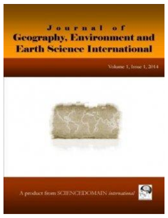

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# Cephalonia-lefkas Transform Fault Zone (CLTFZ) Complexity: Insights from 2015 Lefkas Earthquake Sequence

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author AK designed the study, managed the literature searches, wrote the protocol and the first draft of the manuscript. Author KP performed the Coulomb Stress Transfer Analysis, author VK managed the catalogue unification, analysis and statistics and author GB determined the Focal mechanism solutions. All authors read and approved the final manuscript.*

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## ABSTRACT

In order to define a better model for the Cephalonia-Lefkas Transform Fault Zone the sequence of 2015 Lefkas earthquake was examined. On 17 November 2015 (07:10 GMT) a major earthquake (Mw=6.4) occurred on the central-western part of Lefkas island. Several destructive events were located in the past in this fault zone, so an extensive seismotectonic study is feasible for that area. Manual analysis was performed using a custom velocity model that was determined for that purpose, applying the average travel-time residuals and location uncertainties errors minimization method. Several clusters belonging to the aftershock sequence were identified, whereas three are directly related to the causative fault, covering an area of about 25 km. The central one, which includes the mainshock, comprises of only a few aftershocks. The northern, within which the majority of aftershocks are located, lies in the central part of Lefkas island and the southern

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occurred close to the SW edge of the island. In addition, offshore clusters with distinct characteristics have been identified to the south, between Lefkas and Cephalonia islands. The temporal evolution of the aftershock sequence indicates that no migration was observed, given that after the occurrence of the mainshock the entire epicentral area was activated. Focal mechanisms of the Seismological Laboratory of the University of Athens showed dextral strike-slip faulting for both mainshock and major aftershocks of the sequence. Taking into account the spatial distribution of the aftershocks, supported by the tectonic and geomorphological settings of the region, a deformation pattern, consisting of the Cephalonia-Lefkas and Ithaca-Lefkas major fault zones which converge in the area of Vassiliki bay is proposed. The appearance of the southernmost clusters was interpreted by the positive Coulomb stress changes transfer due to major earthquake Mw=6.4.

*Keywords: Seismotectonic analysis; releasing bends; restraining bends; lefkas aftershock sequence; Western Greece.*

## 1. INTRODUCTION

The Hellenic peninsula is bounded by important geologic and tectonic features such as the Alpine mountain chain to the North, caused by the collision between Europe and Africa [1], the North Anatolian Fault zone to the East [2,3,4,5,6], created by the lateral motion of Anatolia with respect to the European tectonic plate [7] and the Hellenic arc to the south, characterized by the subduction of Tethys oceanic crust [8].

The area of Western Greece (Fig. 1.) which is running from the Greek-Albanian borders to the southern edge of Peloponnese and from the Ionian Islands to eastern Thessaly and Macedonia lies between a continental collision zone to the north (Adria Microplate-Eurasia) and the Hellenic Trough to the south, where remnants of the Eastern Mediterranean oceanic crust subduct under the Aegean continental lithospheric microplate. These zones are linked with the Cephalonia-Lefkas Transform Fault Zone (CLTFZ), playing an important role in the geodynamics of the area. Seismological data for the CLTFZ indicate right-lateral strike-slip focal mechanisms [9,10] which is in agreement with the geodetic data revealing the NNE–SSW direction of slip motion [11,12]. The seismic strain rate is well correlated with the principal horizontal axis of the total geodetic strain rate field. Some smaller neotectonic structures are mainly expressed by minor faults that strike NNE-SSW to E-W direction, overprinting the pre-existing thrust-related Plio-Quaternary features, breaking up the island in multiple independent fault blocks [13].

The broader area of study is characterized by a series of NW–SE striking geotectonic units, such as the Pre-Apulian (or Paxos) and Ionian [14], forming the External Hellenides terrain. These structures which have resulted by a subduction-related compressional regime are coaxial with earlier Alpine ones resulting from the collision of the Pre-Apulian plate with Eurasia. The mountain chain of Hellenides located between southern Albania and the Gulf of Corinth plays an important role on the seismotectonics of the region.

The Ionian Islands are separated from the mainland by rapidly extensional Pliocene-Quaternary basins [15,16]. The oldest sediments that fill those basins are of Pliocene age. In Lefkas Island, carbonate and clastic sediments of the Hellenic arc external geotectonic units dominate the geological setting [17]. The geotectonic units of Paxos and Ionian are separated by a major west-directed thrust [18, 19,14], marked by Triassic evaporitic domes [20].

