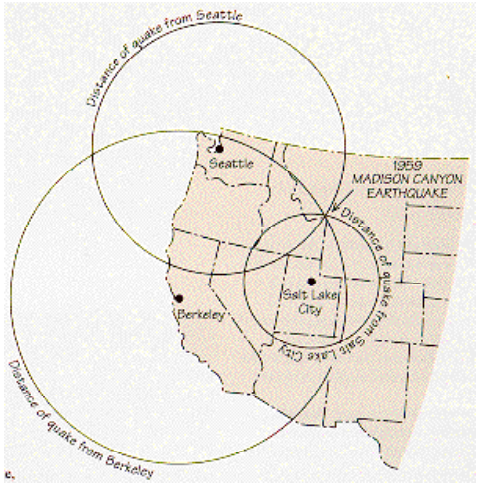
Name _____ Section _____

Geology 120 - Laboratory Exercise
Seismic Methodologies and Hazards

Objectives:
- learn how to calculate earthquake parameters
  - distance and location
  - magnitude
- Mercalli Intensity

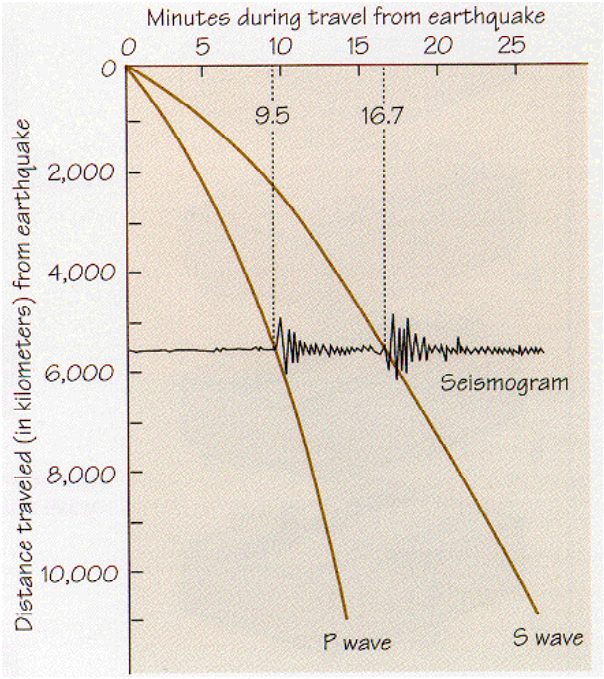


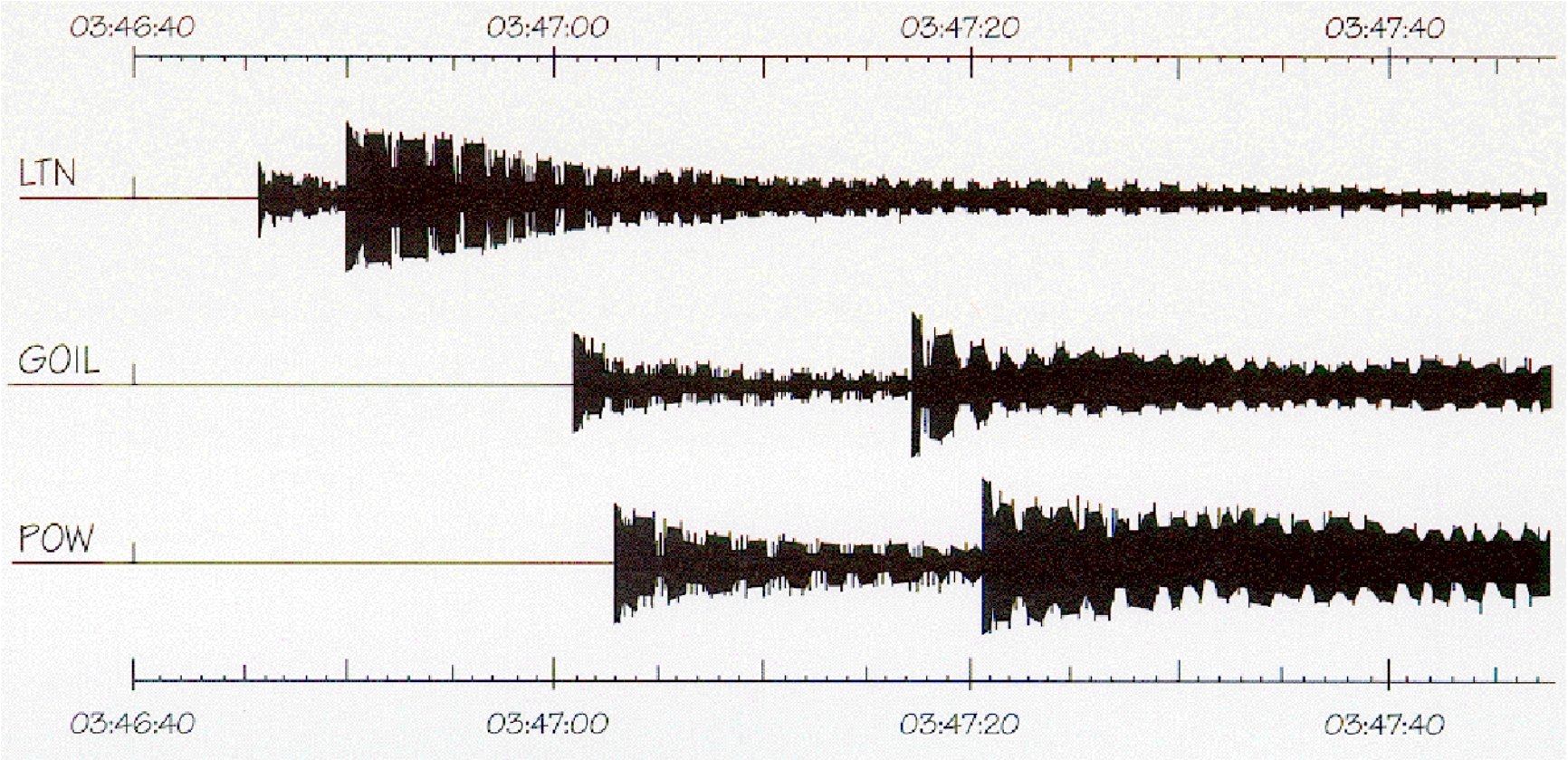
Locating Earthquakes

1. Determine the distance to the earthquake from seismograms for at least three different seismograph stations.
2. Construct a circle around each seismograph station, the radius of which is the calculated distance for each seismogram.
3. The epicenter is found at the intersection of the circles.

Exercise: Determine the Location of a Mid-continent Earthquake

The three seismograms shown page 2 were obtained at three different stations Powhatan, Arkansas (POW), Lennox, Tennessee (LTN), Rosebud, Illinois (GOIL) in the mid-continent of the United States. Using the three seismograms, the time/distance curve on page 3 and the location map on page 4, determine the epicentral location of this earthquake to the nearest tenth of a degree:



