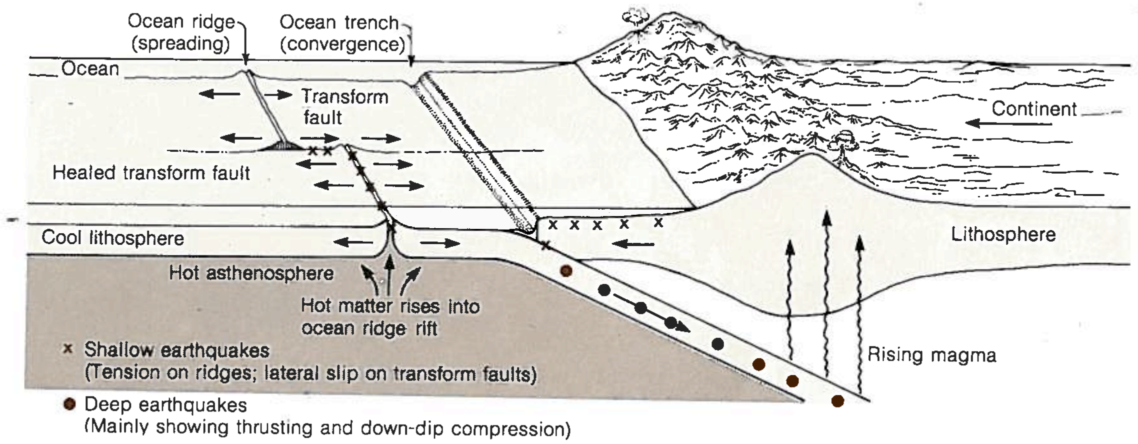

Figure 17-15
Diagram illustrating the association of earthquakes with three types of plate boundaries: ocean ridges, transform faults, and trenches.

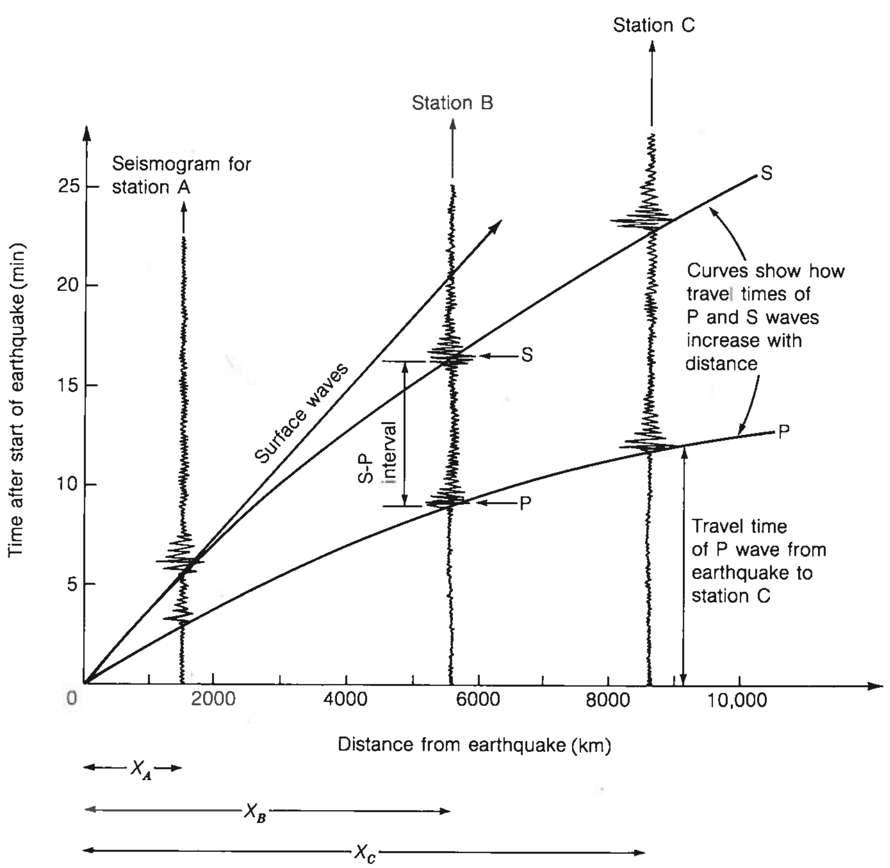

Figure 17-16
The time it takes P-, S-, and surface waves to travel a given distance can be represented by curves on a graph of travel time against distance over the surface. To locate an earthquake epicenter, the time interval observed at a given station is matched against the travel-time curves for P- and S-waves until the distance is found at which the separation between the curves agrees with the observed $S-P$ time difference. Knowing the distance from the three stations A, B, and C, one can locate the epicenter, as in Figure 17-17.

