A very important piece of information about a seismic source is its focal depth below the Earth's surface. This is so because seismic sources much deeper than a few kilometres are unlikely to be clandestine underground nuclear explosions. The enormous costs aside, drilling operations required for such deep test holes are massive and difficult to evade detection from reconnaissance satellites and other NTM.

One of the most telling clues to the source depth may be found by an experienced seismic analyst in subtle changes of the oscillatory behaviour of the seismic record soon after the first-arriving P wave. A body wave leaving an earthquake or explosion source along a fairly steep, upward path is reflected at the Earth's surface (Figure 1). This once-reflected wave will then travel within the deep interior of the Earth, reaching a distant station a short time behind the P wave which has travelled to the station directly without the short detour above the source region. When both of these waves are seen on the station record, the time difference between the two can be used to determine accurately the depth of the seismic source below the Earth's surface.

Experts give this class of surface-reflected body waves a special name: "depth phase". The most commonly observed depth phase is pP, a seismic wave which travels as a P wave before and after the reflection at the Earth's surface above the source region. The time taken for the pP phase to reach a distant station differs from that of a direct P by an amount which roughly corresponds to the duration spent by the former to complete the detour above the seismic source.

The depth phases are elusive creatures, however. For a given seismic event, the depth phases may show up at some stations but not at others. Or they may not show up at all, especially when the sources are shallow, within the uppermost part of the Earth's crust. In some instances, highly sophisticated signal processing may succeed in unmasking their presence. Examples of a successful attempt to unmask hidden pP waves will be shown in Chapter 6.

Source Identification

To verify compliance with a nuclear test ban treaty, it is necessary to identify the nature of the seismic events that one has detected and located. We have already discussed the source differences between earthquakes and explosions. Large earthquakes are rare, and the source identification for these is straightforward. The most powerful earthquake/explosion discrimination method is based on a pair of measured values: body wave magnitude m_b and surface wave magnitude M_S, which we discussed earlier in Chapter 3. At a given m_b value, earthquakes have larger M_S magnitudes than do nuclear explosions. As the source strength decreases, the source identification becomes progressively more cumbersome and less straightforward. Figure 4 shows a plot of observed