The majority of strong earthquakes in the broader region have mainly occurred along the main tectonic features, such as the CLTFZ. Lefkas Island is characterized by the occurrence of large earthquakes, both during the historical and the instrumental era, causing significant damage [21,22]. Most events were located close to the NW part of the island. More specifically, the 22 November 1704 (M=6.3), the 12 October 1769 (M=6.7), the 23 March 1783 (M=6.7), the 28 December 1869 (M=6.4) and the 27 November 1914 (M=6.3) earthquakes were among the most significant ones. They caused several deaths, injuries, collapse of buildings, fissures, liquefactions and landslides at the northwestern and central parts of the island. This is the reason why most epicenters of the historical earthquakes are located close to the northern end of the CLTFZ, in the Ionian Sea [23, 24]. More recently, on 14 August 2003 (05:14 GMT), a large earthquake (Mw=6.3) with a focal depth of 9 km occurred close to the NW coast of Lefkas Island [18,25,26].

On the other hand, only two large events have been located close to the southwestern edge of the Lefkas Island, an area that belongs to the central part of the CLTFZ. Nevertheless, important microseismic activity is observed. The two events, related to this area, are the 22 February 1723 (M=6.7) and the 22 April 1948 (M=6.5) earthquakes. Concerning the latter event, it caused damage at the SW part of the island, while fissures and tsunami waves were also observed. Two months later, on 30 June 1948, an earthquake of magnitude M=6.4 occurred at the NW part of the island.

A strong earthquake of moment magnitude Mw=6.4 occurred on 17 November 2015 at the western part of Lefkas Island, causing some damage, landslides and ground fissures. In the present study, this earthquake sequence is investigated in detail. For that purpose, precise hypocentral locations are required. The latter were obtained using a local velocity model that is determined in this study.

## 2. DATA AND METHODS

The present study focuses in the area of Central Ionian Islands (Western Greece), where data of several local stations belonging to the Hellenic Unified Seismological Network (HUSN) [27] were used for the construction of the local 1D velocity model. HUSN (Fig. 2.) comprises stations from the Seismological Laboratory of the University of Athens (S.L-U.O.A), the Geodynamics Institute of the National Observatory of Athens (GE.IN.-N.O.A), the Geophysical Laboratory of the University of Thessaloniki (G.L.-A.U.TH) and the Seismological Laboratory of the University of Patras (U.P.S.L.).

The data set used in this study comprises of more than 10,000 earthquakes which were obtained from the seismological stations of HUSN and correspond to the time period 2012-2017 (Fig. 2). More specifically, all the event locations were calculated using manually picked P- and S-wave arrival-times, the HYPOINVERSE algorithm [28] a regional 1-D velocity model, while the duration magnitude was calculated according to the formula described by relevant studies [28] [10]. A subset of the data catalogue corresponds to the Paliki (2014) and Lefkas (2015) earthquake sequence, in the vicinity of CLTFZ.

### 2.1 Construction of Local Velocity Model

In the present study, the best located events were used to obtain an accurate local 1D velocity model for the broader area of Lefkas Island. The initial earthquake locations for the area of Western Greece were obtained using the regional velocity model derived by [29]. The selected events had at least fourteen (14) P- and eight (8) S-wave arrival times. The present model was determined by applying the average travel-time residuals and location uncertainties errors (RMS, ERX, ERY, ERZ) minimization method [30,31,32]. The obtained local velocity model (Table 1) yielded improved hypocentral solutions with smaller errors than those derived by the initial one (Table 2).

The value of Vp/Vs ratio was obtained using the following methods: a) Chatelain (1978), that consists of determining the slope of the straight best-fit line of the difference between S-wave and P-wave travel-times for each couple of stations and for each event and b) the travel-time residuals and location uncertainties errors (RMS, ERX, ERY, ERZ) minimization method. The last mentioned Vp/Vs ratio determination method follows the same procedure that was performed in order to define velocity and ceiling depth for each layer. The data for both Chatelain and Spatio-Temporal Error Minimization methods converge to the same Vp/Vs ratio value of 1.79. Error statistics for all spatial groups with both regional and custom local models are presented in Table 2. The mean horizontal (ERH) and vertical (ERZ) location errors of the events located in the broader study area are smaller than 1 km, while the mean RMS error is 0.132 sec.

