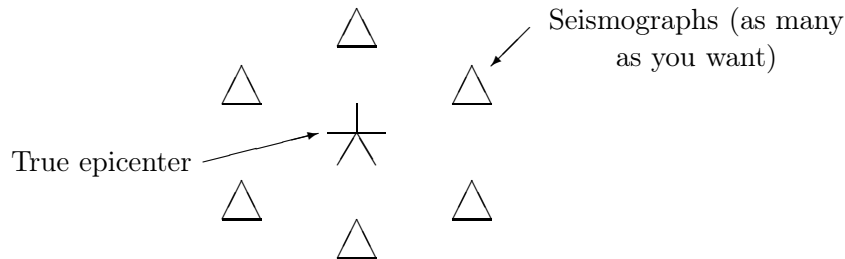


Seismology Example Sheet #2

1. Local earthquakes are frequently located using the time difference between the arrival time of the S-wave and the P-wave, the S-P time. The P-wave velocity of the continental crust averages approximately 6 k/s so that at distances as great as 100 km we can assume that $t_p = x/6$ sec. Assume that the crust is a Poisson solid ($V_p = \sqrt{3}V_s$) and derive a relationship for the distance in terms of the S-P time. Three seismograph stations located at A (-1,1), B (2,2), and C (-1,-2) kilometers from an arbitrary origin record S-P times of A (0.44 sec), B (0.36 sec), and C (0.38 sec), respectively. Assume a surface hypocenter and locate the earthquake.

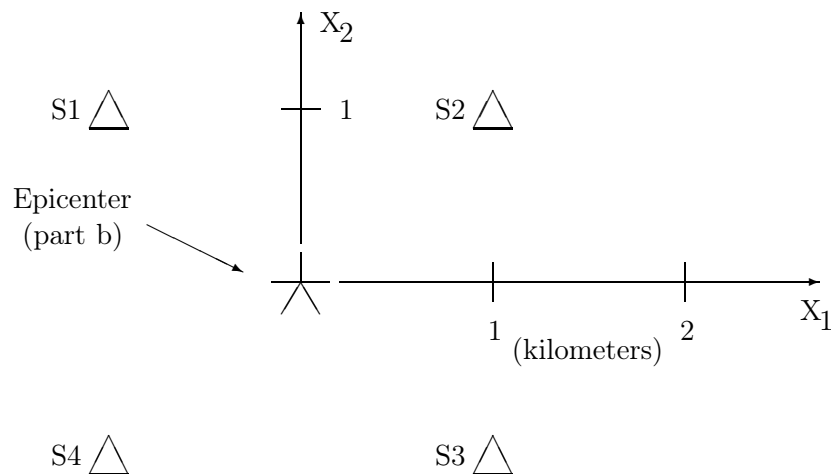
2. A circular array of seismic stations is located on the surface of a perfectly flat, homogeneous, elastic Earth. Assume that an earthquake occurs with epicenter at the center of the array and that all seismic phases can be read perfectly. (a) To what precision can the (i) epicenter and (ii) hypocenter be located using only P-waves? (b) What would be the precision in these locations if both P and S-waves are used?



3. Four seismographs (S1, S2, S3, S4) are located on the surface of a homogeneous half-space. They have, respectively, (x_1, x_2) coordinates: (-1,1), (1,1), (1,-1), (-1,-1) where these values are in units of kilometers. Let $T_j(A, B)$ be the travel time from the j^{th} station to the general point (A, B) on the surface of the half-space. (a) Compare, in algebraic form, the eight partial derivatives at the general point (A, B) as a function of the station coordinates and (A, B) , i.e.,

$$T_{j,i} = \frac{\partial T_j}{\partial x_i}, \quad j = 1, 2, 3, 4; \quad i = 1, 2$$

(b) suppose a surface focus earthquake occurs at the center of the array $[A=0, B=0]$, and that only P-waves can be read to a precision of 0.03 sec (i.e. No S-waves are available). Evaluate the partial derivatives at the center of the array and using these numbers, estimate the precision with which the epicenter can be determined from P-waves measured at the four stations. (c) Repeat (b), but with a surface-focus earthquake at coordinates $A=10, B=0$.



4. Following are four sets of vertical and horizontal component seismograms for a small earthquake. The location of the seismographs are shown on the accompanying map. The only information you have on the velocity structure of this region is the travel time observations in the following table recorded along the seismic profile shown on the map. Locate the earthquake using S-P times. Assume that the p-wave velocity is 1.73 times the s-wave velocity.

