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AN INVESTIGATION OF THE MOHO TOPOGRAPHY BENEATH THE MARMARA REGION FROM THE AZIMUTHAL ANOMALIES

AZİMUTAL ANOMALİLERE GÖRE MARMARA BÖLGESİNDE MOHO SÜREKSİZLİĞİNİN GÖRECELİ TOPOĞRAFYASI

M.F., ÖZER[*], T. TAYMAZ[**] and Ö. KENAR[*]

[*] Department of Geophysical Engineering, Kocaeli University, 41300-Kocaeli
[**] Department of Geophysical Engineering, İstanbul Technical University, 80626 Maslak-İstanbul

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Abstract

Accurate determinations of particle motions is a powerful tool in the investigation of seismic wave propagation. In these studies, the medium is assumed to be homogeneous and isotropic. While the medium is getting more heterogeneous and anisotropic, some deviations are observed in polarization properties, angle of incidence and azimuth of the seismic waves.

Therefore, information about the medium such as heterogeneity and anisotropy could be obtained from particle motion diagrams. We have tried to determine the azimuthal anomalies of the region from the P-wave particle motions using three component short-period seismograms recorded from numerous earthquakes occurred in the vicinity of the Sea of Marmara.

Azimuthal anomalies are generally considered to be related to lateral heterogeneities with the mediums. We have interpreted them in the sense of three dimensional dipping discontinuity (Moho) under the epicentre. Relative topography of the Moho discontinuity beneath the Marmara Region has been obtained using this new assumption.

Introduction

The Sea of Marmara is a marine basin in northwest Turkey that connects the Aegean Sea with the Black Sea. It is 275 km long and 80 km wide with a broad shallow shelf to the south and a series of deep (up to 1250 m) subbasins to the North (Smith et al. 1995). The Sea of Marmara is located at the western end of th North Anatolian fault. Across most of the Turkey the North Anatolian fault is a relatively simple, narrow, right-slip fault zone; however, it splits into several fault strands in the vicinity of Sea of Marmara do that the deformation becomes distributed over an ~120 km broad zone (Şengör et al., 1985; Barka and Kadinsky-Cade, 1988); Suzanne et al., 1990). The distributed deformation continues to the west across the North Aegean (Taymaz et al. 1991). Numerous damaging earthquakes have affected the Sea of Marmara region in historical time (Ambraseys and Finkel, 1991; Ambraseys, 1988). Both strike-slip and pure normal faulting earthquakes have occurred in the region (Taymaz et al. 1991).

In the seismological studies, a simple structure model consists of homogeneous, isotropic and horizontal layers overlying the half space is taken, and plane waves are used in order to help computing. In such a simple model, P-waves propagate in a vertical plane between the source and station, and their particle motion is linear along the ray path. Therefore, vertical-radial (Z-R) and NS-EW diagrams of the P-wave particle motions give the apparent incidence and azimuth angles, respectively. Clearly, this known particle motion will change when the medium is heterogeneous and anisotropic. This property provides the particle motions to be used in for determining the heterogeneity and anisotropy of a region. For example, if there dipping layers, refracted and reflected waves deviate from the source-station vertical plane, i.e. deviations take place in the apparent incidence and azimuth angles of the waves. Deviation in the azimuthal angle is called as *the azimuthal anomaly*, which can be used to determine the topography of discontinuities along which the waves propagate. In this study, topography of the Moho beneath the Marmara region has been investigated from observations of the azimuthal anomalies in Pn-waves. Azimuthal anomalies can be determined from both the polarization analysis and particle motion diagrams. Basa et al. (1994), have given a good example for polarization analysis in which azimuth of the incident wave is estimated. We have determined the azimuthal anomalies directly from the particle motion diagrams.

Determination of the Azimuthal Anomalies From the Particle Motion Diagrams

Since the P-wave particle motion is along the ray path, if the azimuth computed from the coordinates of the station and source is true, maximum and minimum wave amplitudes have to be on the radial (R) and tangential (T) components, respectively.