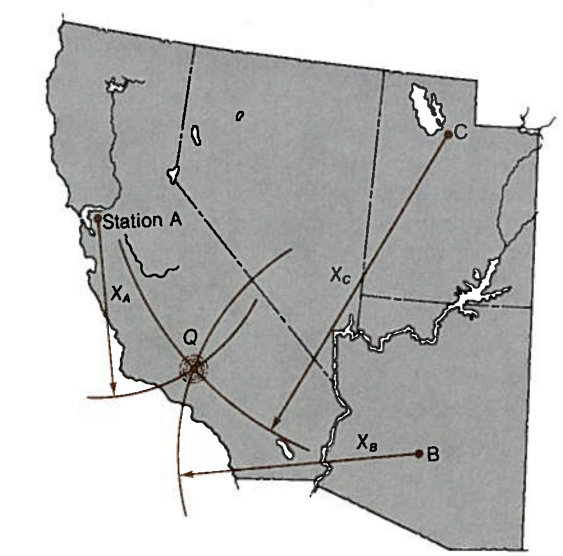

Figure 17-17
Knowing the distance, say X_A, of an earthquake from a given station, as by the method of the preceding figure, one can only say that the earthquake lies on a circle of radius A, centered on the station. If, however, one also knows the distances from two additional stations B and C, the three circles centered on the three stations, with radii X_A, X_B, X_C, intersect uniquely at the point Q, the epicenter.

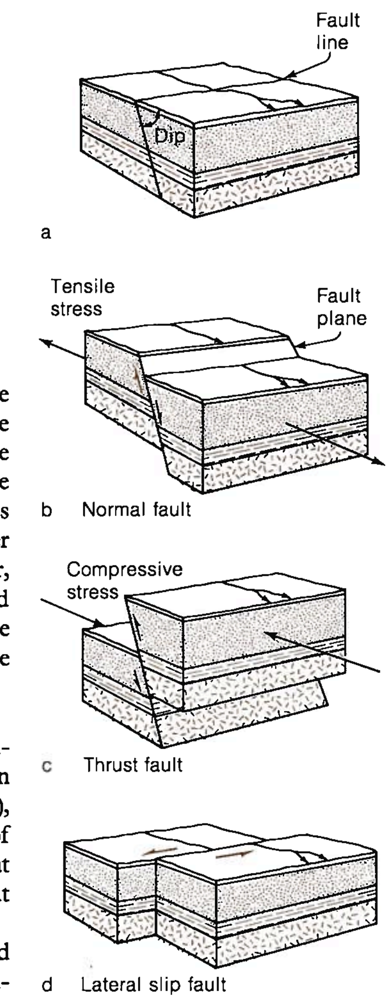

Figure 17-18
Summary of types of fault movement and the stresses that cause them: (a) situation before movement takes place; (b) normal fault due to tensile stress; (c) thrust (or reverse) fault due to compressive stress; (d) lateral slip (or strike slip) fault due to shearing stress.

associated a definite distance to the epicenter. This is indicated on the travel-time chart for P and S waves in Figure 17-16, which shows diagrammatically how the travel times of P and S waves depend on distance and how the $S - P$ interval increases with distance. To get an approximation of the epicenter, the seismologist simply reads off the $S - P$ interval on the seismogram from a given station and uses a nomogram* like that in Figure 17-16 or a table to get the distance to the epicenter. Knowing the distances from three or more stations enables him to pinpoint the epicenter (Fig. 17-17). He can also deduce the time of the shock at the epicenter because he knows the arrival time of the P waves at each station, and from a nomogram or a table he can tell about how long the waves took to reach the station. Once an approximation has been made, the exact location can be found by making refinements. The estimated location of the epicenter is used to predict the arrival time of P waves at each station. These predicted times are compared with the observed values, and the discrepancies are used as a guide to improving the estimated distance to epicenter and time of origin. For example, if all of the predicted times exceed the observed arrival time for P waves, then the estimated time of the earthquake is too late. If all of the stations on the east show earlier predicted times and the stations on the west are late, then the estimated epicenter is moved west. All of this is done in a computer, and the procedure is iterated—that is, repeated with corrections—until the discrepancies are reduced to small values, signifying that a precise location has been found.

*A nomogram is a graph used to determine an unknown quantity from two or more known quantities, saving the time to solve an equation or look up the answer in a table.

Obtaining Stress Patterns. When an earthquake occurs, one block slips relative to an adjacent one along a **fault plane** (Fig. 17-18*a*), as has already been indicated. The orientation of the fault plane and the slip direction are of great interest because they provide information about what happens at plate boundaries.

If the concept of plate tectonics is correct and seismicity is primarily associated with boundaries along which plates separate, collide, or slide past each other, then the fault orientations and slip directions should be different for each type of plate junction. Earthquakes in divergence zones should occur in response to tension, as if the plates are being pulled apart, and **normal faults,** in which the overlying block moves down the dip of the fault plane, should charact-