Distance (km)	Time (sec)	Time (sec)		Distance (km)	Time (sec)	Time (sec)
5.0	0.79			141.0	22.07	23.42
10.0	1.57			157.0	24.72	25.37
15.0	2.34			163.0	24.72	26.13
20.0	3.11			181.0	28.40	
30.0	4.69			196.0	30.63	
42.0	6.59			210.0	32.05	33.07
57.0	8.89			222.0	33.67	35.02
70.0	10.87			235.0	35.17	37.07
87.0	13.59			247.0	36.85	38.96
92.0	14.49			258.0	38.16	40.69
108.0	16.93			270.0	39.59	42.65
114.0	17.95	19.93		293.0	42.45	46.36
127.0	19.87	21.62		300.0	43.24	

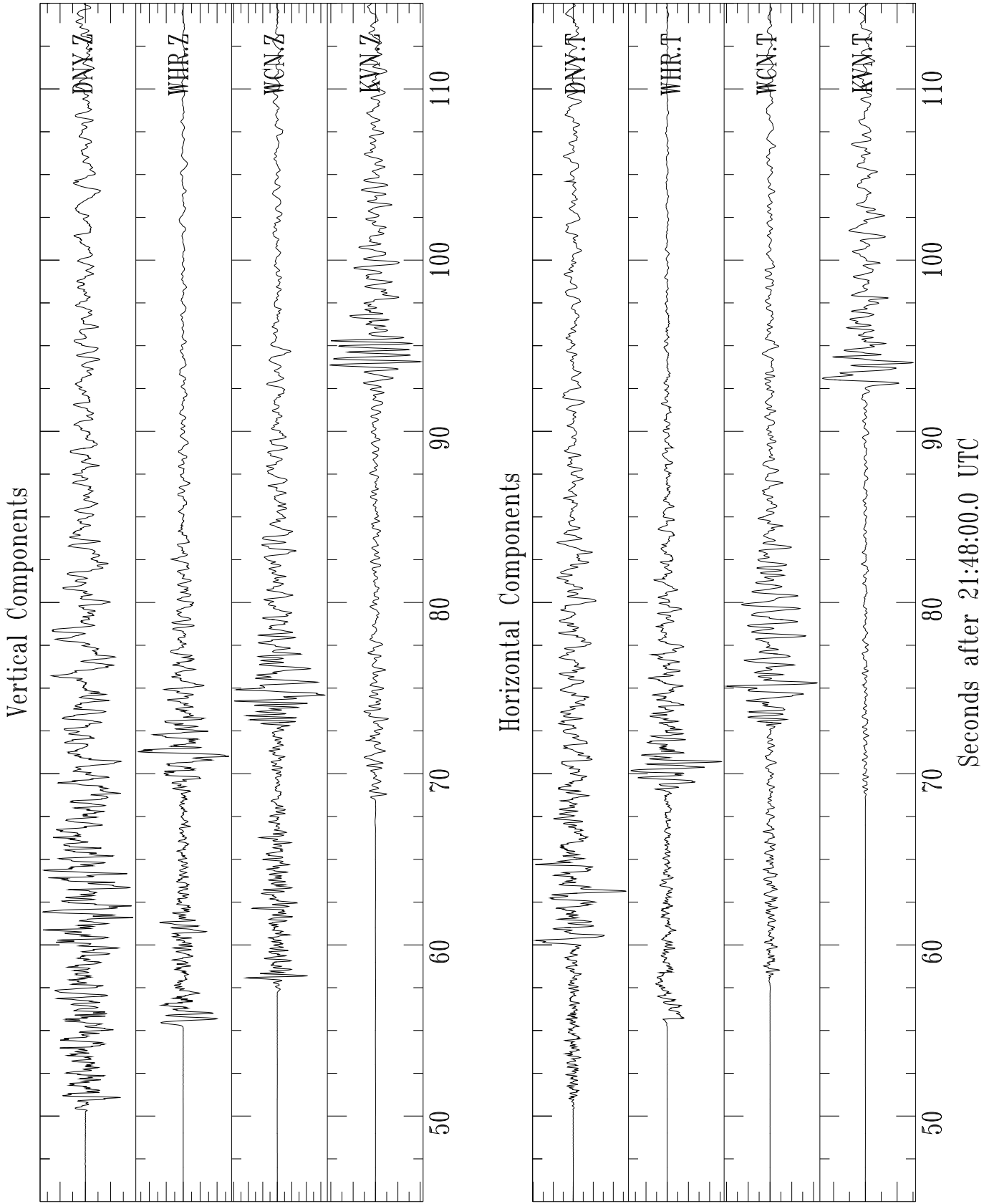


Figure 1: Seismograms for Problem 4.