### 2.2 Coulomb Stress Transfer

In order to investigate the possible acceleration or triggering of the above-observed clusters due to the strong earthquake Mw=6.4, the Coulomb stress changes transfer was calculated in different depths and cross-sections. The transferred ΔCFF was determined on the fault plane with an effective coefficient of friction μ=0.4 [33,34].

## 3. RESULTS AND DISCUSSION

On 17 November 2015 (07:10 GMT) a destructive earthquake occurred along the SE coast of Lefkas Island, in the vicinity of Athani village. There were two fatalities, one due to rockfall and one caused by a paddock collapse. Eight people were injured, two of which children. Certain collapses, rockfalls and landslides have been reported.

Manual analysis was conducted for the mainshock and for more than 2,500 aftershocks for the period between 17 November and 3 December 2015, during which the major part of the ruptured area was activated. Thus, it is considered that this period provides all necessary information to interpret the 2015 Lefkas seismic sequence.

### 3.1 Description of Clustered Seismicity

The hypocentral locations, using the newly developed 1-D local velocity model, revealed that the aftershock sequence mainly occurred in the mid-western part of Lefkas Island. However, another group of events is located S of Lefkas Island, offshore, towards Cephalonia Island. It is worth noting that the largest aftershock (Mw=5.0) occurred near the mainshock, on 17 November 08:33 UTC. Both mainshock and the largest aftershock of 17 November 2015 are well aligned in a SSW-NNE direction. Several linear structures can be distinguished, many of which

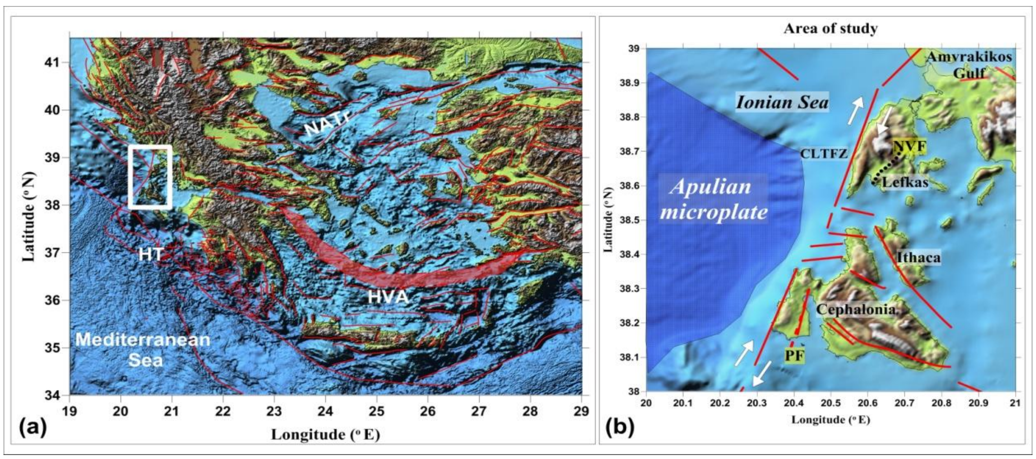


**Fig. 1. a) Main tectonic and volcanic elements of the broader area of Greece [35,29,36]. The study area is highlighted with a white rectangle b) Zoom in the study area of Central Ionian Sea, showing the islands of Cephalonia and Lefkas. Abbreviations in both maps are as following: HT, Hellenic Trench; NATr, North Aegean Trough; HVA, Hellenic Volcanic Arc; CLTFZ, Cephalonia-Lefkas Transform Fault Zone; PF, Paliki Fault; NVF, Nydri-Vassiliki Fault**

