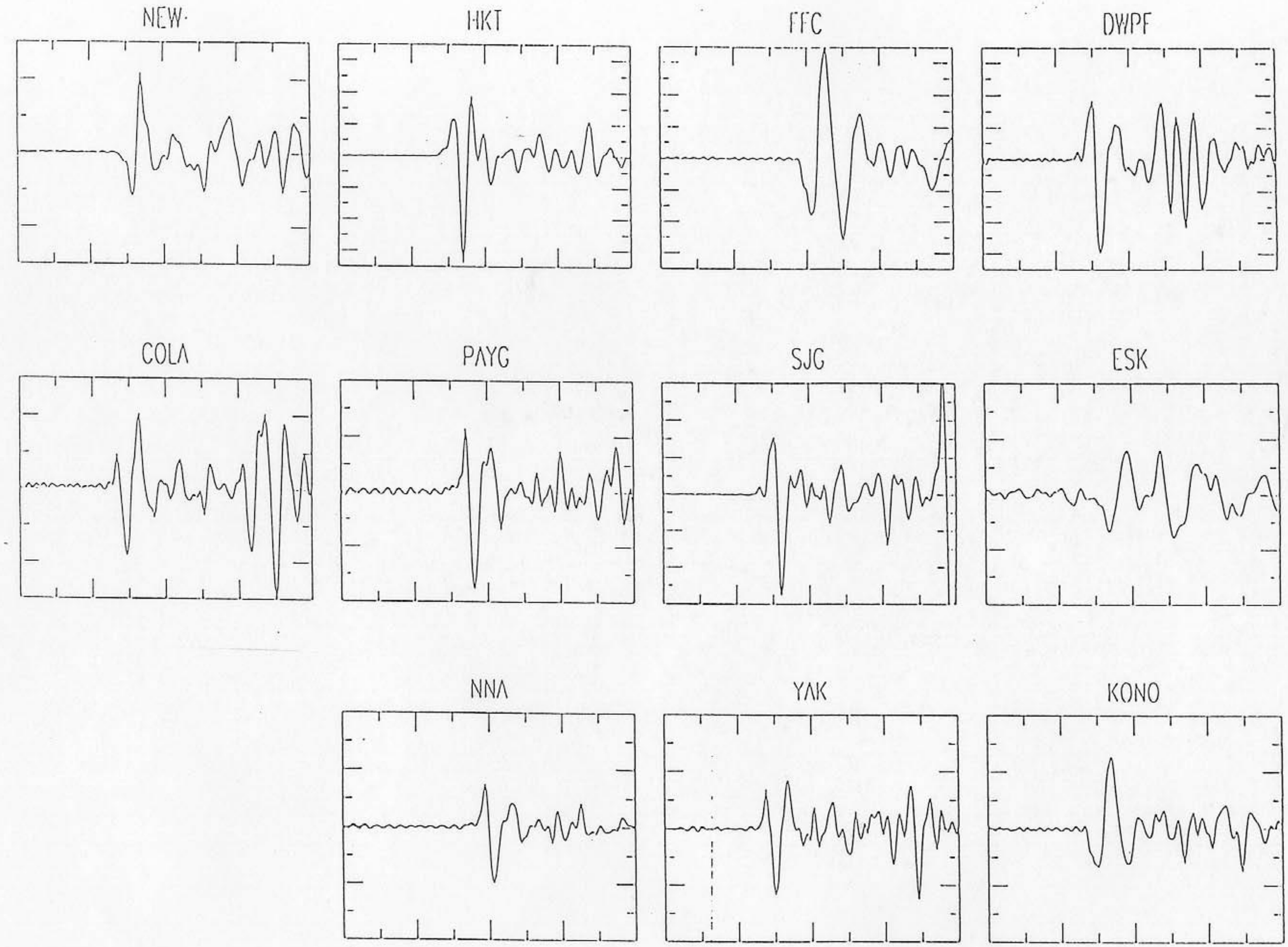
Q/ Developing a fault plane solution data set from seismic records.

