THE DETERMINATION OF CRUSTAL THICKNESS FROM THE SPECTRUM OF P WAVES

by

Luis M. Fernandez, S.J., S.T.L., M.S.

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The layers of the earth's crust act as a filter with respect to seismic energy arriving at a given station. Consequently the motion recorded at the earth's surface depends not only on the frequency content of the exciting seismic energy and on the response characteristics of the recording instrument, but also on the elastic parameters and thicknesses of the layers. This latter dependence is the basis for a method of investigating the structure of the crust.

In order to obtain information independent of the time history and spatial distribution of the source of energy the spectrum of the vertical component of motion is divided by the spectrum of the horizontal component. This ratio represents the tangent of the apparent angle of emergence as a function of frequency. It depends only on the angle of incidence of the ray and the system of layers below the recording station. The parameters of the crust may be determined by comparison of theoretical and observed spectra of this ratio.

To facilitate this comparison a set of master curves was calculated using the matrix development of Haskell. Calculations of these curves are in terms of a dimen-

sionless frequency. This presentation allows the grouping of the curves corresponding to different crustal models into families of curves. A set of master curves of the apparent angle of emergence for one-layer models and for different angles of incidence and contrasts of velocities between the crust and the mantle is presented. This set is complete in the sense that any one-layer model may be interpolated. A second set for some combinations of two-layer models is also presented.

The characteristics of these curves are discussed from the point of view of their "periodicity" in the frequency domain and of their amplitude in order to investigate the influence of the layer parameters. Considerations either of constructive interference or of Fourier analysis of a pulse multiply reflected within the crust reveal that the amplitude of peaks and troughs in the spectrum depends on the velocity contrast at the interfaces of the system. The "periodicity" or spacing of peaks and troughs depends on the time lags between the first arrival of the direct P wave and the secondary arrivals of the converted waves or of multiply reflected and refracted waves. Closely spaced fluctuations correspond to large time lags, and widely spaced

fluctuations to short time lags.

Observations of the spectrum of the apparent angle of emergence were obtained by dividing the smoothed / spectra of the vertical and horizontal component seismograms. In order to avoid the influence of reflections at the crust near the source or of reflections from the core of the earth, the earthquakes selected were of intermediate and large focal depth and were restricted to epicentral distances less than 55°.

Application of the method to the long-period seismograms of the Saint Louis University Network of stations gives an average P velocity in the crust of 6.6 km/sec and a total thickness of the crust of 42 km for the central part of the United States under these stations.