DETERMINATION OF SOURCE CHARACTERISTICS OF UNDERGROUND NUCLEAR EXPLOSIONS FROM ANALYSIS OF TELESEISMIC BODY WAVES

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One of the classical problems of seismology is the recovery of information about the source of seismic waves using observations made at large distances from the focus. In this dissertation we have used long-period seismograph records of the body waves from a relatively simple type of source, an explosion, and applied equalization techniques in an attempt to retrieve information about the energy release, the source dimensions, and the strain levels near the focus.

We performed a spectral analysis of seventy-five P-wave records and five S-wave records from eight large, underground nuclear explosions. The displacement amplitude spectra in the frequency band from 0.05 to 1.0 Hertz were reduced to the source by application of the method of amplitude equalization. Estimates of the energy spectrum, cumulative energy spectrum, and strain spectrum on the focal sphere were derived for each event from the average displacement amplitude spectrum reduced to the focal sphere.

The total P-wave energy in the frequency

band from 0.1 Hertz to 0.7 Hertz was computed for each explosion for four different absorption models and the results compared. The energy calculations were found to be strongly dependent on the choice of the absorption model. At the present time, the effect of absorption on body-wave amplitudes is not well understood and is the subject of much discussion. The results we present here emphasize the need for an accurate knowledge of the absorption behavior in amplitude studies.

The portion of the total P-wave energy to be expected in the limited frequency band from 0.1 to 0.7 Hertz was calculated on the basis of Sharpe's theory and was determined to be of the order of one-sixth for a typical model of a one megaton explosion. Seismic coupling factors were obtained by comparing observed energies to the yields measured independently. These results were again found to be critically dependent on the absorption model. The model which gave efficiencies of the order of 10^{-3} is recommended as being the most appropriate for describing the absorption in the frequency band from 0.1 to 0.7 Hertz; this model corresponds to the assumption that (T/Q_{AV}) equals one and a half seconds where T is the travel time of the ray. Relations between magnitude and band-limited energy and magnitude and yield were developed.

The strain level on the elastic-nonelastic boundary of an explosion was computed from the P-wave magnitude using a ray-tracing technique. The value of this strain was found to be approximately 10^{-4}. Based on this same approach, the distance from the focus at which each explosion reached the same level was calculated. The results were compared to observations by others of the radius of the boundary between elastic and nonelastic behavior based on Sharpe's theory and to the relative size of the nonelastic zone obtained by comparing the levels of the strain spectra on the focal sphere. The correlation seems to be fairly good.