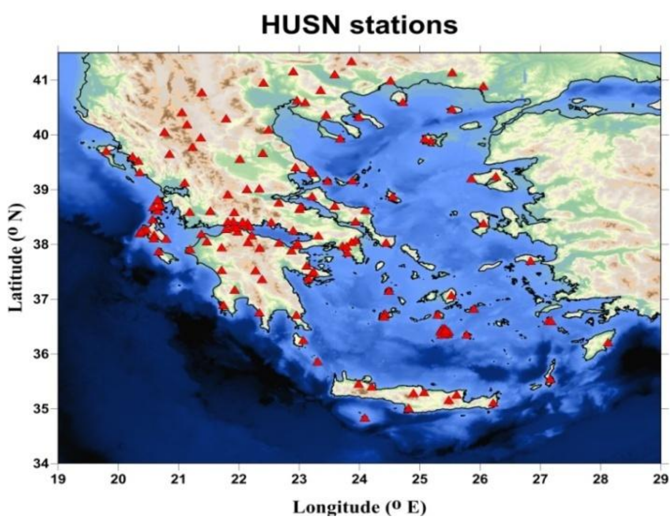


**Fig. 2. Distribution of HUSN stations (red triangles) throughout Greece**

**Table 1. Regional and custom velocity model**

| | Karakonstantis (2017) $V_P/V_S$=1.79 | | This Study $V_P/V_S$=1.79 | |
|---|---|---|---|---|
| Layer | $V_P$ (km/s) | Depth (km) | $V_P$ (km/s) | Depth (km) |
| 1 | 5.3 | 0.0 | 4.9 | 0.0 |
| 2 | 6.0 | 6.0 | 5.2 | 4.0 |
| 3 | 6.3 | 11.0 | 5.9 | 7.0 |
| 4 | 6.5 | 14.0 | 6.2 | 11.5 |
| 5 | 6.7 | 21.0 | 6.4 | 13.0 |
| 6 | 7.3 | 39.0 | 6.5 | 16.0 |
| 7 | 8.0 | 80.0 | 7.3 | 39.0 |

**Table 2. Statistics of location uncertainties and median depth for the regional and custom model**

| | Karakonstantis (2017) | This Study |
|---|---|---|
| Mean RMS (s) | 0.139 | 0.132 |
| Median RMS (s) | 0.110 | 0.110 |
| Mean ERH (km) | 1.125 | 0.909 |
| Median ERH (km) | 0.730 | 0.580 |
| Median ERX (km) | 0.510 | 0.380 |
| Median ERY (km) | 1.070 | 1.050 |
| Mean ERX (km) | 0.614 | 0.459 |
| Mean ERY (km) | 1.636 | 1.360 |
| Mean ERZ (km) | 1.933 | 1.323 |
| Median ERZ (km) | 1.310 | 0.870 |
| Mean Depth (km) | 7.542 | 8.765 |
| Median Depth (km) | 6.860 | 8.375 |
| St.Dev.Y (km) | 13.036 | 13.076 |
| St.Dev.X (km) | 6.569 | 5.963 |
| St.Dev.Z (km) | 3.550 | 3.459 |

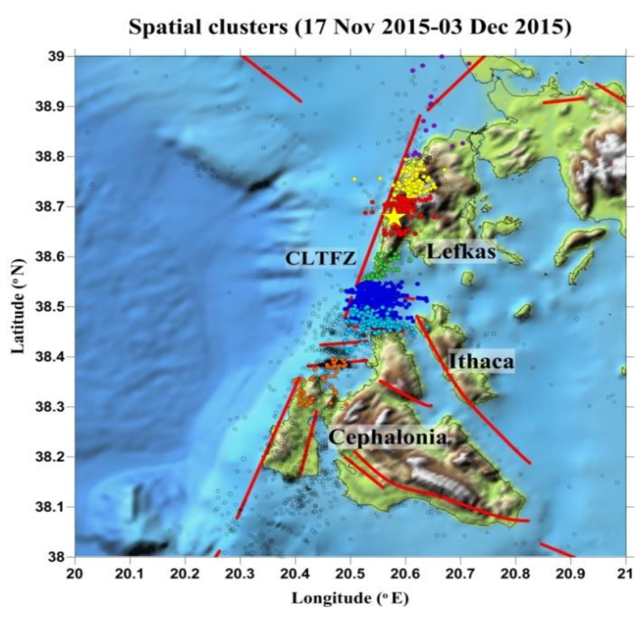


**Fig. 3. Map of the study area showing the seven (7) main spatial clusters marked with different colors: cluster #1 (orange), cluster #2 (cyan), cluster #3 (blue), cluster #4 (green), cluster #5 (red), cluster #6 (yellow) and cluster #7 (purple). The back ground seismicity, before and after the main body of the aftershock sequence is marked with grey open circles**

