An investigation of the slab stress in the Hellenic arc

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Abstract

We investigate the stress regimes of the slab in the Hellenic trench with respect to geometry of the Wadati-Benioff zone in the framework of the "Ping-Pong" model. The dominant stress pattern observed is down-deep extension. The combination of strong curvature and moderate dip angle of the slab results in a minor deviation from the "Ping-Pong" model. According to the observations, the deviation is not great enough to induce many earthquakes with lateral extensional stresses.

Introduction

The Hellenic trench, featured the subduction of the eastern Mediterranean lithosphere (front part of the African plate) under the Aegean lithosphere (front part of the Eurasian plate), exhibits strong trench curvature on the surface (Figure 1). In previous study (Chen et al., 2004), we have learned that the stress regimes of a subducting slab with both strong trench curvature and steep dipping angle tend to exhibit lateral extension, as suggested by the "Ping-Pong" model (Frank, 1968). In this study, we thus investigate the relationship between stress orientations of intermediate-depth earthquakes and the geometry of the Hellenic Wadati-Benioff zone in the framework of the "Ping-Pong" model. Methods and codes of the investigation are readily developed by Chen et al. (2004). Results show that the dominant stress in the slab of the Hellenic arc are down-dip extension, except for a few deeper earthquakes showing lateral extension.

Methodology

To determine the dip angle of the slab from seismicity (data from Papazachos et al., 2000 and Engdahl et al., 1998), we need to account for the continuing change of trench strike due to its strong curvature. A cylindrical projection is applied. It is performed by finding the pole of the small circle, which best fits earthquakes between 80 to 100 km. An earthquake is projected with the abscissa being the horizontal distance between the pole and the epicenter and the ordinate being simply its depth. The dip angle can then be determined from the plane. The local slab strike is defined as normal to the azimuth of the pole with respect to the epicenter. With dip and strike determined, we use local slab coordinates to project the P and T axes of intermediate-depth earthquakes from their moment tensor solutions. The solutions are derived from the Harvard CMT catalogue (Dziewonski et al. 1983, and subsequent quarterly updates).

Results

Upon fitting intermediate-depth seismicity, the radius of curvature (RC) angle in the Hellenic trench is 2.8° and the dip angle is 29°. The deviation of half of the dip angle and the RC angle is around -12°. Upon projecting earthquake stresses with slab coordinates, the stress pattern is mostly down-dip extension with a few deep events showing lateral extension (Figure 2). Figure 3 is the spatial distribution of the tension axes. Although the trench curvature is strong, the dominant stress is not lateral extension. This is because the dip angle is not particularly steep and thus there is only a slight deviation (-12°) from the "Ping-Pong" model.

Reference

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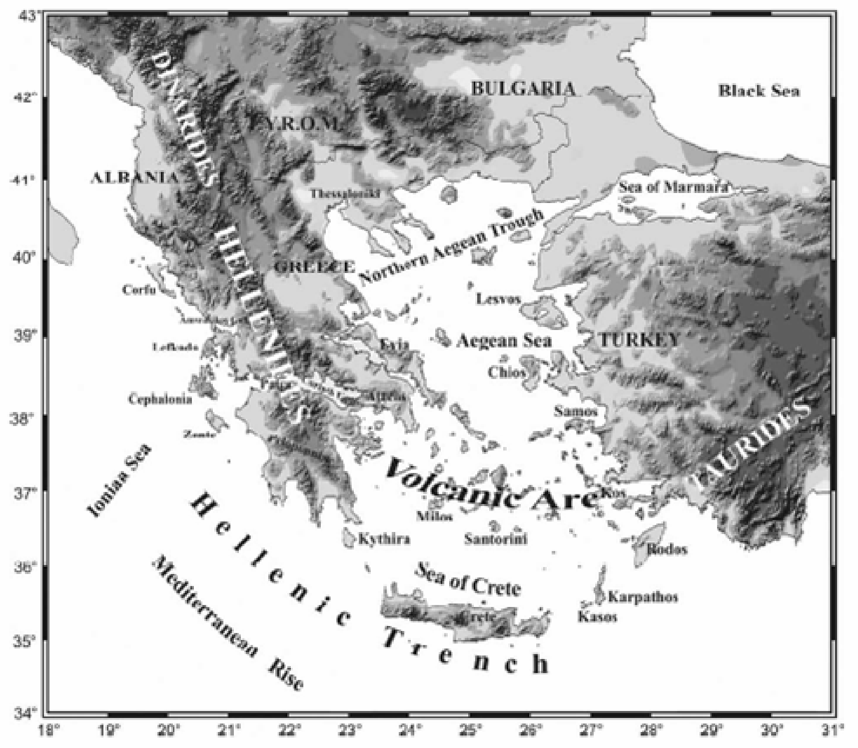

Figure1. Main tectonic features of the Aegean Sea and the surrounding lands (Benetatos et al. 2004).