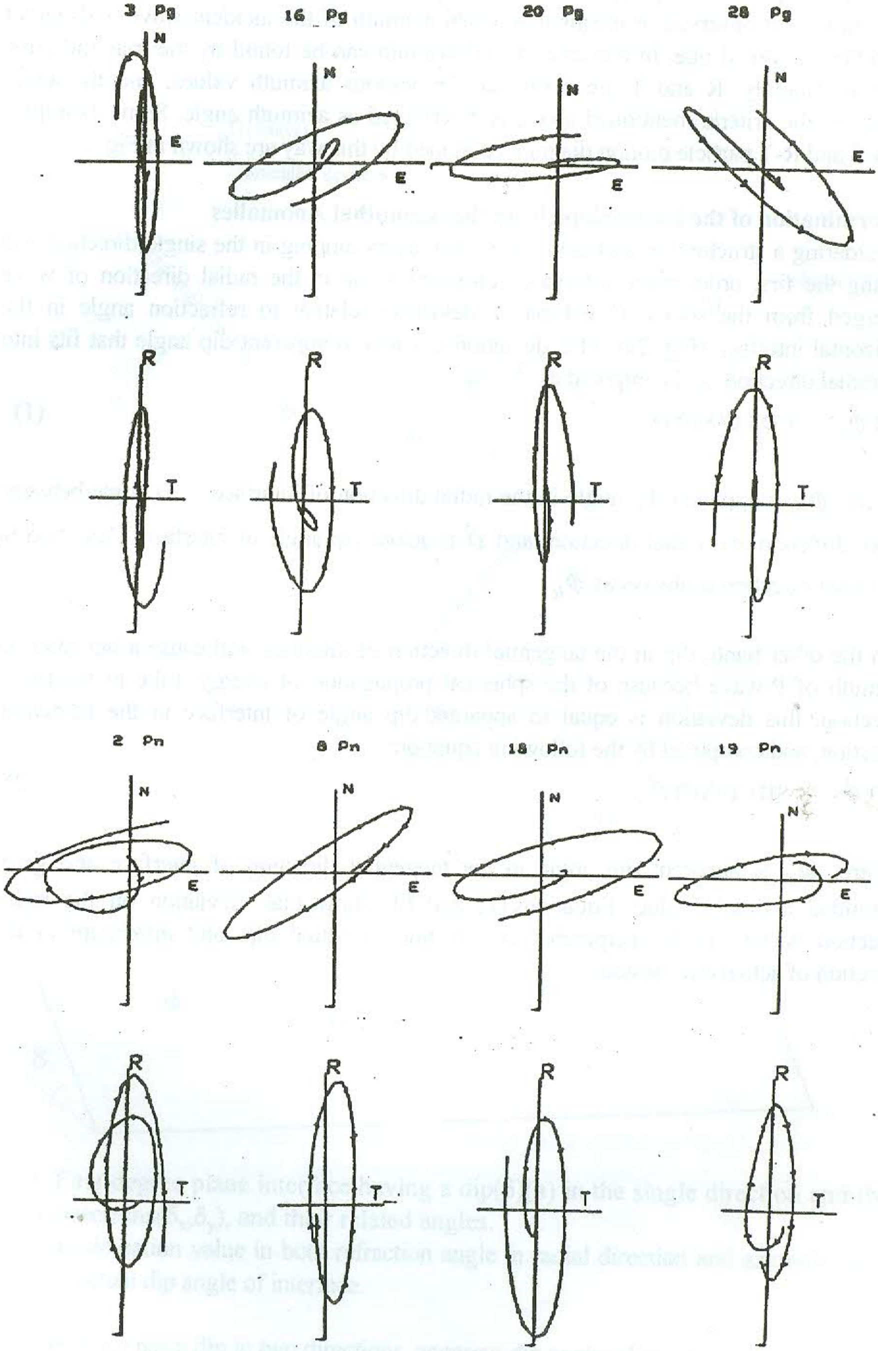

Fig. 1. The particle motion diagrams for earthquakes studied. Earthquake numbers in Table 1 and their first arrivals are at top of diagrams. N-E diagrams are unrotated, and their rotated diagrams are plotted at the bottom.

Thus, it is expected that particle motion fits into radial direction on the R-T diagram. If this can not be observed, it means that actual azimuth of the incident wave is different from the computed one. In this case, actual azimuth can be found by the trial and error method. Namely, R and T are computed for various azimuth values, and the angle satisfying the criteria mentioned above is determined as azimuth angle. Some examples of N-S and R-T particle motion diagrams obtained by this way are shown in Fig. 1.

Determination of the Layer Slope from the Azimuthal Anomalies

Considering a structural model consists of two layers dipping in the single direction and having the first order plane interface, refraction angle in the radial direction of wave emerged from the source O exhibits a deviation relative to refraction angle in the horizontal interface (Fig. 2a). This deviation is equal to apparent dip angle that fits into the radial direction, and computed as

$$\sin \phi_R = \cos \psi \sin \delta \tag{1}$$

Where, ϕ_R is apparent dip angle in the radial direction of interface, is angle between strike direction and radial direction, and δ is actual dip angle of interface. Deviation in the radial direction is always as ϕ_R.