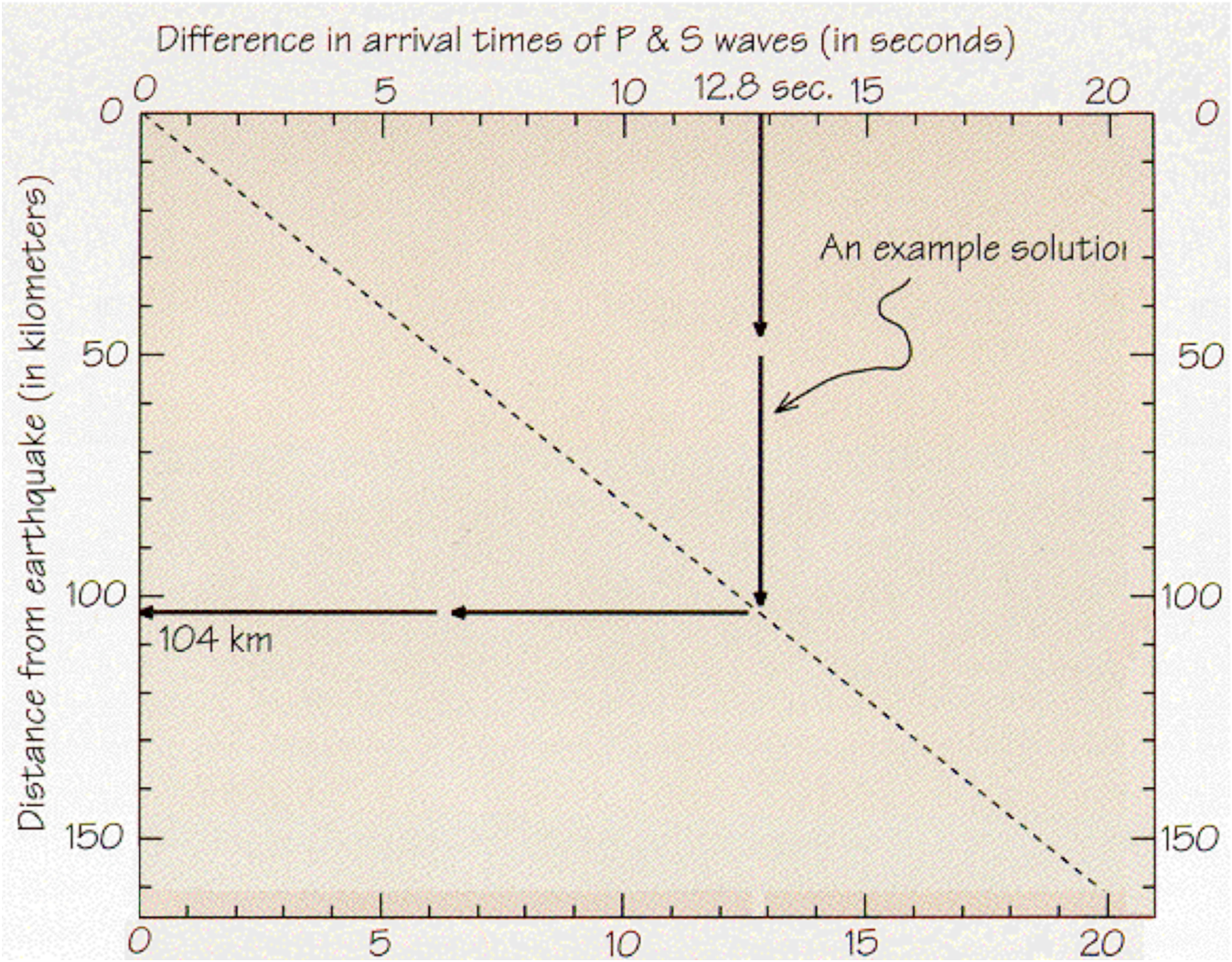

03:46:40
03:47:00
03:47:20
03:47:40
LTN
GOIL
POW
03:46:40
03:47:00
03:47:20
03:47:40

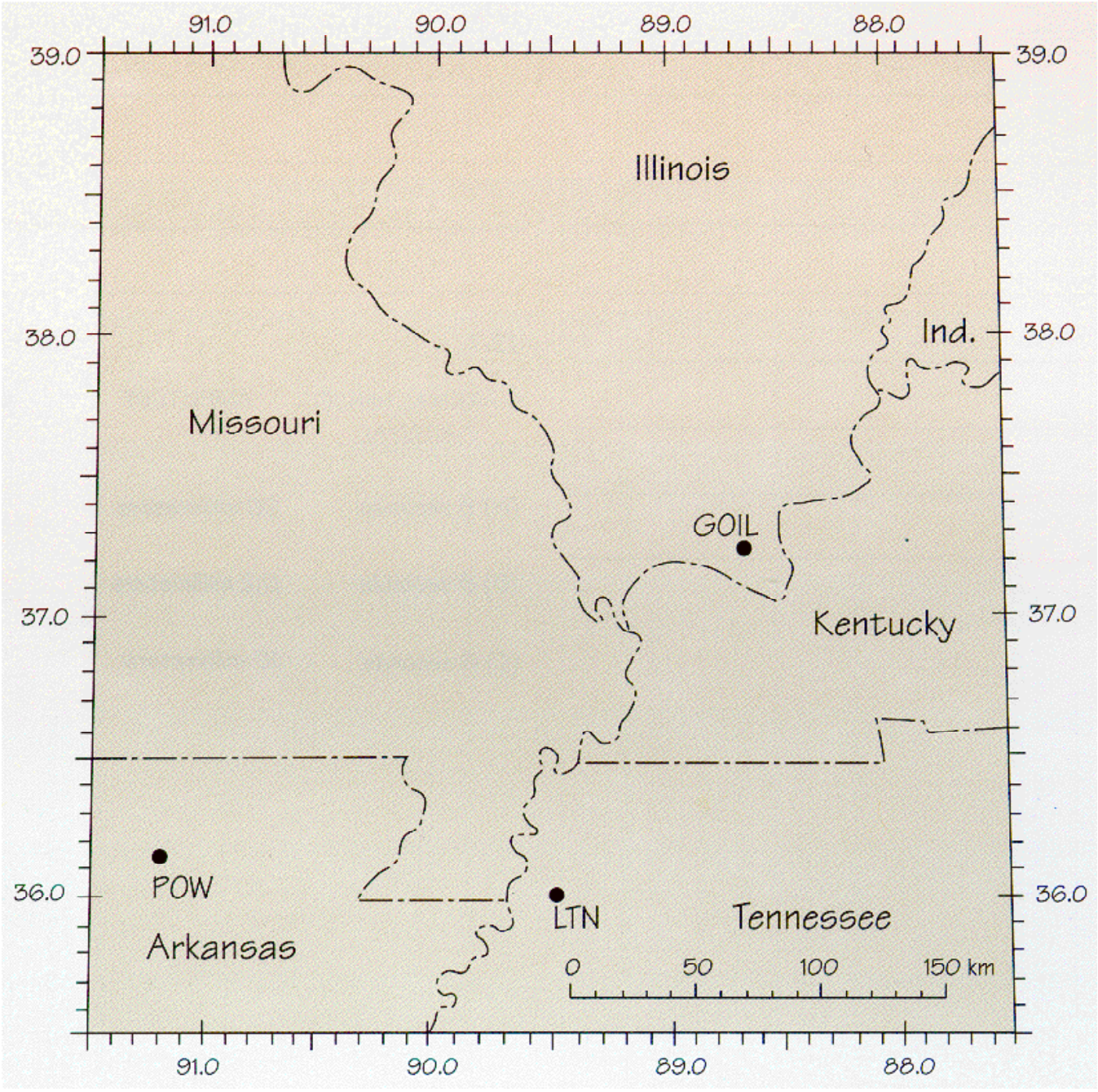
Worksheet:

LTN: P-wave arrival time _____
S-wave arrival time _____
difference Δt _____
distance _____

POW: P-wave arrival time _____
S-wave arrival time _____
difference Δt _____
distance _____

GOIL: P-wave arrival time _____
S-wave arrival time _____
difference Δt _____
distance _____





Latitude: _____.____o Longitude: _____.____o

Modified Mercalli Scale of Earthquake Intensities - Effects on People and Structures

I Not felt except under unusual circumstances. Doors may swing very slowly

II. Felt indoors by few, especially on upper floors. Suspended objects may swing.

III. Felt indoors by several. Sometimes not recognized as an earthquake. Vibrations like that of a passing truck. Standing automobiles rock slightly.

IV. Felt indoors by many, outdoors by few. Some light sleepers awakened. Vibrations like that of a heavy truck. Sensation like a heavy object striking a building. Rattling of dishes, windows and doors. Creaking walls in frame buildings. Standing automobiles rock noticeably.

V. Felt indoors by everyone and outdoors by many. Many sleepers awakened. Some broken dishes, glassware and windows. Unstable objects overturned. Hanging objects and doors swing. Moves small objects and furniture slightly. Trees and bushes shaken slightly.

VI. Felt indoors by everyone and outdoors by everyone. Many people frightened and run outdoors. All sleepers awakened. Some ringing of church bells. Some fallen plaster. Some small cracks in masonry. Considerable broken dishes, glassware and windows. Some FURNITURE moved.

VII. All people frightened and run outdoors. Many experience difficulty standing. Noticed by persons driving automobiles. Rings large church bells. Heavy furniture overturned. Negligible damage to well designed structures. Considerable damage to poorly built or badly designed buildings. Cracking of chimneys and masonry walls. Large amounts of fallen plaster and stucco. Numerous windows broken. Bricks and stones dislodged.

