# A PROPOSAL FOR THE STUDY OF THE CRUSTAL AND UPPER MANTLE STRUCTURE OF THE WESTERN MEDITERRANEAN BY SURFACE WAVE DISPERSION

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With the development of modern seismological measuring techniques it is possible to determine the crustal and near-mantle structure of a given region by the use of the dispersion of Rayleigh waves from a distant earthquake.

It is known that Rayleigh waves in layered structures are dispersed; that is, waves of certain frequencies travel faster than do waves of other frequencies. Figure 1 shows the curve of phase velocity in km/s as a function of period for an homogeneous crust of 25 km thickness overlying an homogeneous half-space. The physical properties of the two regions are taken to correspond to average values for a normal crust and upper mantle. The major variation in velocity with frequency occurs in the period range 10-40 s.

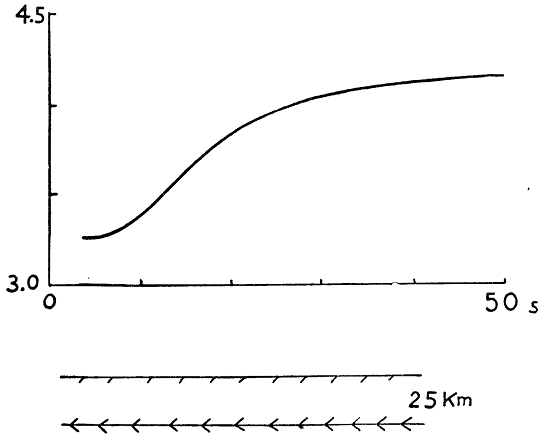


FIG. 1. — *Rayleigh wave phase velocity for homogenous layer 25 km thick overlying homogenous half-space.*

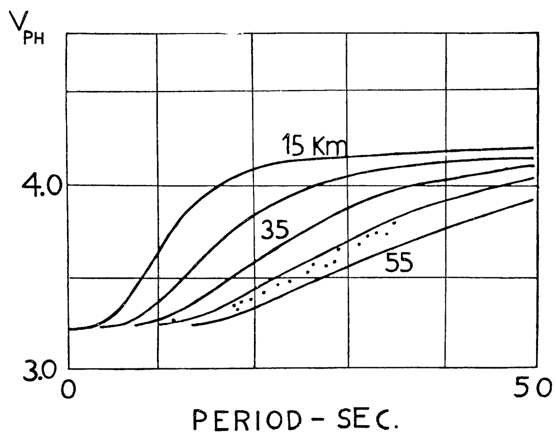


FIG. 2. — *Rayleigh wave phase velocities for the Rocky Mountains compared with theoretical curves for single layers of different thicknesses overlying a half-space.*

If the thickness of the crust is varied, other dispersion curves are obtained; a different curve of phase velocity as a function of period will correspond to each assumed structure. This is illustrated in figure 2. It is seen that the phase velocities all fall between 3,2 km/s for the short period surface waves and 4,15 km/s for the longer period waves. The period at which the curves have their inflection is approximately characteristic of the thickness of the assumed structure for the crust.

It therefore follows that a measurement of the phase velocity in a given region, this measurement made as a function of period should yield information about the crustal thickness. A result of such a measurement is shown in figure 2 (EWING and PRESS, 1959). In this case, for the Rocky Mountains of the United States, the crust is about 48 km thick.

A more sophisticated method of the interpretation of surface wave phase velocities in terms of the structures which give rise to the dispersion has now been made. This is an analytical method requiring extensive computation but which refines the structure obtained and gives more detail than that of the simple example presented here.

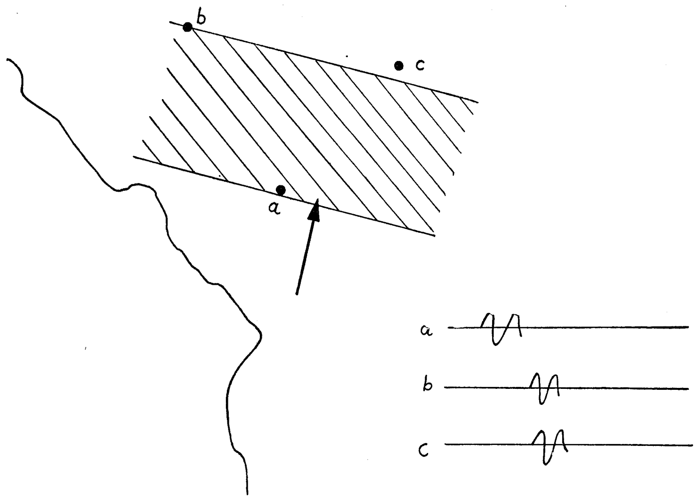


FIG. 3. — *Region governed by array of seismographs.*

The experimental procedure is as follows. Measurements are made with long-period seismographs, capable of operating in the range 10-60 s. With three such instruments placed in a triangular array, we measure the travel time of surface waves of each period through the region governed by the array (fig. 3). Three stations are necessary to eliminate the problems of skew directions of arrival.