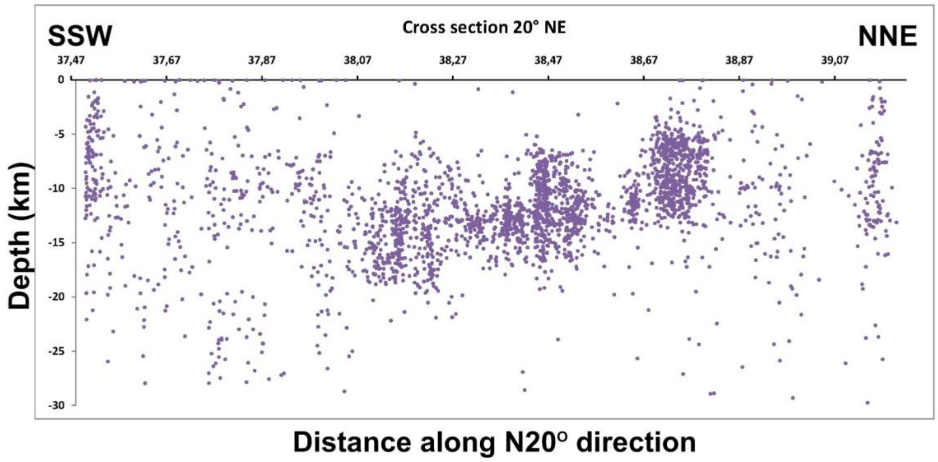


**Fig. 4. SSW-NNE cross-section of the main body of the aftershock sequence. Top axis is marked by the values of latitude (°N) that the thin section passes by**

offshore, south of Lefkas island, trending roughly E-W. The aftershock distribution appears mostly aligned in a N20°E direction with several branches oriented ~N30°E, including the northernmost and southernmost tips (Fig. 3).

The cross-section drawn at N20°E (Fig. 4.), roughly parallel to the CLTFZ, indicates that the total length of the activated area is approximately 60 km. The focal depths are distributed between 5 and 15 km, with the clusters in the northern group (5 - 7) being generally shallower than those of the southern group (1 - 4). The mainshock, as well as the strongest aftershock (Mw=5.0) of 17 November are contained in cluster #5.

The epicenter of the major events of this cluster are mainly aligned SSW-NNE, with the smaller sub-cluster being apparently oriented E-W near Vassiliki bay. By far the largest cluster is #6, which contains more than 100 events of the aftershock sequence (17/11/2015-03/12/2015). Cluster #6 is divided into two branches in its shallower parts (4-6 km), one SSW-NNE, similar to cluster #5, and another trending WSW towards the western coast, extending a bit deeper (8-9 km) ENE. The described hypocentral distribution is probably related to fault network complexity, which has possibly acted as a barrier, prohibiting the main rupture to extend further north. It also contains most of the major aftershocks (13 events with Mw≥3.9) which are, on average, located at slightly larger focal depths (~10 km) than the smaller ones (~6 km). Further north, cluster #7 extends ~17 km and deepens from ~6 km onshore (excluding a few sparsely located shallower events) down to ~15 km and includes the second largest aftershock (Mw=5.0) which occurred on 18 November 2015, 12:15 UTC. The cluster could be further divided in 2 sub-clusters, the one for the shallower, roughly onshore events, trending S-N and the other, offshore further north, containing fewer events and apparently trending SW-NE.

At the southern group, the northern tip of cluster #4 is ~4-5 km south of the mainshock and the cluster extends about 8 km SSW while its median focal depth (~12 km) is larger than the one for cluster #5 (~9 km). It probably belongs to the same fault plane as the one of the main rupture and defines its deeper seismogenic part. Clusters #2 and #3 are less dispersed than cluster #4 and their distribution is roughly oriented E-W. Cluster #2, in particular, contains 2 large sub-clusters at 8 – 13 km depth and a smaller sub-cluster at 15 km depth. The southernmost cluster #1 is a bit offset from the cross-section line (Fig. 4). Its main body is located at 7-9 km depth and it also includes several sub-clusters dispersed further south. At the very southern edge of the study area, a group of 3 deeper events at ~23-24 km, with epicenters between Ithaki and Cephalonia islands, are also included in cluster #1.

The Lefkas 2015 aftershock sequence is typical in terms of its spatio-temporal characteristics. Aftershocks were generated at both northern and southern edges of the zone within minutes to hours following the mainshock, as it is evident from S.L-U.o.A catalogue (http://www.geophysics.geol.uoa.gr/stations/gma ps3/leaf_significant.php?mapmode=mech&lng=en&year=2015#mapanc) while the largest one (Mw=5.0) occurred in less than 2 hours after the main event, in the same cluster. By the end of December 2015, the activity in most of the spatial groups had diminished (Fig. 5), with the exception of cluster #6, and the sequence was typically over, as confirmed by routine observations of the seismicity rate during the following months.