VIII. Many people frightened. Near panic. persons driving automobiles are disturbed. Trees shaken strongly and branches and trunks broken off. Very heavy furniture moved and overturned. Slight damage in brick structures designed to withstand earthquakes. Considerable damage in other masonry structures. Twisting or fall of chimneys, columns, monuments, factory stacks and towers.

IX. General panic. Damage considerable in masonry structures designed to withstand earthquakes. Some wood-frame houses out of plumb or shifted off foundations. Conspicuous ground cracks. Underground pipes sometimes broken.

X. Severe damage to well-built wooden structures and bridges, some destroyed. Most masonry structures destroyed. Railroad rails bent slightly. Cracked ground, especially when loose and wet, up to several inches. Open cracks and broad wavy folds in cement pavements and asphalt road surfaces.

XI. Severe damage to wood-frame buildings. Few if any masonry buildings remain standing. Railroad rails bent greatly. Buried pipelines completely out of service. Broad fissures and slumps in soft, wet ground.

XII. Total destruction. Practically all works of construction are greatly damaged or destroyed. Numerous and extensive landslides. Numerous shearing cracks in the ground.

Mercalli Intensities

The Mercalli intensities for the April 25, 1992 Cape Mendicino earthquake are shown on the following page for a large region of northern California and surrounding states.

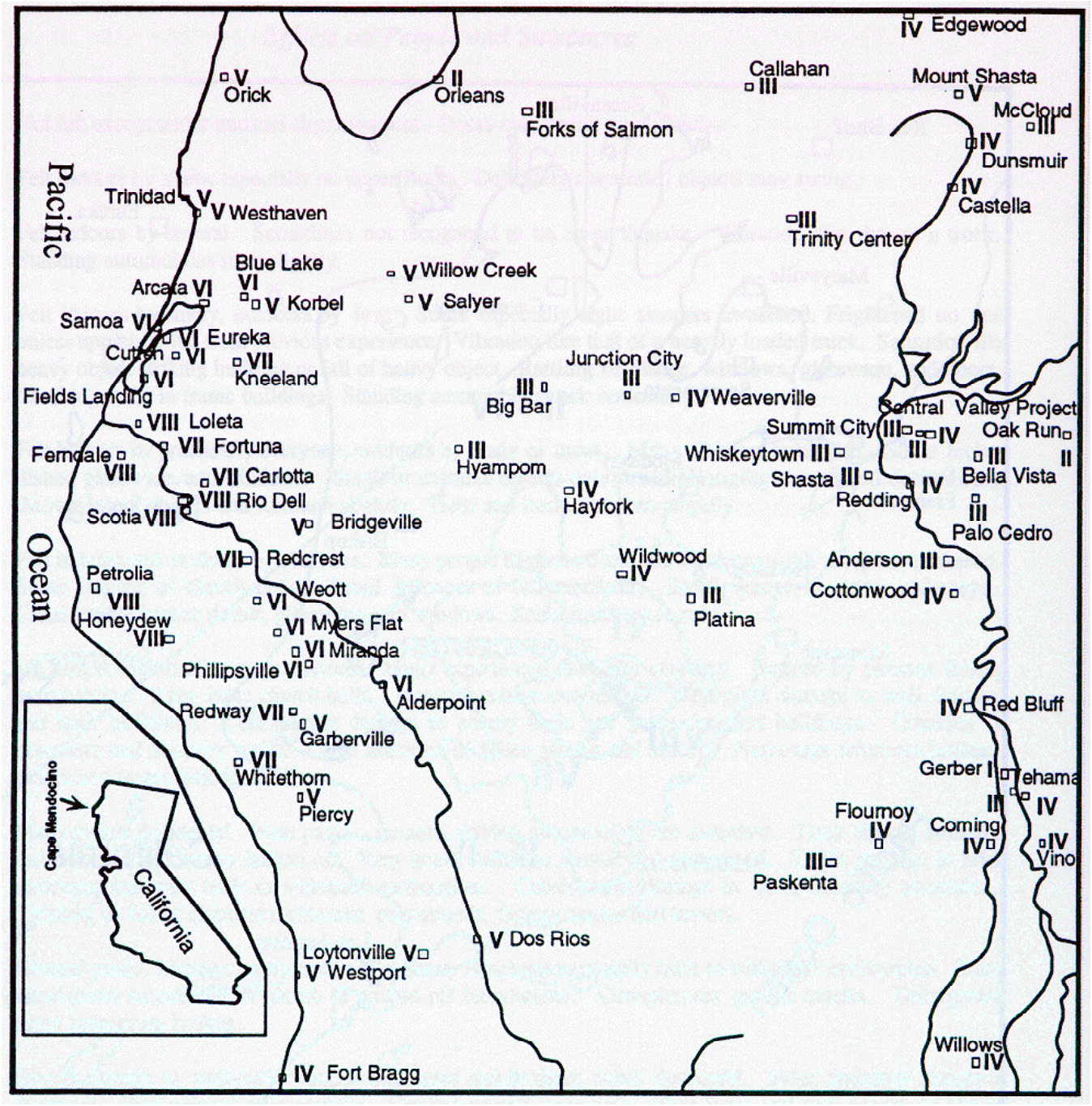
1. Contour the Mercalli intensities to produce and isoseismal map for the Cape Mendicino earthquake.

