TRAVEL-TIME CURVES AND UPPER MANTLE STRUCTURE FROM LONG PERIOD S-WAVES

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The Twelfth General Assembly of the International Union of Geodesy and Geophysics (1960) identified the structure of the upper mantle as one of the key problems of the physics of the earth. From a study of this problem may come the answer to questions such as the causes of crustal movement and the generation of deep focus earthquakes. In recent years there has been a substantial amount of research related to this problem. For these upper mantle studies investigators have made use of body wave, surface wave and free oscillation data. Each method has its own characteristic advantages and limitations.

Recently investigators have exerted much effort in revising the travel-time curves for the P-wave, but little for the S-waves because of the lack of good data. Often the onset of the P-wave is clear and easy to identify. The reasons for the scarcity of S-wave data are:

1. The beginning of the S-phase may be overlapped by later motion of the P-group.

2. The high magnification seismographs have selective frequency characteristics so as to enhance the P-wave motion. Consequently they discriminate

against the lower frequency S-waves.

3. Complexities which arise due to the fact that beyond the critical angle of incidence there are phase differences between the vertical, the horizontal transverse and the horizontal radial components of the displacements of the S-wave motion at the free surface.

4. Complexities due to constructive and destructive interferences produced by crustal layering at the station.

Due to these difficulties no empirical S-wave travel-time curves comparable to the P-wave curves exist for shallow earthquakes in the distance range of about 1500 to 3000 km.

This dissertation concerns an attempt to construct such travel-time curves for the long period S-wave. Special techniques were used in determining the onset of the S-phase for constructing the travel-time curves, since the determination of the onset by visual inspection in this range of distance is doubtful. Observationally determined travel-time curves were obtained and interpreted in terms of the velocity variation within the upper mantle.

Some of the results obtained from this investigation are:

1. An observationally determined multi-branched travel-time curve for the long period S for

distances of 3 to 64 degrees and focal depths of 33 and 120 km.

2. An average velocity-depth function for the S-phase for the upper mantle beneath the United States.

3. Evidence for the existence of a pronounced low-velocity layer for S which resulted in two overlapping branches in the travel-time curves rather than a shadow zone. The top of the layer is of a depth of about 150 km, and it is about 50 km thick.

4. An indication of two less pronounced low-velocity layers at depths of about 340 km and 670 km.

5. An indication that particle motion diagrams can be used as a powerful technique for determining the S-phase and later arrivals which may be hard to identify by visual inspection of seismograms.