Recent Seismicity and Deformation Patterns in the Ionian Sea region

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The Ionian Sea, between the Calabrian and Hellenic Arcs, is a the most seismically active area in Europe due to the active collision and subduction processes that involve the African and Eurasian plates. Many large and catastrophic earthquakes have occurred along the western coasts of Greece and offshore in the Ionian islands throughout history, however it was following the ‘Great Ionian Earthquake’, which struck the southern Ionian islands on August 12th, 1953, that a Wood-Anderson seismograph was installed on the island of Kefalonia by the National Observatory of Athens (NOA). Subsequently, the NOA seismographic network expanded and improved with new station installations and standard observatory practice, in order to produce detailed monthly bulletins and a homogeneous and complete earthquake catalog.

During the last five years and in order to further improve the assessment of the tectonic stress field and the seismic hazard of the Ionian Sea region, NOA established six permanent GPS stations on the islands and in Western Greece, all transmitting real-time data. In this study we determine and map: a) the spatial and temporal seismicity rate changes, b) the tectonic stress field associated with the recent seismicity and c) the GPS deformation patterns, of the Ionian Sea region. From this multi-parameter approach, the results converge to indicate that advances or retardations of the seismicity follow the patterns of stress increase and decrease as predicted by the Coulomb hypothesis.
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Western Greece comprises a seismo-tectonically complex area of rapid and intense deformation and the central Ionian Islands (Lefkada, Zakynthos and Cephalonia) are the most active zone of shallow seismicity. This is reflected on the existed comprehensive catalogue of seismic events for Greece, where the occurrence of more than 4500 intermediate-size earthquakes during the last 50 years, with several large and destructive events among them, can be confirmed. The high seismicity level which characterizes the broader area of Ionian Sea occurs due to its position, as it’s situated between a subduction zone to the south and a collision zone to the north. The Eastern Mediterranean lithosphere, which is the front part of the African lithosphere, is subducted beneath the Aegean lithosphere, which is the front part of the Eurasian lithosphere, along the Hellenic Arc – Trench System. This subduction zone terminates against the Cephalonia Transform Fault (CTF), which links this subduction boundary to the continental collision between the Apulia microplate and the Hellenic Foreland further north. The area of Zakynthos characterized by horizontal compression almost perpendicular to the Hellenic Arc, which is thought to have been induced during the Miocene, while the area of Cephalonia and Lefkada is strongly associated with right-lateral strike-slip faulting along the Cephalonia Transform Fault, with earthquake magnitudes up to 7.4. Concluding, the area of the Ionian Sea, may be considered as a key area for a better understanding of the processes related to the collision of the African and Eurasian plates.

GPS DEFORMATION

We model stress transfer using the Okada (1992) methodology using the Coulomb 3.3 software (Lin and Stein, 2004, Toda et al. 2005) to compute the static Coulomb stress changes for the three largest recent earthquakes after 2006. In all cases, we adopted a value of 8 × 10^5 bar for the Young modulus, a value of 0.25 for the Poisson's ratio and a value of 0.4 for the effective coefficient of friction. We used the fault model provided by the NOA MT (Moment Tensor) solution to calculate Coulomb stress changes on receiver faults parallel to us, and with the same sense of dip, on source model hypocentral planes. We used the empirical magnitude-area relations of Wells and Coppersmith (1994) for strike slip and reverse faults to constrain the rupture extent.

1. For the Mw=5.4 normal event near the southern coast of Zakynthos which occurred on 2006/04/04, we used the fault model provided by the NOA MT (315/69/-84 at 25 km depth) and we estimated an average, right-lateral strike-slip displacement (us) of -0.026 m (left-lateral offset) and a dip – slip displacement (ud) of -0.043 m (upwards offset).

2. For the strike-slip event near Cephalonia Island (Mw=5.5) which occurred on 2007/03/25, we used the fault model provided by the NOA MT (324/48/83 at 5 km depth) and estimated an average, right-lateral strike-slip displacement (us) of -0.043 m (left-lateral offset) and a dip – slip displacement (ud) of 0.346 m (upwards offset).

3. For the thrust event near the coastline of Epirus (Mw=5.2) which occurred on 2007/06/29, we used the fault model provided by the NOA MT (314/88/83 at 5 km depth) and estimated an average, right-lateral strike-slip displacement (us) of -0.053 m (left-lateral offset) and a dip – slip displacement (ud) of 0.24 m (upwards offset).

Seismicity Rate

For the seismicity analysis we employ the ZMAP software (Warner, 2001) and the NOA earthquake catalog.

The results indicate an agreement in the distribution pattern of the:

- Seismicity Rate
- CMT/Stress Tensor
- Coulomb Stress
- GPS Velocity