

# Evidence for tidal triggering on the earthquakes of the Hellenic Arc, Greece



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## ABSTRACT

In this paper we investigate the tidal triggering evidence on the earthquakes of the seismic area of the Hellenic Arc using the Hist(ogram)Cum(mulation) method. We analyze the series of the earthquakes occurred in the area which is confined by the longitudes 22° and 28°E and latitudes 34° and 36°N in the time period from 1964 to 2012. In this time period 16,137 shallow and of intermediate depth earthquakes with  $M_L$  up to 6.0 and 1,482 deep earthquakes with  $M_L$  up to 6.2 occurred. The result of the this analysis indicate that the monthly variation of the frequencies of earthquake occurrence is in accordance with the period of the tidal lunar monthly variations, and the same happens with the corresponding daily variations of the frequencies of earthquake occurrence with the diurnal luni-solar (K1) and semidiurnal solar (S2) tidal variations. These results are in favor of a tidal triggering process on earthquakes when the stress in the focal area is near the critical level.

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## 1. Introduction

The question of the possible connection of Earth tides with earthquake occurrence is a very old one and has been tackled by a number of researchers for over one hundred years. The results were contradictory with most of the outcomes to disapprove the possibility of any correlation between earthquake occurrence and Earth tides, see for instance Schuster (1897), Knopoff (1964), Simpson (1967), Shudde and Barr (1977), Rydelek et al. (1992), Vidale et al. (1998) and many others. On the other hand, the outcome of a considerable number of relatively recent works is in favor of such a correlation, see for instance Enescu and Enescu (1999), Stavinschi and Souchay (2003), Tanaka et al. (2002, 2006), Cadicheanu et al. (2007) and many others.

Nevertheless, although the stress drop in an earthquake event is two or three orders higher than the amplitude of the tidal stress variations, the tidal stress rate is comparable or much higher than the tectonic stress accumulation in a fault. Thus, unless the earthquake event is a result of a sudden stress accumulation on a fault (Vidale et al., 1998), one has to conclude that Earth tides act as a triggering mechanism in a mature fault i.e. a fault for which the stress accumulation approaches the critical point for a rapture occurrence. Recent analyses point to this fact (Tanaka et al., 2002, 2006; Cadicheanu et al., 2007). In these papers not only the tidal triggering for global (Tanaka et al., 2002) and local

(Tanaka et al., 2006; Cadicheanu et al., 2007) scale were found, but in addition in the last two papers the increase of the reliability of the tidal-earthquake occurrence correlation is indicated as precursory phenomenon for strong earthquakes. Quite similar results were found by the authors on analyzing earthquake occurrence in areas of Greece in relation to the Earth Tides (Contadakis et al., 2009, 2012).

In this paper, which maybe considered the third of a series of works aiming at the same scope, we analyze a series of 16,137 shallow and of intermediate depth earthquakes as well as 1,482 deep earthquakes which occurred in the area of the Hellenic Arch in the period from 1964 up to 2012 with the purpose to investigate a possible tidal triggering effect on earthquake occurrence.

## 2. Data

The data set consist of a series of 16,137 shallow and of intermediate depth earthquakes with  $M_L$  up to 6.0 and 1,482 deep earthquakes with  $M_L$  up to 6.2 occurred within the time interval from February, 24 1964, to January 31 2012, in an area bounded by  $34^\circ \leq \varphi \leq 36^\circ$  and  $22^\circ \leq \lambda \leq 28^\circ$ . The magnitudes were quoted from the Catalogue of Geodynamic Institute of the National Observatory of Athens (<http://www.gein.noa.gr/services/cat.html>). Fig. 1, quoted from Papazachos et al. (1998) displays the main morphotectonic characteristics and Fig. 2, quoted from Papazachos et al. (1999) displays the main faulting zones and faulting type in the area of Greece. The area under study is the one along the