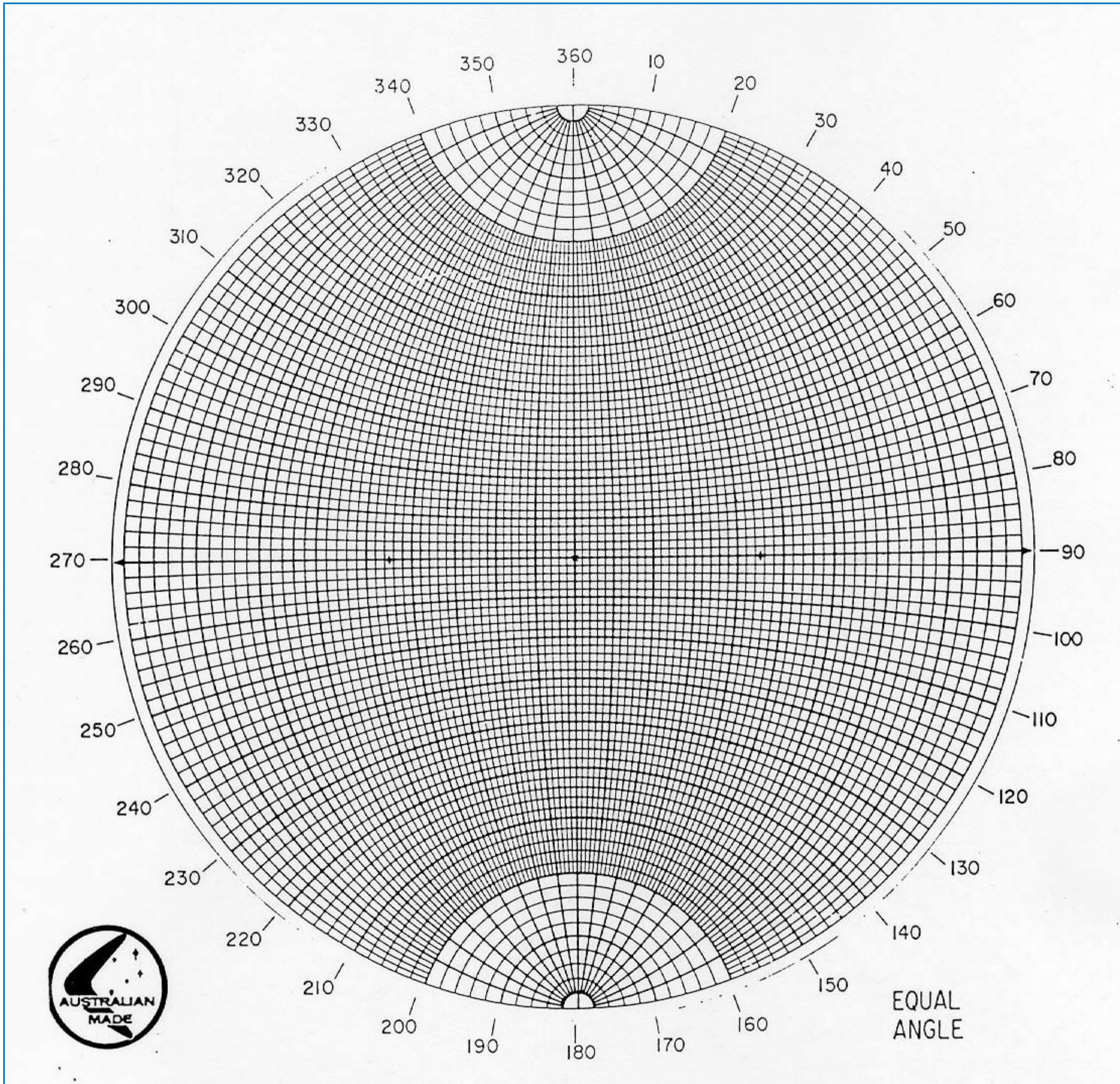
The table below lists the following quantities for a particular earthquake: (1) code of seismic station; (2) epicentral distance (Δ, in degrees of arc) of that station from the earthquake; (3) azimuth (Az) *from earthquake to station; and (4) the sense of the first Pwave* first motion (**compression [C]** or **dilatation [D]**) observed at that station.

Station	△ (0)	i (0)	Az (0)	First Motion
NEW	14		358	
GW01	18		65	D
GW02	18		147	C
GW03	18		160	D
HKT	18		99	
GW05	19		250	C
GW04	19		336	C
FFC	23		22	
GW08	25		62	D
GW10	25		240	D
DWPF	30		92	
COLA	36		338	
PAYG	43		140	
SJG	47		97	
GW06	55		232	D
GW09	55		254	C
NNA	59		134	
GW07	67		160	D
YAK	70		333	
ESK	74		33	
KONO	76		25	
GW11	87		224	D

GEOS 322

△ (0)	i (0)	△ (0)	i (0)
13	47	54	25
15	45	49	24
17	43	51	23
18	39	55	22
21	35	59	22
23	32	63	21
25	30	67	20
27	29	71	19
29	29	75	18
31	29	79	17
33	28	83	16
35	28	87	15
37	27	91	14
41	26	95	14


NEW
HKT
FFC
DWPF
COLA
PAYG
SJG
ESK
NNA
YAK
KONO


360
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350
AUSTRALIAN
MADE
EQUAL
ANGLE