### 3.2 Focal Mechanisms

Fault plane solutions of the largest aftershocks (Mw≥5.0), determined by the Seismological Laboratory of the University of Athens (S.L-U.o.A; http://www.geophysics.geol.uoa.gr ), indicate dextral strike-slip faulting. As an example, the focal mechanism of the largest (Mw=5.0) aftershock, occurred on 17 November 2015 (08:33 GMT), 4 km SSW of the mainshock, is presented in Fig. 5.

Focal mechanisms revealed the activation of an almost vertical right lateral strike slip fault, in agreement with the ENE-WSW oriented CLTFZ. The obtained results indicate that the dimensions of the activated fault, located between the main aftershock cluster in the central part of the island and the respective one SSW of Lefkas, are 25 km length and 10 km width. The focal mechanisms of the events located offshore, between Lefkas and Cephalonia Islands, are similar to the respective solution of the mainshock. Nevertheless, taking into account additional characteristics, such as the spatial distribution of the aftershocks and the shallower bathymetry, both planes of the focal mechanism of the offshore events could be considered as the activated fault, as it will be discussed in more detail in the following section.

### 3.3 Coulomb Stress Transfer results

The ΔCFF distribution, as well as the cross section parallel to the fault, is presented in figure 6a and 6b respectively. The Coulomb stress distribution showed that the earthquake with magnitude Mw=6.4 caused strong positive stress changes transfer in the directions NNW and SSE, (Fig. 6c.) as well as in the upper layers from the depth of 8Km until the surface (Fig. 6d.). Additionally, the max stress coulomb values were calculated for a depth range 0-20Km with step 2Km (Fig. 6e.). The results lead to the conclusion that the southernmost clusters are triggered due to the positive Coulomb stress transfer during the fault rupture which occurred on the central-western part of Lefkada island, on 17 November 2015, (Mw=6.4). It is worth noting that the same procedure was observed for the 2003 Lefkas rupture process [26].

### 3.4 Discussion

The 2015 Lefkas aftershock sequence is characterized by the existence of several clusters. However, the spatial distribution of the sequence revealed the activation of a large area that extends further than the mainshock's rupture length. Its first characteristic is that only few aftershocks are located in the vicinity of the epicenter. On the contrary the most important cluster is situated at the central part of the island. It is characterized by high concentration of events, constituting the main cluster, and it is observed towards the northern end of the activated fault segment, at the mid-northern part of Lefkas Island. In the same area, an important cluster occurred during the 1994 sequence, as described by [21]. More specifically, on 29 November 1994 a moderate event of Mw=5.1 took place on the northern part of CLTFZ, close to the west coast of Lefkas Island, followed by a M=4.8 aftershock on 1 December 1994. Aftershock activity was concentrated in the west-central part of the island, in the region where the main cluster of the 2015 sequence occurred. In addition, the 1994 sequence was characterized by an almost vertical distribution, reaching 12 km depth [21]. The above-mentioned observations suggest that this area produces a complex seismicity pattern, which is probably due to the existence of a local minor fault system. This is supported by the high seismic rates, observed in the central part of Lefkas Island following the occurrence of moderate or large local events.

In addition, spatially clustered seismic activity occurred to the south, close to the NNW part of Cephalonia Island, probably is not directly related to the main activated fault since they are not located along the CLTFZ but they are shifted eastwards forming a step over of the ruptured zone. The southern clusters (#1, #2 and #3) are stretched in a roughly WNW-ESE direction, separated by gaps between them, possibly indicating the existence of small parallel left-lateral structures, transverse to the main CLTFZ. Another couple of small clusters of undefined geometry are located near the southern coast of Lefkas Island (spatial group #4). Other than that, the vicinity of the mainshock's hypocenter is characterized by few sparse aftershocks. The area defined by the spatial groups #5 and possibly #4 is considered to be the main rupture area, likely a barrier that left a few unbroken asperities where the seismic clusters are observed. However, certain clusters occurred to the south, between Lefkas and Cephalonia Islands. Taking them into account, the spatial distribution spans roughly ~60 km in a SSW-NNE direction, while focal depths vary between 5 km (mostly onshore) and 15 km (offshore). The temporal evolution of the aftershock sequence is generally smooth. No significant migration patterns were observed, as almost the full extent of the aftershock zone was activated within the first 24 hours after the mainshock.