The seismograms are digitized and a Fourier analysis is then performed on a Bendix G-15 or an IBM 709 computer. The phase spectrum, the ratio of the sine and cosine transforms, yields the relative arrival times as desired over the entire frequency range. This procedure is more reliable than that of determining periods by measuring zero-crossings. The interpretation proceeds as described earlier.

At the present time we have a program of this type in operation in and around the Alps. We are attempting to determine the crustal and nearmantle structure of the Alps. With the co-operation of the European Seismological Subcommission (1) we have obtained permission to install four Press-Ewing vertical long-period seismographs at four seismographic observatories in and around the Alps. Our four stations are : (fig. 4) Stuttgart, Germany; Chur, Switzerland; Besançon; France; Oropa, Italy. These are indicated by large dots on the map; other observatories in the region are indicated by smaller dots. The four instruments are identical. The period of the seismograph is 15 s; the period of the galvanometer is 90 s. The maximum amplification is 4000.

The three seismograms (fig. 5) show records for october 5, 1960, taken at Chur, Besançon and Oropa. The dispersion is evident in each of these; the long periods in the earthquake come in much sooner than do the short periods. The seismograms are different at the three stations thus indicating that phase shifts have taken place and that the Alps themselves have further dispersed the waves. The epicenter for the earthquake was in Japan.

Duplicate records are taken at all stations. One set is sent to us for study. A second set is deposited in a central bureau (in this case, Stuttgart) for use by any members of the European

(1) Chairman, Professor H. CLOSS of Hannover.

Subcommission. There are many recordings that are not useable for our purpose which, nevertheless, contain other important scientific information that may be of interest. For this reason our duplicate records are made available to our colleagues. For example, on november 23, 1960, we recorded a strong earthquake amid a microseismic storm. In the example of figure 6 both P and S are clear and distinct. The problems of epicenter location, first motion studies, microseisms, local seismicity are not of interest to us; the details from our recordings are made available to all.

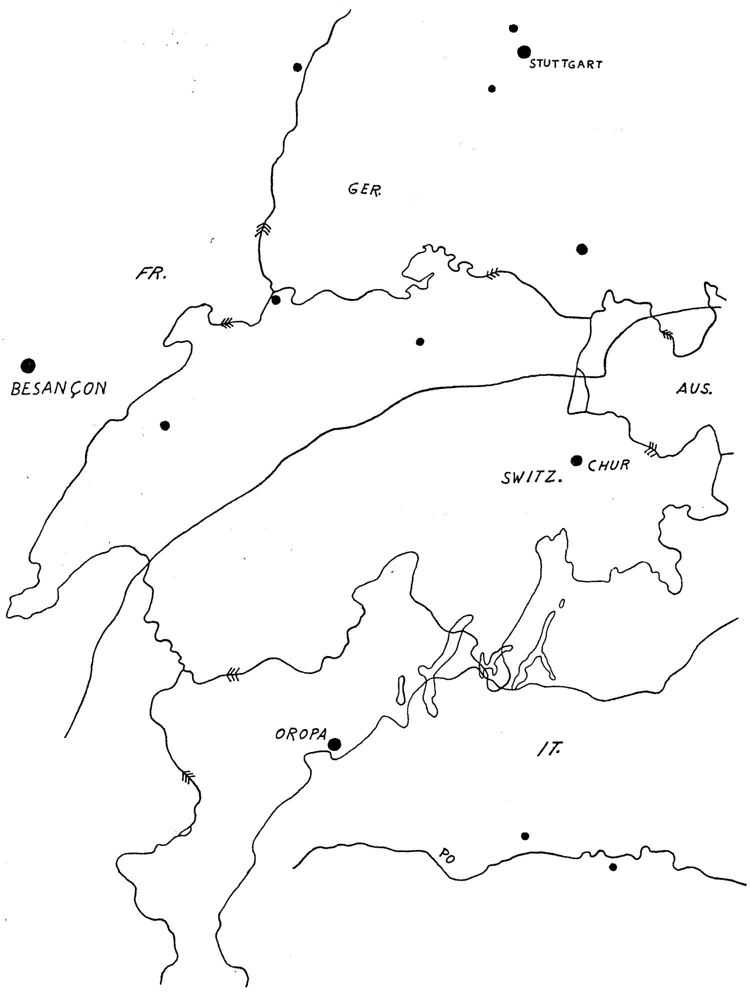


Fig. 4. — *Alpine Network.*

Figure 7 shows the phase spectrum obtained from the digitization and Fourier analysis of a seismogram obtained at Chur due to the earthquake on the Mid-Atlantic Ridge on october 6, 1960. The analysis for the other three stations is now under way.

