The structure of the crust and upper mantle under the Mediterranean Basin from Rayleigh wave dispersion

by

D. SEIDL, S. MUELLER, M. CAPUTO, G.F. PANZA and L. KNOPOFF

Abstract

The results of Rayleigh wave dispersion measurements in the Mediterranean Basin are summarized. They reveal as the predominant feature a well-developed low-velocity channel in the upper mantle with variable regional structure. An outlook is presented on the current dispersion observations in Italy and around the Tyrrhenian Sea. These investigations are performed in cooperation between the Geophysical Institute of the University of Karlsruhe, (Germany), the Istituto di Geodesia of the University of Bologna (Italy), and the Institute of Geophysics and Planetary Physics of the University of California at Los Angeles (U.S.A.).

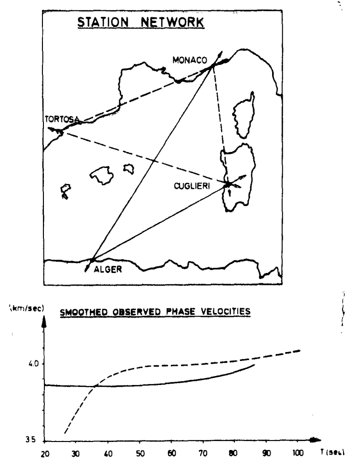

FIG. 1. — Stations around the Western Mediterranean Basin with propagation paths across the network and smoothed observed phase velocities of Rayleigh waves.

Phase velocities of Rayleigh waves have been studied 1961 [BERRY & KNOPOFF, 1967] along some station profiles in the network Monaco, Tortosa, Cuglieri and Alger. (Fig. 1). The smoothed observed phase velocities are clearly separated into two groups (Fig. 1) : The solid curve is made up of the data for the lines Monaco-Alger and Alger-Cuglieri through the central part of the basin. The dashed curve corresponds to results for profiles along the margins : Tortosa-Cuglieri. A broad phase velocity plateau

* Tortosa-Monaco and Monaco-Cuglieri, as well as the line.

Rapp. Comm. int. Mer Médit., **21**, 11, pp. 873-876, 2 fig. (1973).

is found in both dispersion curves. The inversion of these data leads to the following conclusions about the structure of the crust and upper mantle : The channel shear velocity below the central part of the basin decreases to the unusual low value of 4.1 km/sec, and it has a value of 4.45 km/sec under the margins. The top of the channel is found at a depth of about 50 km under the center of the basin and drops to approximately 100 km depth under the margins.