Recent seismotectonic studies suggest that either the CLTFZ in this area is collinear with its northern segment west of Lefkas, while further south it is shifted by some kilometers to the west of Cephalonia coast due to a transfer zone of extensional step overs [27,11] or that the CLTFZ does not consist of a single dextral strike-slip fault, but rather a system of faults. Even though the 2015 Lefkas aftershock sequence was mainly distributed in the northern segment of the studied fault zone, some significant spatial clusters to the south of Lefkas Island appeared almost perpendicular, in a mean WNW-ESE direction, with the focal mechanisms implying sinistral strike-slip faulting. The results of the present study are in general fairly correlated to the scenario of previous seismological studies in the area [20], with the exception of the smaller than expected, according to their model, fault's dimensions, taking into account the southern clusters of the 2015 Lefkas sequence. Thus, the perpendicular secondary fault system of the latter model has to be prolonged towards the north, up to the southern part of Lefkas. In that case, the negative flower structure model, proposed by [20], could be adjusted by making a double left-bend which explains lots of the superficial geological and geomorphological features at the SW edge of Lefkas [13,37,7,38]. The advantage of this model is that it explains the observed seismicity south of Lefkas, while its disadvantage is the steep bending of the main part of the fault zone which is not compatible with the rupture process of the mainshock (Fig. 7a.).

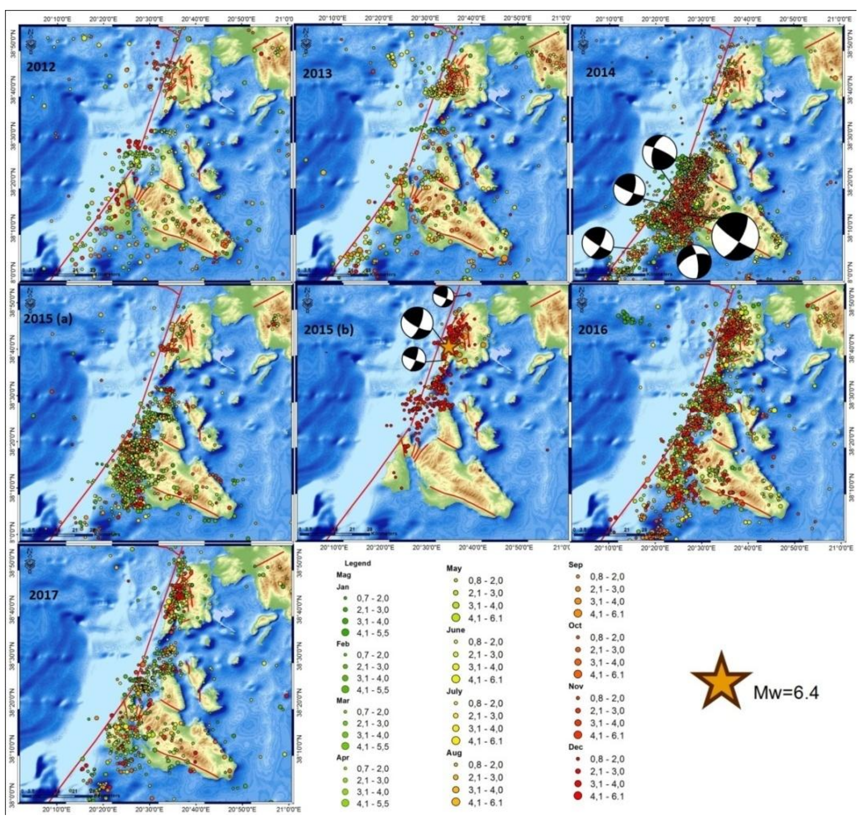


**Fig. 5. Evolution of the seismicity in the study area before (2012-2015a) and after (2015b-2017) the occurrence of November 17, 2015 M6.4 Lefkas earthquake**