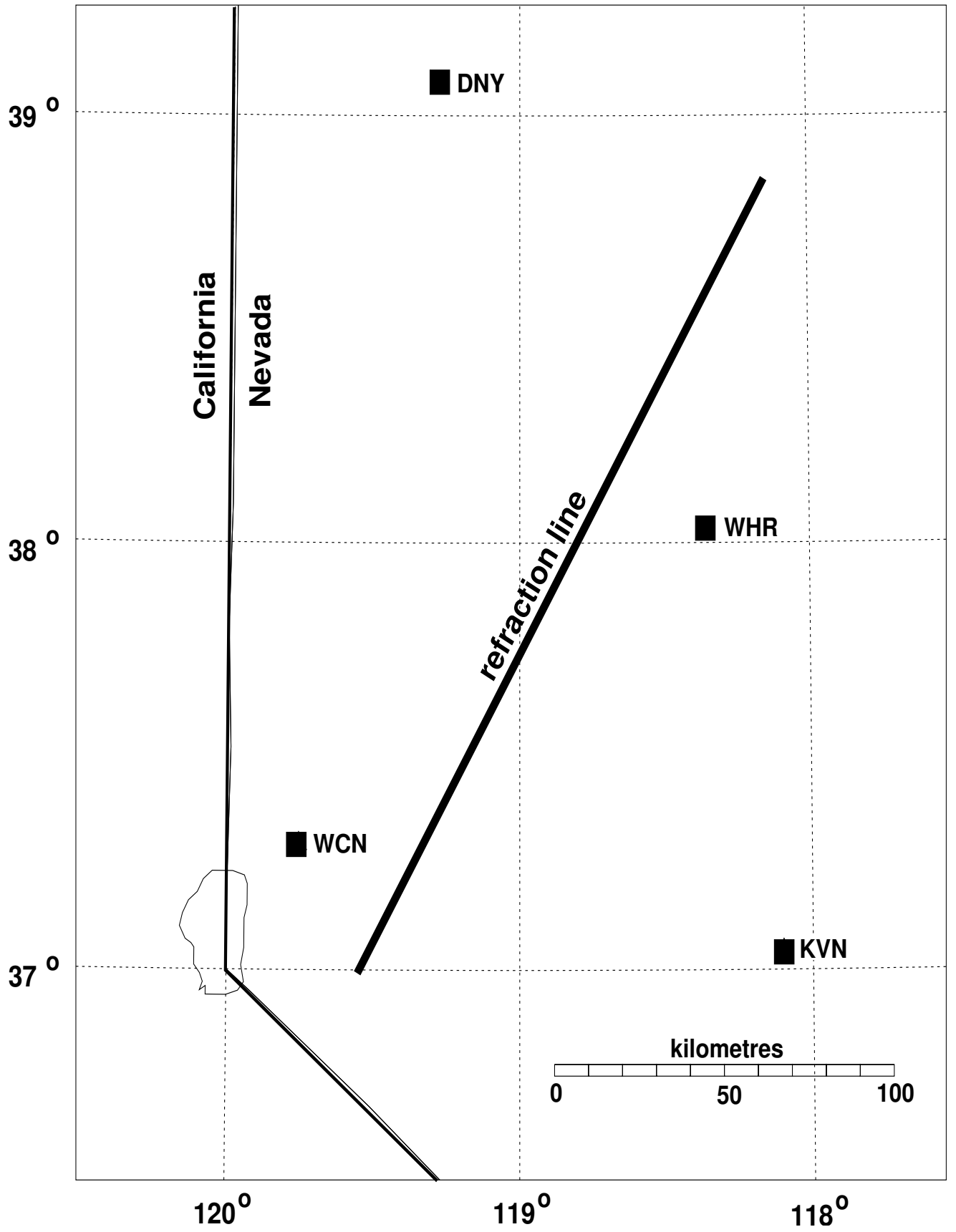


Figure 2: Map for Problem 4.