PHYSICAL GEOLOGY
RELATIVE MOTION OF ROCKS ALONG A FAULT

ADAPTED FROM *LAB MANUAL IN PHYSICAL GEOLOGY* (AGI AND NAGT)

NAME__________________________

PERIOD_____

The relative motion of blocks of rock on either side of a fault zone can be determined by mapping the way the pen on a seismograph moved (up or down on the seismogram) when P-waves first arrived at various seismic stations adjacent to the fault. This pen motion is called *first motion* and represent the reaction of the P-wave to *dilation* (pulling rocks apart) and *compression* (squeezing rocks together), as observed on seismograms (Figure 1).

If the first movement of the P-wave was up on a seismogram, then that location (where the seismogram was made) experienced compression during the earthquake. If the first movement of the P-wave was down on a seismogram, then that location was dilational during the earthquake.

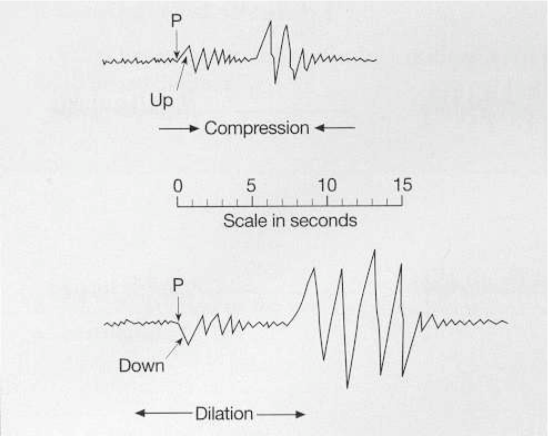


FIGURE 1 Sketch of typical seismograms for compressional first motion (first p-wave motion is up) compared with dilational first motion (first p-wave motion is down).

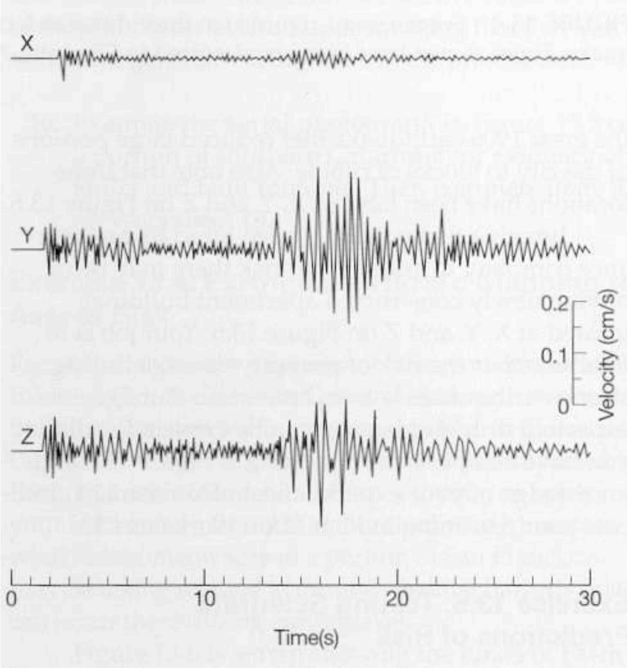


FIGURE 2 Seismograms recorded at stations X, Y, and Z for a strong (Richter Magnitude 4.6) aftershock of the Loma Prieta, CA, earthquake (USGS). During the quake, little damage occurred at X, but significant damage to houses occurred at Y and Z.

What was the first motion at all of the seismic stations in Figure 2?

ANSWER: the first movement of the pen was up for each P-wave, so the first motion at all three sites was compressional.

By plotting the first motions observed at seismic stations on both sides of a fault that has experienced an earthquake, a picture of the relative motions of the fault emerges. For example, notice that in Figure 3 the first motions observed at seismic stations on either side of a hypothetical fault are plotted in relation to the fault. The large open arrows drawn on either side of the fault show that the motion along the fault proceeded AWAY from the stations where dilation (D) was recorded (those rocks were stretched), and TOWARD the stations where compression (C) was recorded (those rocks were squeezed). The diagram therefore reveals that Block X has moved in a southeasterly direction relative to Block Y as indicated by the half-arrows drawn along the fault.