2. Describe the possible shaking and damage that might have occurred in the town of Petrolia, California.

3. Describe the possible shaking and damage that might have occurred in the town of Blue Lake.

4. Describe the possible shaking and damage that might have occurred in Fort Bragg.

5. Based on your isoseismal map, where is the possible epicenter for the earthquake?


Pacific
Ocean
Edgewood IV
Callahan III
Mount Shasta V
McCloud III
Dunsmuir IV
Castella IV
Trinity Center III
Orick V
Orleans II
Forks of Salmon III
Trinidad V
Westhaven V
Blue Lake VI
Arcata VI
Korbel V
Willow Creek V
Salyer V
Samoa VI
Eureka VI
Cutten VI
Kneeland VII
Fields Landing VI
Junction City III
Big Bar III
Weaverville IV
Central Valley Project
Summit City III
Oak Run IV
Loleta VIII
Fortuna VII
Ferndale VIII
Hyampom III
Whiskeytown III
Shasta III
Bella Vista III
Carlotta VII
Rio Dell VIII
Hayfork IV
Redding IV
Scotia VIII
Bridgeville V
Palo Cedro III
Wildwood IV
Anderson III
Redcrest VII
Petrolia VIII
Weott VI
Platina III
Cottonwood IV
Myers Flat VI
Honeydew VIII
Miranda VI
Phillipsville VI
Alderpoint VI
Redway VII
Garberville V
Red Bluff IV
Gerber III
Tehama IV
Whitethorn VII
Piercy V
Flournoy IV
Coming IV
Vino IV
Paskenta III
Cape Mendocino
California
Dos Rios V
Loytonville V
Westport V
Willows IV
Fort Bragg IV

Earthquake Frequency and Recurrence Intervals

The data tabled below are annualized data for different parts of the world. We will use these data to explore the relationship between earthquake frequency and magnitude and then use the data to predict how often large earthquakes might be expected to occur. For your information, these data represent averaged numbers for the last 10 years and while a single magnitude value is listed, each actually represents a range (i.e. 4.5 is for 4.0 to 4.99).

Magnitude	World	United States	Southern California	Japan
0.5				
1.5				
2.5			2399.2	
3.5		2512.0	306.3	3427.2
4.5	16443.8	391.9	31.7	401.1
5.5	1659.3	56.8	3.3	60.5
6.5	148.4	5.7	1.0	9.1
7.5	14.4	0.7		2.2
8.5	1.3			

Sample: World (we will do this together)

- Download from Moodle: Earthquake Frequency Lab
- Using Excel, copy both the Magnitude and values column into Excel
- Construct a Chart plotting
  - magnitude on the x-axes and
  - numbers on the y-axis
- Create a log-log plot – in Excel…
  - select the numbers in the World column
  - under the Insert Menu, select Chart, X-Y Scatter
  - now, click on one of the plotted data points. The plot formula will be displayed. Place your cursor between the two commas and then highlight the corresponding magnitude range (4.5 – 8.5)
  - on the chart, double click on the vertical axis. When the Format axis menu appears, go to Scale and check the logarithmic scale box – click ok. The data points should now be in an approximate straight line.
- Calculate a best-fit equation to these data points…
  - click on the data points
  - under the Chart menu, select Add Trendline…
  - select Type and then highlight the exponential box
  - select Options and check the Display equation on chart option
- Use this equation to estimate the number of magnitude 9.5 earthquakes that will occur annually worldwide.

