DEEP AZIMUTHAL SEISMIC ANISOTROPY IN THE WESTERNANATOLIA AND AEGEAN SUBDUCTION ZONE

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Keywords: Anisotropy, shear wave splitting, Aegean region and subduction zone

ABSTRACT *Shear wave splitting due to source-side mantle anisotropy is estimated from broadband teleseismic and local S waves using a suite of Aegean subduction zone events. The data have been recorded by Kandilli Observatory and Earthquake Research Institute (KOERI) stations, at the depth of more than 30 km, from 2000 to 2007. We assume that there are at most two anisotropic regions along the ray path: one on the source-side and the other one on the receiver-side. It has been known that receiver-side splitting is found from analysis of SKS waves. Aim of this study is to investigate the kinematics of subduction; its influence on mantle convection and related deformation by using seismic anisotropy. From the combined analysis of SKS, local S, and teleseismic S waves, we have concluded that there must be azimuthal seismic anisotropy in the deep part of the mantle around the consuming slab. The splittings of the waves recorded at the stations in the western Anatolia have allowed us to constrain the orientation and depth distribution of the anisotropy both below and above the slab. In the lithospheric mantle beneath the western part of the Anatolia, S- wave fast propagation direction is parallel to the direction of the extension of the Aegean region. Our results at Balıkesir (BALB), Antalya (ANTB) and Dalyan (DALT) stations show that fast split shear wave direction is about NE and delay time greater than 1 sec. These findings give information about the nature of the deformation and the coupling between the subducted lithosphere and surrounding asthenosphere. These results are consistent with the presence of azimuthal seismic anisotropy in the asthenosphere below the slab. Local S phases recorded at Southern Aegean Region (SAR) stations, yield fast directions that are not similar to the pattern of the SKS results at the depth of 133 km. We have found high delay times among the S phases in this region (SAR). This situation can be explained with the important coupling between cold slab and the intense mantle convection.*

INTRODUCTION

In the combination with the westward motion along the North Anatolian Fault Zone, the southwestern motion of the Hellenic arc results from the continental collision between Arabia and Eurasia plates (Fig.1). The extension in the Aegean region focused on the role of the westward push of Turkey versus that of the slab pull-related forces acting in the Hellenic trench region [Taymaz et al.,1991]. The complex structure of Aegean region can be understood not only the seismicity but also the analysis of seismic anisotropy. Mapping azimuthal seismic anisotropy is very crucial to determine the location and extent of seismic anisotropy in complex structures of the earth and to investigate in dynamic structure of the mantle by using shear wave splitting parameters.

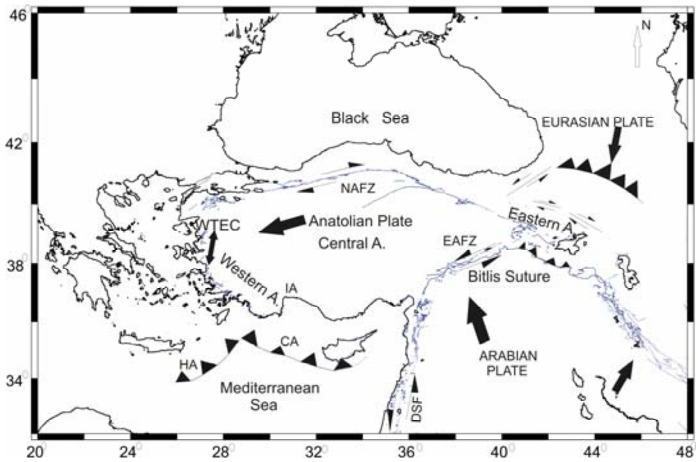

Figure-1. Tectonic structure of Turkey and surrounding areas

Many researchers investigate the details of seismic anisotropy in the mantle wedge and asthenosphere under subducted slabs by using teleseismic S and SKS splitting parameters combining with local S waves above subduction zones [e.g., Fouch and Fisher, 1996; Sandvol and Ni, 1997]. In this study we use both local and teleseismic data recorded by Kandilli Observatory and Earthquake Research Institute (KOERI) stations (Fig.2).