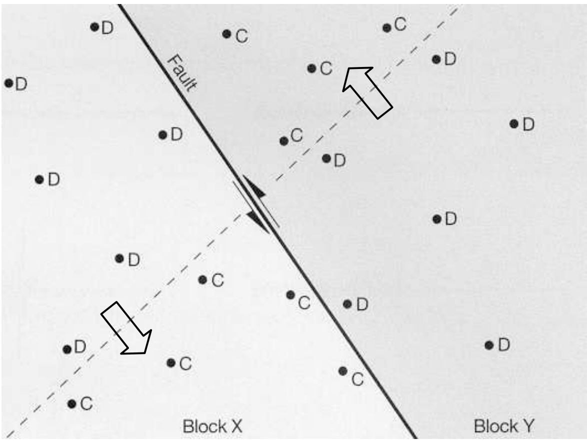


FIGURE 3 Map of a region showing a fault along which an earthquake has occurred, and the P-wave first motions (C=compresssional, D=dilational) observed for the earthquake at seismic stations adjacent to the fault. Stress moves away from the field of dialtion and toward the field of compression on each side of the fault (large open arrows), so the relative motion of the fault is as indicated by the smaller half-arrows.

Faults such as this one, where the motions are horizontal (with little or no vertical displacement) are called *strike-slip faults*. These faults are further characterized by the direction of movement. If you imagine yourself standing on one of the fault blocks and facing the fault, a fault in which the block opposite you moves to the right is called a *right lateral strike-slip fault*. If the block opposite moves to the left, the fault is classified as a *left lateral strike-slip fault*. What type of strike slip fault is drawn in Figure 3?

(ANSWER: The relative motion of the opposite block is to the left, so it is a *left lateral strike slip fault*.)

A REAL EXAMPLE

The New Madrid Fault System is located within the Mississippi Embayment, a U-shaped geological feature filled with Mesozoic and Cenozoic rocks and surrounded by Paleozoic and Precambrian rocks (Figure 4). Faults of the New Madrid System are not visible at the surface of the earth because they occur in old Paleozoic and Precambrian rocks that are buried by younger Mesozoic and Cenozoic sediments. Such faults are called ***blind faults***.

The main fault of the New Madrid System is drawn on Figure 4. It is well know because a series of strong earthquakes occurred along it in 1911 and 1912. One of these earthquakes was the strongest earthquake ever recorded in North America, and the potential for more strong

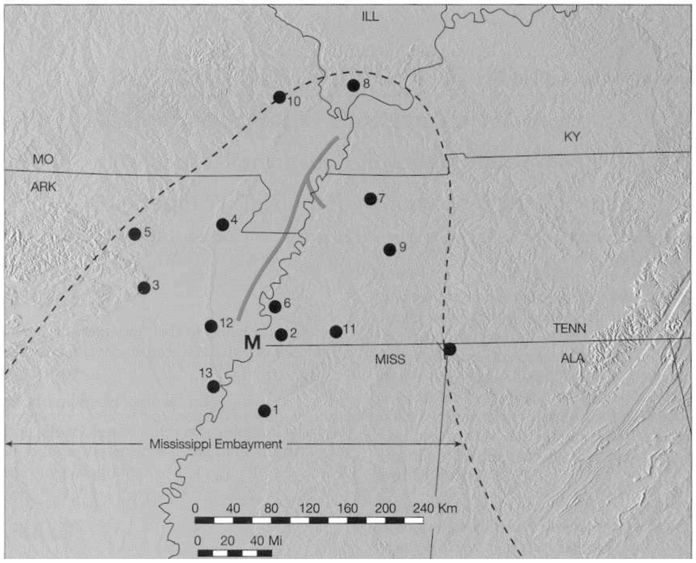


FIGURE 4. Map of the Mississippi Embayment showing the location of the main fault of the New Madrid (Blind) Fault System, numbered seismic stations (as in Figure 5), state boundaries, and the city of Memphis (M).

earthquakes here is a lingering hazard. The locations of thirteen seismic stations are also plotted on Figure 4. Seismograms from those stations from an earthquake along the fault are provided in Figure 5.