Name _____

Earthquake Frequency

	# per year	years between events
The World	_____	_____

Other Areas.

- Use the same procedure to estimate how often a magnitude 8.5 event might be expected for:

	# per year	years between events
The United States	_____	_____
Southern California	_____	_____

Turn in:

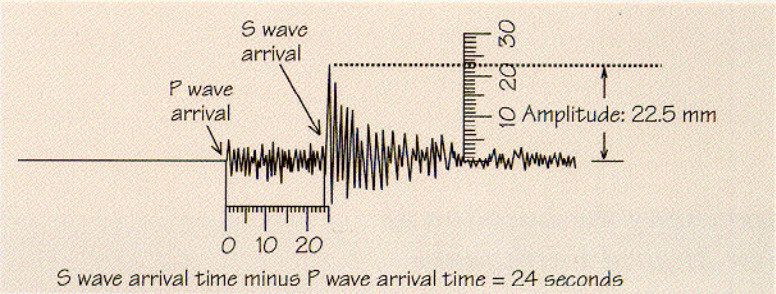
1. This sheet
2. An excel sheet showing the plot and calculations for each of the areas estimated plotted.

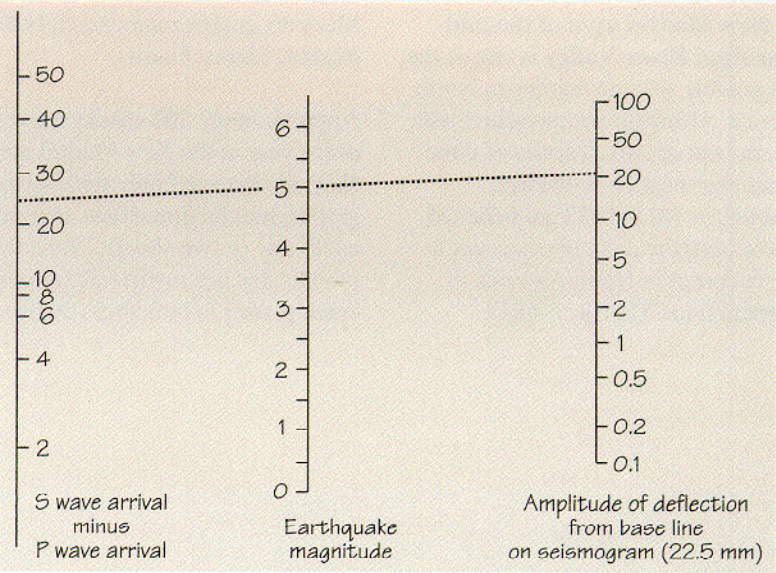
Calculating Magnitude

1. Determine the difference in arrival time for the P- and S-waves (in seconds). This is proportional to the distance from the epicenter.
2. Measure the amplitude (height) of the largest amplitude wave on the seismogram.
3. Place a straightedge on the nomogram at the appropriate values for the arrival-time difference and amplitude.
4. Read the magnitude directly from magnitude scale.

Exercise: Determine the Magnitude of Earthquakes

Using the nomogram shown below, calculate the magnitude for the earthquakes listed below. A nomogram is a device used to solve the earthquake magnitude at a specific seismograph station. Each station has a different nomogram since the seismograph amplification is built into the graph.





P- & S-wave time difference	Amplitude	Magnitude
a) 8 seconds	20 mm	_____
b) 8 seconds	.2 mm	_____
c) 6 seconds	10 mm	_____
d) 40 seconds	10 mm	_____

Why is there a difference in the calculated magnitude for the two events (c and d) that both have an observed amplitude of 10 mm?