On the other hand, dip in the tangential direction of interface will cause a deviation in azimuth of P-wave because of the spherical propagation of energy. Like in the radial direction, this deviation is equal to apparent dip angle of interface in the tangential direction, and computed by the following equation;

$$\sin \phi_T = \sin \psi \sin \delta \tag{2}$$

Where, ϕ_T is apparent dip angle in the tangential direction of interface and gives azimuthal anomaly value. Equations (1) and (2) show that deviation on the radial direction is zero in the perpendicular direction to actual dip, and maximum in the direction of actual dip. Besides,

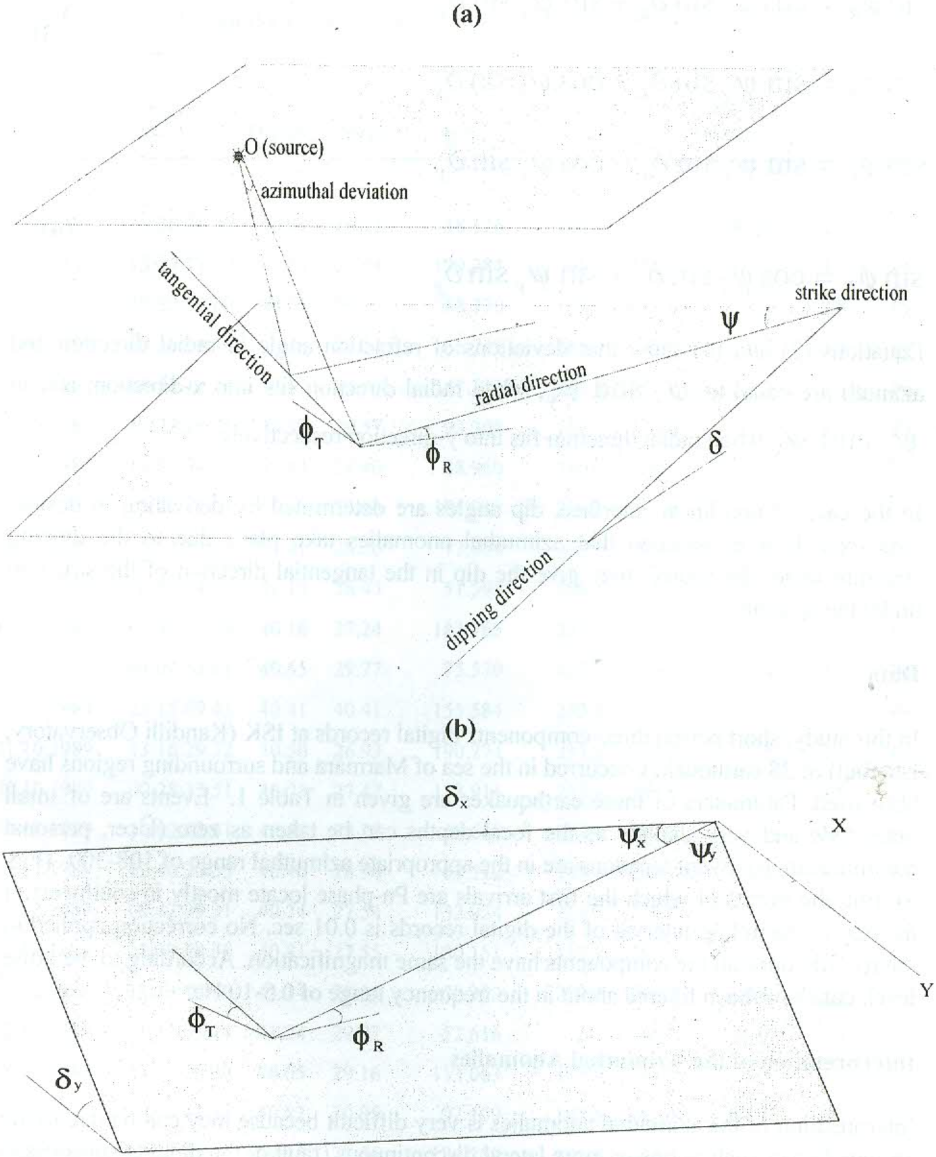

Fig. 2. First degree plane interface having a dip(δ)**(a)** in the single direction and **(b)** in two directions(δ_x,δ_y), and their related angles.

maximum deviation value in both refraction angle in radial direction and azimuth angle will be as actual dip angle of interface.

When interface has a dip in two directions, apparent dip angles (Fig. 2b) are computed by the following equations;