Our instruments reside in one locality for about four to six months. We record, on average, about two earthquakes each day. We obtain from our analysis an average picture of the crustal structure within and near the area covered by our instruments.

We request that this International Commission give its approval to our undertaking of a program of study of the western Mediterranean in the same way that its sister commission has approved our study in the Alps. We propose that, in the spring of 1961, we bring our four instruments from the Alps to stations surrounding the western Mediterranean; figure 8 shows a map

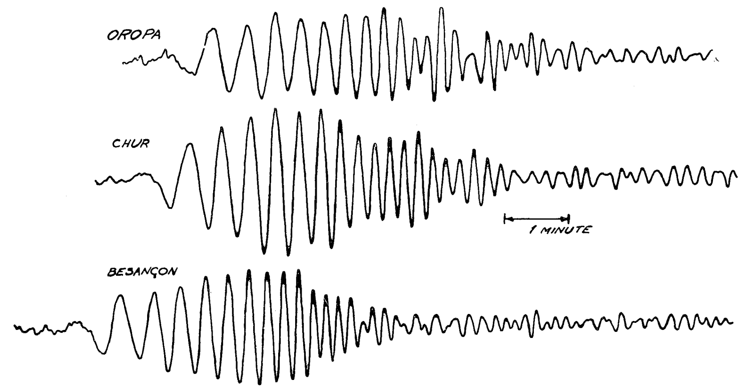


FIG. 5. — *Seismograms for october* 5, 1960.

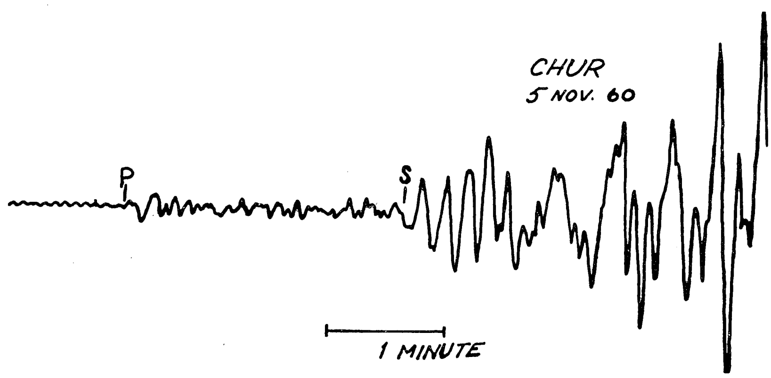


FIG. 6. — *Earthquake of november* 5, 1960 *recorded at Chur.*

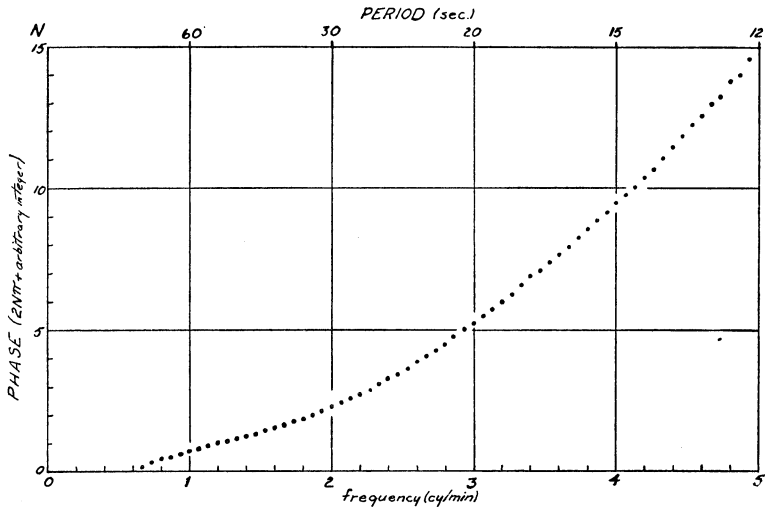


FIG. 7. — *Phase spectrum for earthquake of october* 5, 1960, *as recorded at Chur.*

of this area. Seismic stations are shown by dots. The stations most appropriate for our purpose wil be Tortosa, Spain; Cuglieri, Sardinia; Algiers and Monaco — all shown by heavy dots.

The stations in the Alpine network are also shown by heavy dots. With the installation of the four new observatories we shall embark upon a program to supplement meager explosion

FIG. 8. — *Proposed network for the western Mediterranean.*

seismic data and to provide a rough picture of the crustal structure in this region. Duplicate records will be deposited, if desired, in a site of the Commission's choice.

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RÉFÉRENCE

EWING (M.) and PRESS (F.), 1959. — *Bull. Geological Soc. America*, **70**, p. 229.