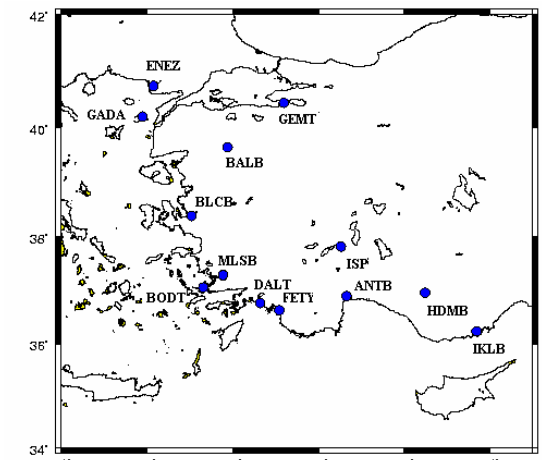

Figure-2. Broadband stations used in this study

DATA AND METHOD

In this study events are selected in terms of some criteria include the depth of greater than 30 km and distance range is smaller than 10 deg for local events and greater than 10 degre for teleseismic events. Broadband data are used to determine the depth extent of seismic anisotropy. Furthermore, we use the high quality data with S wave incidence angles of 35^{o} or less in terms of signal to noise ratio. Local S waves have angles of incidence much larger than the critical angle in which case the shear waves get distorted because of the effect of the free surface [Nuttli,1961; Kennett, 1991]. Assuming that the azimuthal anisotropy is distributed in terms of depth, it is expected that upgoing S waves originating from deeper hypocenters have larger lag times than S waves originating from more shallow earthquakes. In subduction zone, the SKS lag time minus the local S wave lag time causes the lag time stemming from the azimuthal anisotropy beneath the hypocenter. The method of Silver and Chan (1991) and the bootstrap technique [Sandvol and Hearn 1994] are used to measure the shear wave splitting parameters for SKS and SKKS waves. We minimize the smaller of the two eigenvalues in horizontal covariance matrix to determine the splitting parameters for both local and teleseismic S waves [Silver and Chan, 1991]. The horizontal covariance matrix is defined as:

Where k is the digital time index, n is the sampling rate, and N is the total number of data points for the given time series. As applying the method to our data, once the

$$C_{ij} = \sum_{K=1}^{N} u_i(k - n * \delta t) * u_j(k)$$

receiver-side splitting is removed to get source-side splitting. The spitting parameters of the receiver-side corrected S waveforms can be determined by the same methods applied for SKS, SKKS and local S waves. Also, each of the source-side fast directions about the back azimuth to correct for the difference in geometry between a downgoing and an upgoing ray path [Russo and Silver, 1994].

RESULTS

Local split S waves at BALB station (Fig.3) show that fast directions are parallel to the Hellenic Arc. Event 2 is located near to Kythira. Its fast direction is perpendicular to E-W extension of the Hellenic Arc but Event 3 is parallel to the Hellenic Trench. The result of ISP station shows that fast polarization directions do not have an uniform pattern. It could be related to intersection between the E-W extension of the Hellenic arc and N-S extension of the western Anatolia. Fast polarization directions at the event 2 and the event 3 are consistent with the ISP and other stations that are used in the study. Changes in the amount of delay time might not be consistent with the increase in focal depths of the used eartquakes in the study. However, amount of delay time obtained from most of the stations except ISP and ANTB at Cyprus Arc are very reasonable and consistent with the focal depth of the earthquakes that occured in this region. The amount of delay time at ISP is different from HDMB, DALT, FETY and BODT stations, but their fast polarization directions are all in NW-SE. Their fast polarization directions except ANTB are parallel to the Cyprus Arc.

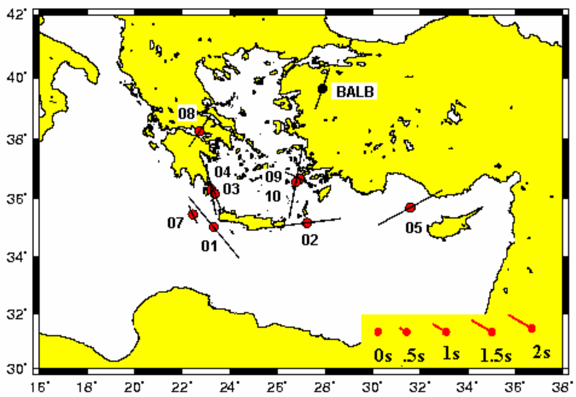

Figure-3. Source-side splitting parameters for BALB station

CONCLUSION

Almost all local splitting values along the Subduction boundary zone are parallel to the consuming direction and the slab retreating direction because azimuthal anistropy could be resulting from slab movements and related deformation in it. The observed shear wave splitting directions get complex at the edge of the Hellenic subduction near to the south-west of the Anatolian plate in terms of our results. All earthquakes have moderate depths at Cyprus Arc. Splitting directions along the Cpyrus arc observed parallel to it but it is contrast to the Hellenic Arc. This may be related to continent–continent collision along the Cyprus Arc. In another words, the collision in the south of the Cyprus island causes parallel deformations especially in northwest–southeast directions along the arc. The young age of the collision may explain the small delay time in this region. Although seismic anisotropy in Cyprus arc is only related to the present deformation, the existence of anisotropy in Hellenic arc may be related with the metastable and higly anisotropic olivine. The consistency between the directions of fast polarized SKS waves and local S waves suggests that the presence of anisotropy in the North-West part of the Aegean subduction zone is linked to coherent mantle flow.

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