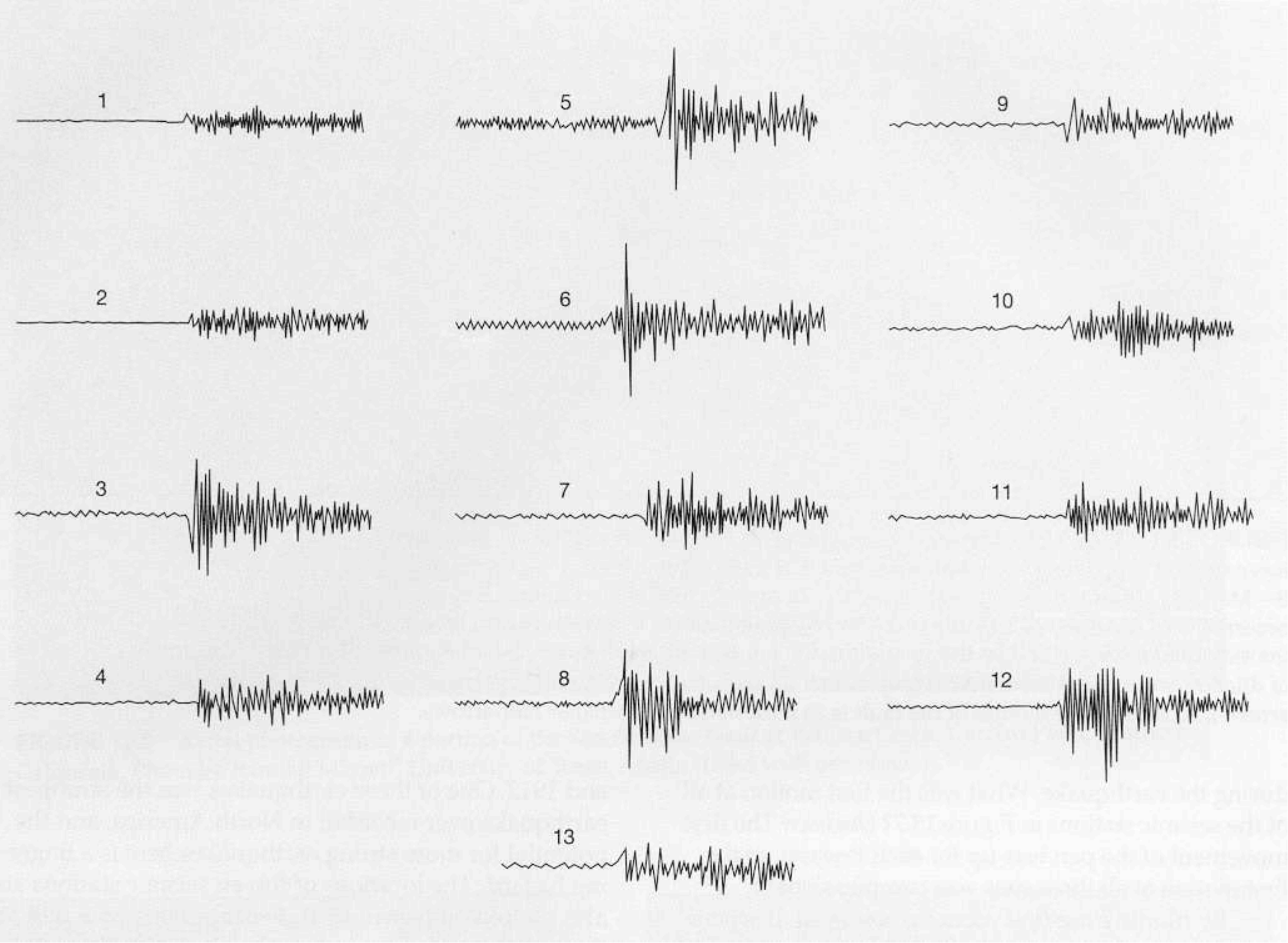
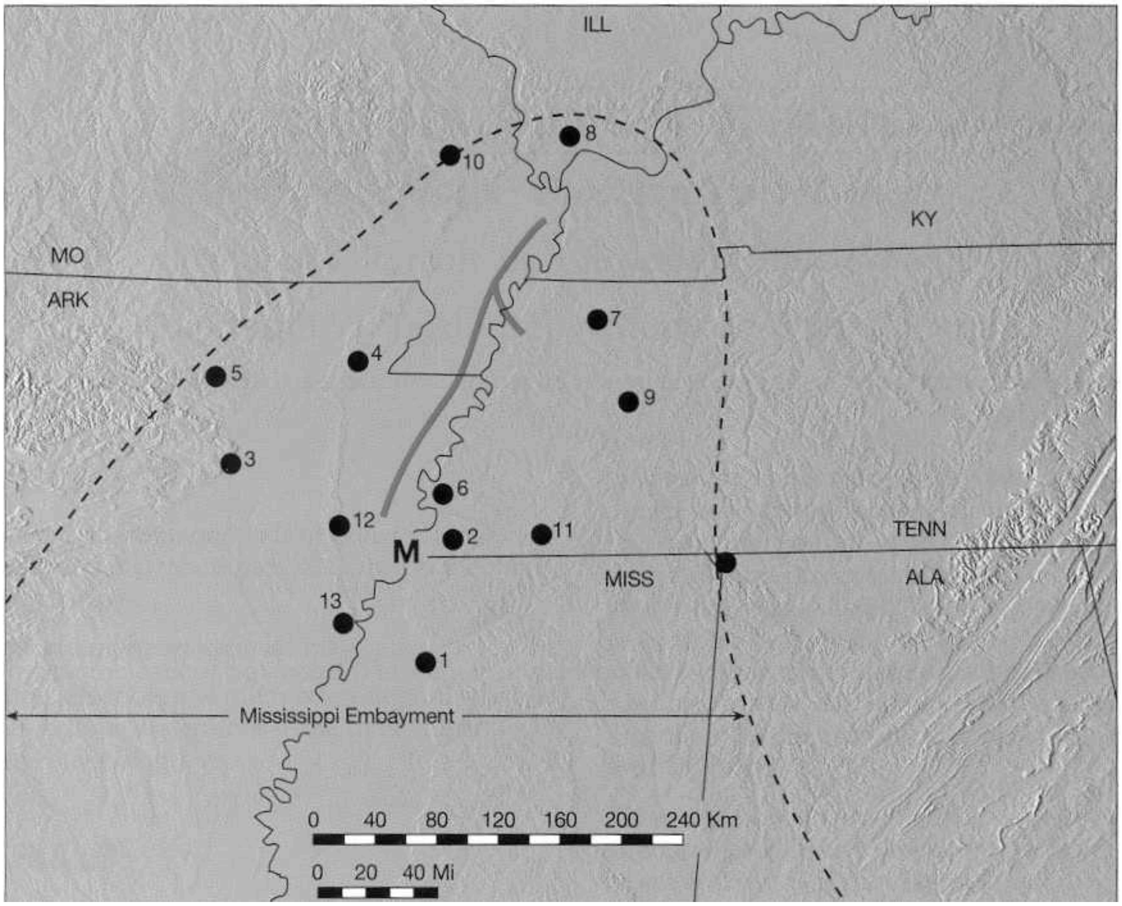


FIGURE 5. Seismograms from the 13 numbered seismic stations in the Mississippi Embayment after an earthquake that occurred in the New Madrid Fault System.

PROCEDURE

Use the seismograms in Figure 5 to determine whether the first motions at each station were dilational or compressional, and plot this information on the enlarge copy of Figure 4 below by writing either “D” (for dilational) or “C” (for compressional) beside each station.



Use the data you’ve plotted to draw the appropriate half arrows, in their proper places, showing the directions of motion along the fault.

What type of fault is this?________________________________

In terms of plate tectonics, what is unusual about the location of this fault?____________________

____