THEORETICAL DISPERSION OF SURFACE WAVES FOR SOME CRUSTAL MODELS*

By L. THOMAS†

Dispersion curves of seismic surface waves, showing phase velocities as functions of period for both Rayleigh waves and Love waves, can be determined experimentally (e.g. Brune, Nafe, and Oliver 1960), and can also be calculated theoretically for given models of the crust (Haskell 1953; Bolt and Butcher 1960). Such models may be tested and perhaps refined by comparing theoretical with observed dispersion curves for a particular region.

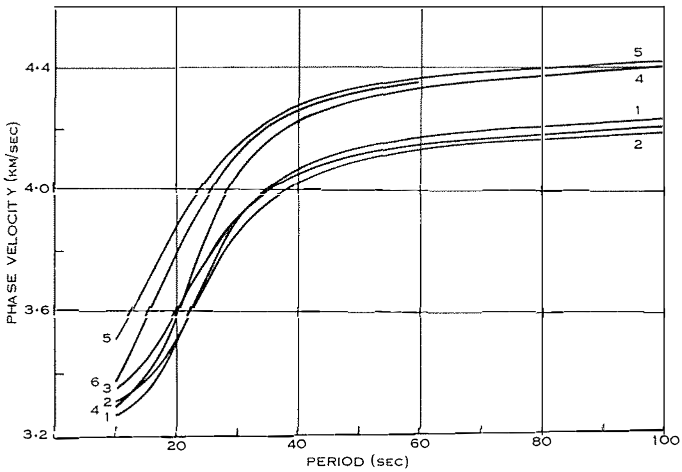

Fig. 1.—Rayleigh wave velocities for models 1–6.

To provide the theoretical curves of phase velocity as a function of period (the dispersion curves) for both Rayleigh and Love waves, computer programs have been written for the C.D.C. 3600 computer of the CSIRO in Canberra. The computer programs have been written in the form of "function subroutines" and are available from the program library of the Computing Research Section, CSIRO. One program (VELLR) calculates the velocity of a Rayleigh wave of given period, and the other (VELLQ) calculates the Love wave velocity.

The matrix method of Haskell (1953) is used in each case to calculate the phase velocity of the surface wave at a given period. The Earth models used may consist of up to 24 layers of homogeneous perfectly elastic media in welded contact with each other, overlying a similar medium of infinite depth. The properties of each layer are fixed by specifying the density, thickness, and compressional and shear velocities in that layer. The velocity value obtained is correct to four significant figures.

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† Physics Department, University of Adelaide.

The VELLR subroutine returns a velocity value to the main program in about $0\cdot5(L-1\frac{1}{3})$ sec, where L is the number of layers in the model, and VELLQ returns its value in about $0\cdot15(L-1\frac{1}{8})$ sec. The times increase slightly as the period increases.

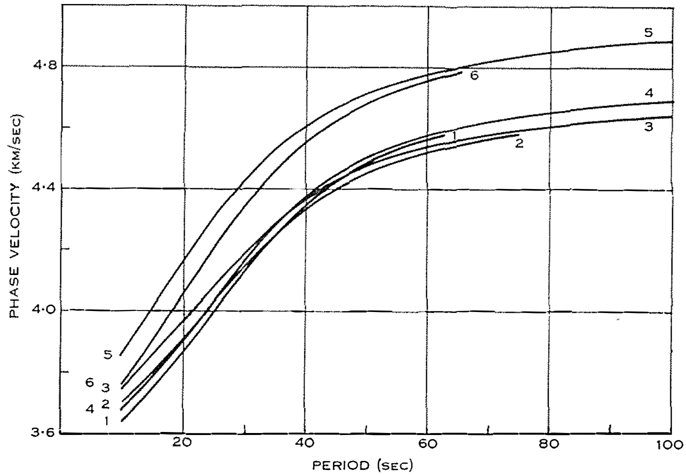

Fig. 2.—Love wave velocities for models 1–6.

TABLE 1

COMPARISON OF THE CRUSTAL MODELS

Properties of the Layers*	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
ρ_1	2·65	2·67	2·6	2·75	2·75	2·75
d_1	36	37	20	3	3	3
α_1	6·03	6·03	6·03	5·9	5·9	5·9
β_1	3·55	3·61	3·61	3·5	3·5	3·5
ρ_2	3·4	3·33	2·7	2·75	2·75	2·75
d_2			20	32	11	17
α_2	8·21	8·16	6·5	6·18	6·18	6·18
β_2	4·75	4·7	3·85	3·59	3·59	3·59
ρ_3			3·33	3·5	3·05	3·05
d_3					28	22
α_3			8·16	8·48	7·24	7·24
β_3			4·7	4·95	4·15	4·15
ρ_4					3·5	3·5
α_4					8·48	8·48
β_4					4·95	4·95

* ρ = density of layer (g/cm^3), d = thickness of layer (km), α = velocity of compressional wave in layer (km/sec), and β = velocity of shear wave in layer (km/sec).

By minor changes to the programs, more than 24 layers may be accommodated, or greater or less accuracy may be obtained.

Computations were carried out for a number of models relevant to the Australian continent and the results are shown in Figures 1 and 2. The models are described in Table 1. Model 1 is based on the results of Bolt, Doyle, and Sutton (1958). Models 2 and 3 were suggested by Underwood (personal communication) and models 4, 5, and 6 by Everingham (personal communication).

The density values for model 1 were chosen somewhat arbitrarily, and several different combinations were computed. These results were used to calculate curves of $\partial c/\partial w$ (where c is the phase velocity and $w = \rho_1/\rho_2$, ρ_1 being the density of layer 1,

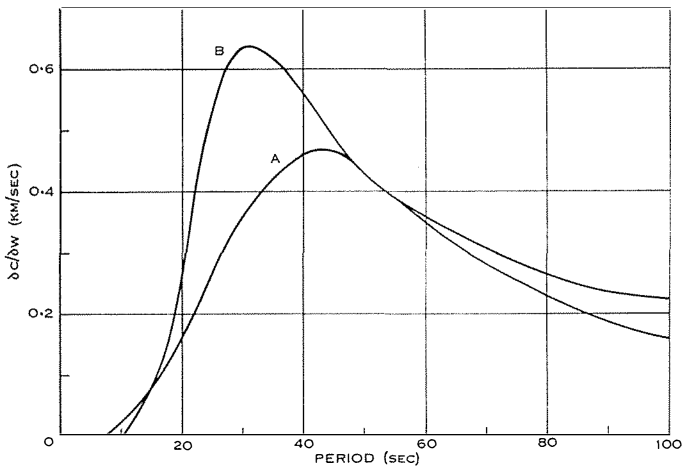

Fig. 3.—Curves of $\partial c/\partial w$ at various periods for (A) Love and (B) Rayleigh waves.

ρ_2 the density of layer 2) at various periods for both Love and Rayleigh waves. These curves are shown in Figure 3, and illustrate one way in which the computer subroutine might be used to improve Earth models.

With the increase, in recent years, of the number of long-period seismographs in Australia, and the use of computing facilities as described above, the study of surface wave dispersion can be expected to produce important information about the crust of the Australian continent.

References

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Bolt, B. A., Doyle, H. A., and Sutton, D. J. (1958).—*Geophys. J. R. Astr. Soc.* **1**: 135.
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