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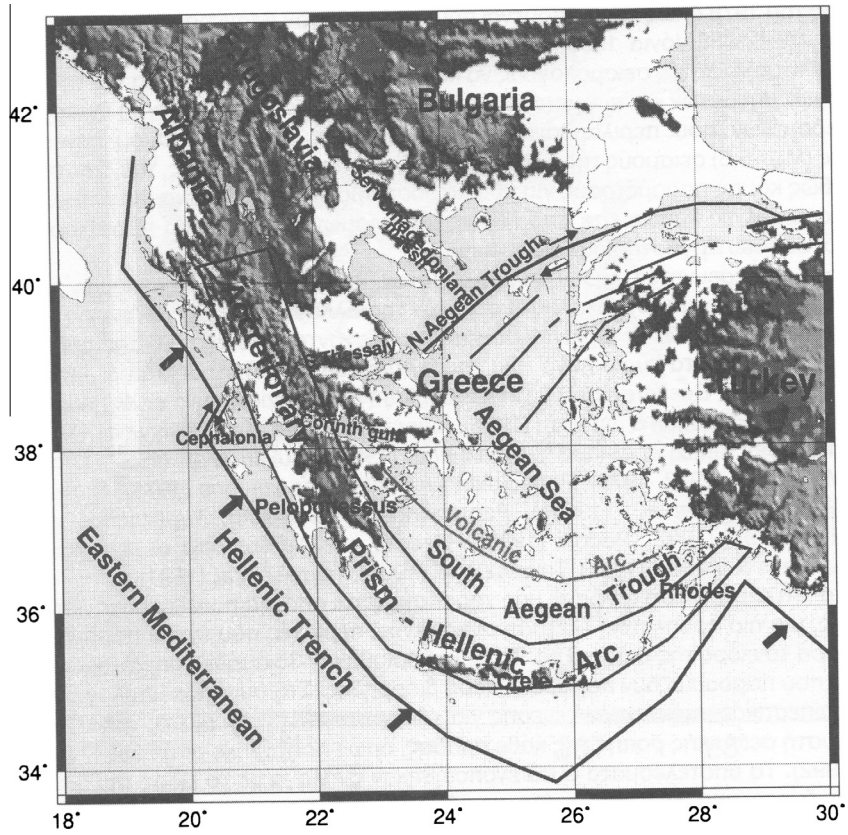


Fig. 1. The main morphotectonic characteristics of the broader area of Greece (Papazachos et al., 1998).

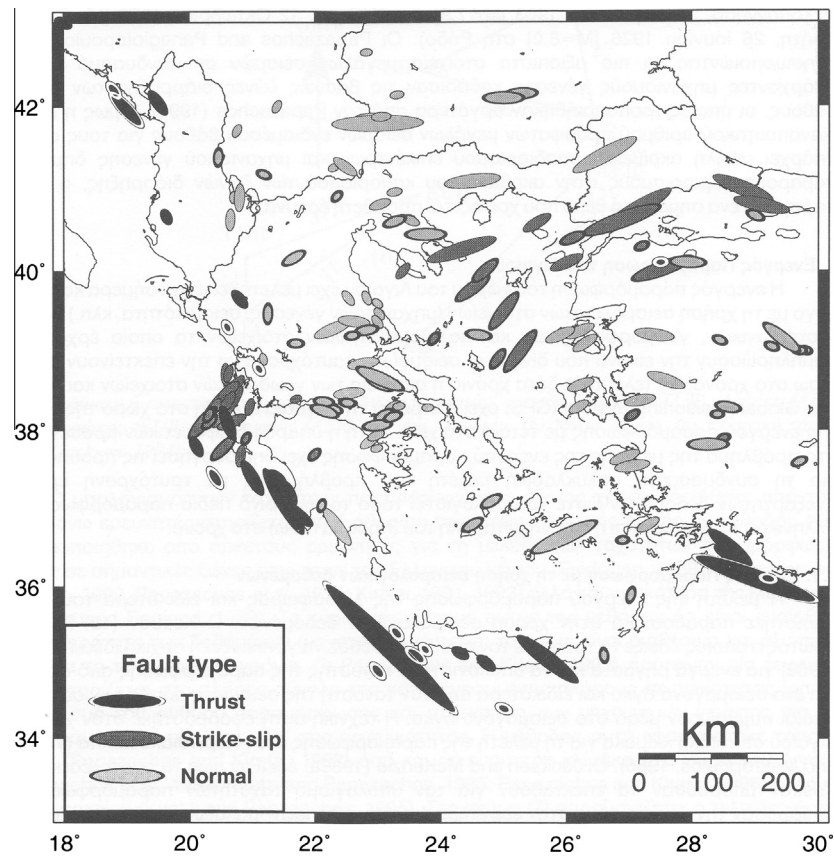


Fig. 2. Rapture zones in the area of Greece (Papazachos et al., 1999).

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