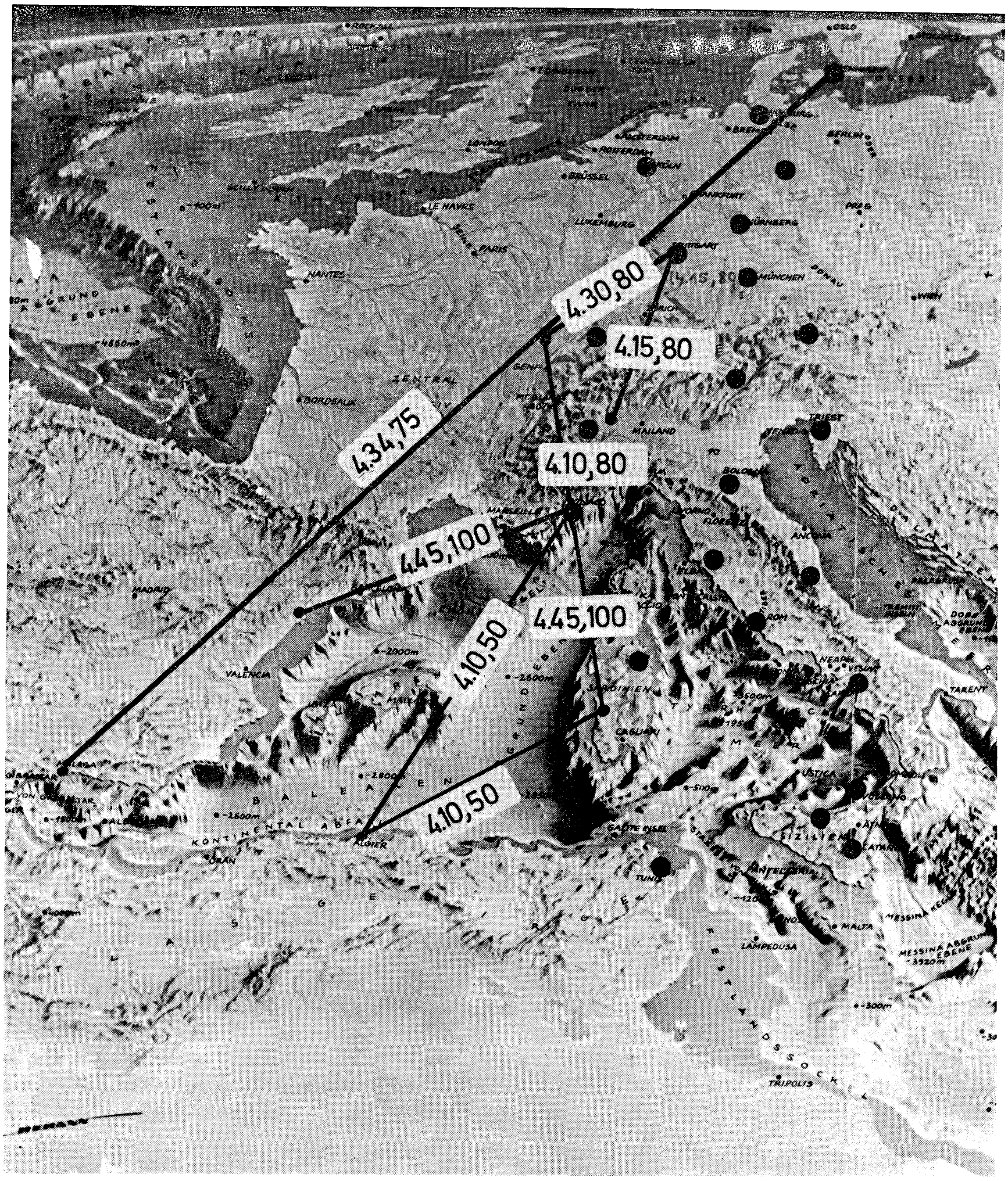

FIG. 2. — Mean values of the channel shear velocity and the depth to the top of the channel for some profiles in Europe. The black dots indicate the position of the stations within the new projected network.

Although the upper crust has no significant influence on the phase velocities for periods greater than 20 s, the crustal model derived by FAHLQUIST [1963] from refraction data for the central basin was used in the inversion process. The horizon with a P-velocity of 7.70 km/s and a S-velocity of 4.5 km/s found by FAHLQUIST [1963] at a depth of 11 km under the center, was detected by surface waves at 30 km depth below the margins.

To fit the dispersion data, a layer with shear velocity 4.75 km/s and P-velocity 8.15 km/s had to be assumed between the channel and the 7.70 km/s layer. The depth to the top of this layer seems to be 30 km under the center and 60 km around the margins. This fact suggests that the crust of the central basin is similar either to a continental crust or to a crust in transition to one of continental properties.

The mean shear velocity and the depth to the top of the low velocity channel show characteristic regional variations. In a topographic map of the Mediterranean Sea and the adjoining regions these two parameters are shown for some profiles (Fig. 2). A similar channel velocity as detected under the center of the Mediterranean basin has been found below the Alps [KNOPOFF, MUELLER & PILANT, 1966] as indicated for the profiles Monaco-Besançon and Stuttgart-Oropa in northern Italy. The top of the channel is found at a depth of about 50 km under the central basin. It drops to a depth of nearly 100 km under the margins and rises to approximately 80 km below the Alps. Additional observations will be required to clarify the problem whether there is a continuous connection between the central Mediterranean and the Alpine low-velocity channel. For the line Stuttgart-Besançon the values found are 4.3 km/s and 80 km, and for the trans-European profile Malaga-Copenhagen 4.34 km/s and 75 km. For this line the bottom of the channel has been found at 280 km depth from the dispersion of long-period surface waves [SEIDL, 1971].

A new program of Rayleigh wave observations in Italy, the Tyrrhenian Sea and central Europe will be started in 1971. This project is performed in cooperation between the Geophysical Institute of the University of Karlsruhe (Germany), the Istituto di Geodesia of the University of Bologna (Italy) and the Institute of Geophysics and Planetary Physics of the University of California at Los Angeles (U.S.A.). Long period seismographs will be installed in Tunis, Catania, Gibilmana, Lipari, Salerno, Olbia, Grosetto, Bern, Bolzano and Radstadt. Also the long period stations in Roma, Bologna, Fürstenfeldbruck, Gräfenberg and Bensberg as well as the WWSS-Stations in Aquila, Trieste, Stuttgart and Copenhagen will be used.

Three main topics of the new program should be mentioned :

1. Phase and group velocity observations in the broad period range from about 10 to 200 s.

The structural interpretation of these data will cover the depth range reaching from the upper crust to nearly 450 km depth. An especially interesting point is the determination of the regional variations of depth of the bottom of the low-velocity channel within the upper mantle.

2. Fine structure investigations, using higher modes of Rayleigh waves.

The interpretation of fundamental mode data only reveals the mean structure over a broad depth range. In the last years new numerical techniques for the analysis of multimode signals have been developed. Since the dispersion curves of these higher modes are very sensitive against structural variations, variations in the fine structure, especially of the low-velocity channel can be resolved by analyzing the dispersion of higher modes.

3. A continuous mapping of the crust and upper mantle structure for the entire European network.

The simultaneous observation in this expansed network will help to clarify the problem whether there is a continuous connection between the different channel structures indicated in the map of Fig. 2, for example between the low-velocity channels found below the central basin of the Western Mediterranean Sea, the Tyrrhenian Sea and the Alps.

References

BERRY (M.J.) & KNOPOFF (L.), 1967. — Structure of the upper mantle under the Western Mediterranean Basin. *J. geophys. Res.*, 72, pp. 3613-3626.

FAHLQUIST (D.A.), 1963. — Seismic refraction measurements in the Western Mediterranean Sea. *Thesis*, Cambridge, Massachussett Institute of Technology.

KNOPOFF (L.), MUELLER (St.) & PILANT (W.L.), 1966. — Structure of the crust and upper mantle in the Alps from the phase velocity of Rayleigh waves. *Bull. seismol. Soc. Amer.*, 56, pp. 1009-1044.

SEIDL (D.), 1971. — Spezielle Probleme der Ausbreitung seismischer Oberflächenwellen mit Beobachtungsbeispielen aus Europa. *Dissertation*, Universität Karlsruhe.