The Low-Velocity Channel of the Upper Mantle under the Mediterranean Basin

by

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Tripartite phase velocities for long-period surface waves have been observed for the western basin of the Mediterranean Sea. These have been used to interpret the crustal and upper mantle structure of the region. A similar set of observations and interpretations has already been made and reported for the Alps region to the north of the Mediterranean area under discussion here [KNOPOFF et al, 1966]. A preliminary report, giving an outline of the work proposed, was presented to the Commission internationale pour l'exploration scientifique de la mer Méditerranée, Monaco, at its meeting in Monaco in December, 1960 [KNOPOFF & PRESS, 1961]. The present paper is a report ont he completion of the program of observations; a more detailed discussion of these observations and interpretations has been published elsewhere [BERRY & KNOPOFF, 1967].

In summary, the crust under the center of the basin is thinner than at the margins. A well-developed low-velocity channel is found under both regions, deeper under the margins and with a lower velocity in the channel under the center.

We have inquired whether the 7.70 km/sec horizon found at a depth of 10 km below the central basin [FAHLQUIST, 1963] extends as deeply as the low-velocity channel or whether we must introduce material with higher velocity at upper mantle depths. The depth to bottom of a postulated layer with S-velocity 4.45 km/sec, corresponding to a P-velocity of 7.70 km/sec, is 30 km in the center and 60 km around the margins of the basin. Despite uncertainties in the thickness of the layer with velocity 7.70 km/sec, it seems certain that the region with P-wave velocity about 8.15 km/sec is deeper under the margins of the basin than under the central section and that, on all accounts, higher velocity material *must be introduced* between the low-velocity channel and the 7.70 km/sec layer and at depths of the order of 30 to 60 km beneath the surface. In each case, we find such a layer to be necessary to achieve a fit. However, the existence of discrete layers is a computational device. There is no evidence for sharp discontinuities in surface wave interpretations; a gradual transition to velocities of this order at this depth is also consistent with the data.

The fact that material with P-wave velocity 8.1 km/sec is placed so deeply beneath both the central and marginal surfaces suggests that the crust of the central Mediterranean basin is similar either to a continental crust or to a crust in transition to one of continental properties. The 30 km depth to the 8.1 km/sec material is common on the continents, while the high velocity 7.7 km/sec material close to the surface under the center of the basin is typical of what KOSMINSKAYA [1963] calls a subcontinental crust found under the Kuriles and other island arcs and under the mid-oceanic ridges. To the east of the main crest of the Western Alps lies the Ivrea zone with its associated gravity high. This feature has been studied extensively by seismic refraction methods and it has been found that material with P-wave velocity 7.5 km/sec lies about 10 km below the surface in this region [FUCHS *et al*, 1963]. This crustal structure and the gravity values are remarkably similar to those associated with the structure in the center of the western basin directly to the south, although there is a difference in topographic relief of more than 3 km between the two regions.

Although our upper crust is typically oceanic, the lower crust and upper mantle structures postulated for the center of the Mediterranean basin are quite similar in character to 1) structures on the continental margins, as for example, our own marginal Mediterranean structures and those of southern Cali-

Rapp. Comm. int. Mer Médit., **19**, 4, pp. 669-670 (1969).

fornia [Press. 1960] and 2) structures in the continental interiors, as in eastern Nevada [Pakiser & Hill, 1963] and the Ivrea zone, and 3) structures under island arcs.

Beneath a lid, the region with P-wave velocity postulated to be 8.1 km/sec, which is present in all our cross-sections, a low-velocity channel is found. The velocity in the channel and depth to its top are well-determined by the interpretation. Because of the small uncertainties in these quantities, the differences between the cross-sections may be looked at more closely. The interpretation shows a well-developed channel of unusually low-velocity material with an S-wave velocity of 4.10 ± 0.05 km/sec under part of the western basin. A similar channel velocity is found under the Alps. There are no data as yet which delimit the lateral extent or possible northern extension of the Mediterranean channel; however, in the south the channel appears to be quite narrow. Along the margins of the basin, material of S-wave velocity 4.43 ± 0.10 km/sec is found in the channel. The channel with unusually low S-wave velocity appears to be confined to the eastern part of the basin, and to be surrounded by material of S-wave velocity 4.43 km/sec. The top of the channel is found at a depth of about 80 km under the Alps, but lies only 50 km under the western basin of the Mediterranean. This roof drops to depths of approximately 100 km under the margins. It is not clear whether the Alpine-central Mediterranean channel represents a continuous structure under the coast at Monaco. Additional observations will be required to clarify this point.

The gravity map of Europe and North Africa [de Bruyn, 1955] shows a strong gravity high in the shape of an inverted L lying along the line from Monaco to Alger, with the foot extending east to west, north of the coast of Africa. It is tempting to associate this gravity feature with the low-velocity channel and to postulate that the channel bends to the west around the southern edge of the Balearic Island chain toward the Straits of Gibraltar; however, we have no direct evidence on this point. In the absence of heat flow data, we are unable to correlate the low channel velocity in the center of the basin with a high thermal flux in this region, as was done in the case of the Alpine interpretation.

We are not able to draw any definite conclusion from our data regarding the bottom of the channel. However, there are weak indications that the bottom of the channel rises from a postulated depth of 220 km under the Alps to an average depth of 190 km under the central basin. Alternatively, we could interpret the central profile as having a dipping boundary at the bottom of the channel. In this case, the bottom of the channel might rise to as high as 170 km near the African coast. The marginal profiles indicate depths similar to those under the Alps.

An ultra-low channel velocity of 4.10 km/sec is found underneath both the western basin of the Mediterranean and the Alps. Thus, the low-velocity channel represents a mantle structure at shallow depth which is uncorrelated with widely discordant topographic and geological features, a similar structure being found under both seas and mountains. This would seem to demonstrate that the forces producing the sea and mountain features are not significant agents of deformation at depths as low as the low-velocity channel, if these features are of comparable age.

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