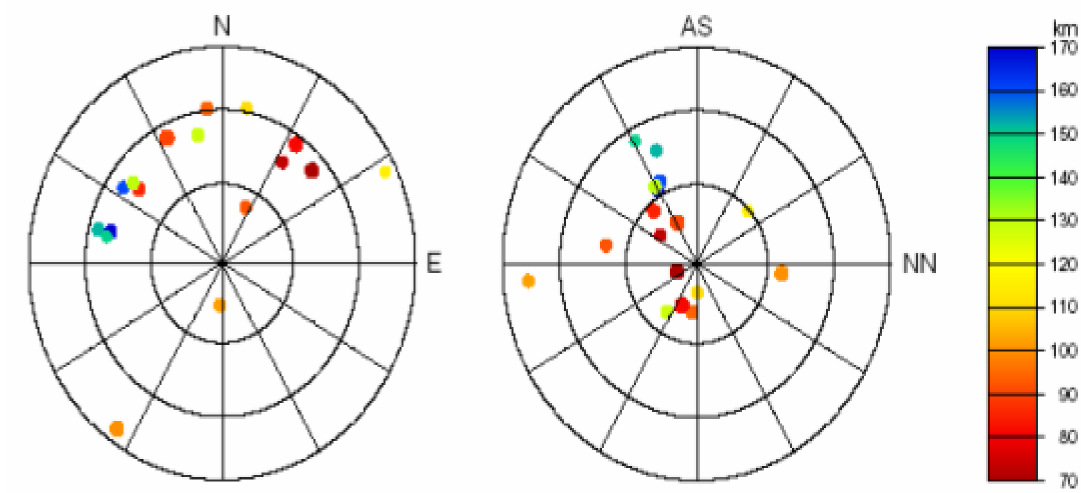

Figure2. Left: projection of T axes using geographical coordinates. Right: projection of T axes using local slab coordinates. Note that most T axes exhibit down-dip direction (right).

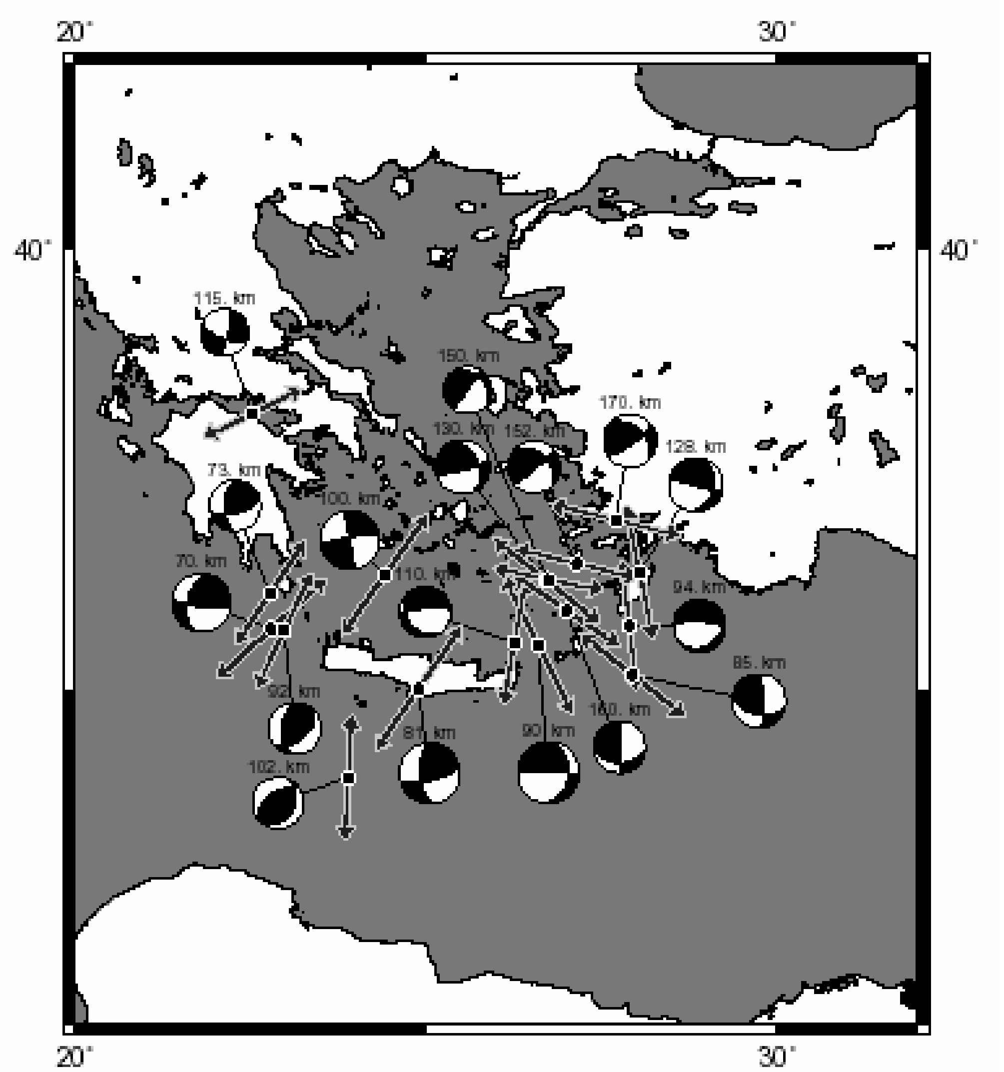

Figure 3. plot of focal mechanisms for events in this study with tension axes and earthquake depth shown.