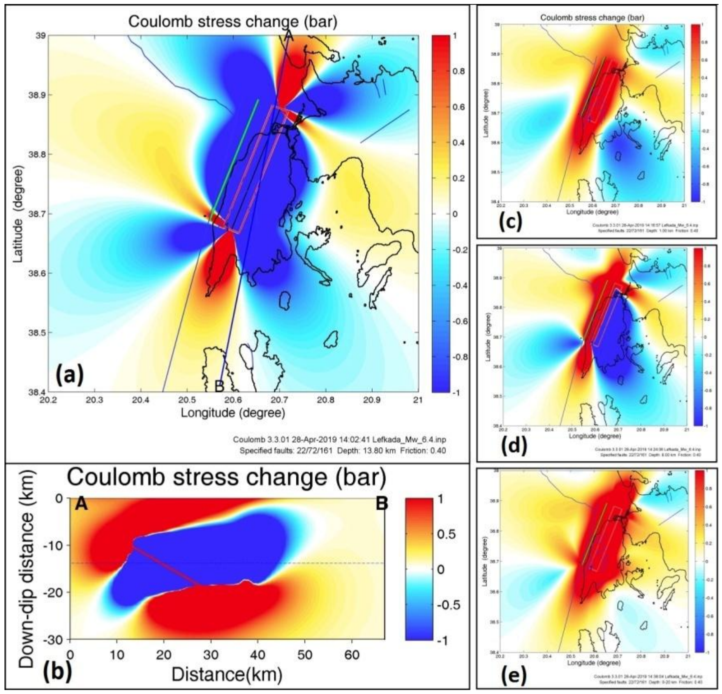


**Fig. 6. Distribution maps of Coulomb stress changes (ΔCFF) due to the 2015 earthquake Mw=6.4 at the focal depth (a) and cross section AB for strike 10°N (b). ΔCFF Maps for depths 1Km (c), 7Km (d), respectively. Max values of Coulomb stress changes for depth range 0-20Km (e)**

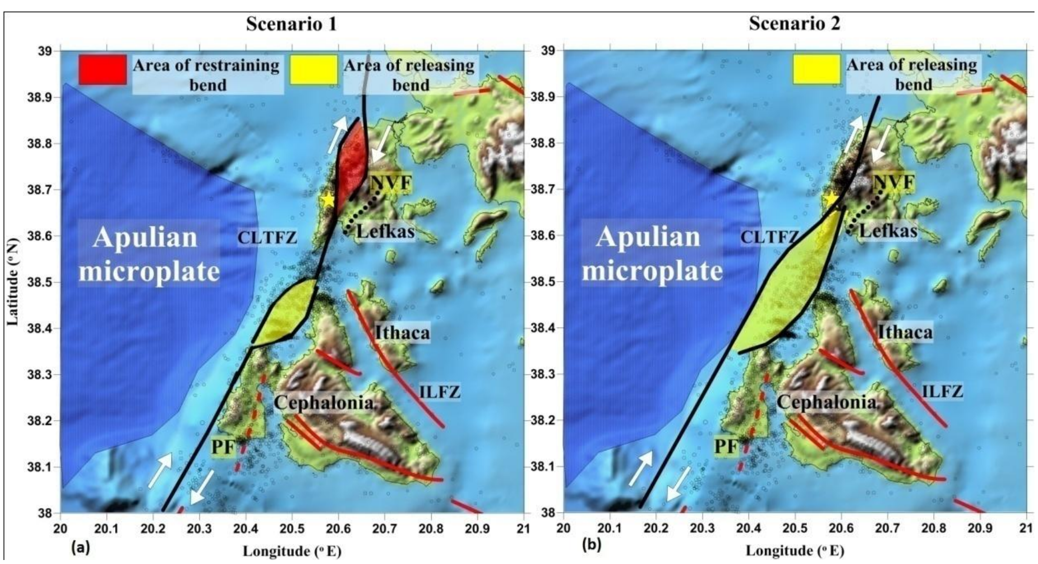


**Fig. 7. a) Double left-bend of CLTFZ model (scenario 1) and b) two major converging fault zones (CLTFZ and ILFZ), forming an almost antithetic system of strike-slip faults (scenario 2)**

Another scenario, which fits most of the results obtained by this study, is combined with previous knowledge based on GPS measurements [39], geophysical [40] geomorphological and tectonic elements at the southern part of Lefkas and the sea-bottom of Myrtos Gulf [13,7,38]. It includes two major fault zones, the CLTFZ and Ithaca-Lefkas (ILFZ), converging in the area of Vassiliki bay forming en-enchelon arrays of WNW-ESE minor faults and fractures, separated by smaller NE-SW strike-slip faults in between (Fig. 7b), such as the one of Nydri-Vassiliki (NVF). In this model, there is the major NNE-SSW striking CLTFZ offshore, which makes a right bend NW of Myrtos bay, forming a releasing bend in a region SSW of Lefkas Island, as in California's deformation model described by [41]. On the other hand, the NNW-SSE ILFZ and CLTFZ converge in western Lefkas Island, forming an antithetic system of strike-slip faults to the overall sense of the zone's shear, comprising crustal rotated blocks of oblique minor faults in the area between Cephalonia and Lefkas Islands (Fig. 7b.).

## 5. CONCLUSION

The 17 November 2015 Mw=6.4 Lefkas earthquake is located at the southwestern part of the island and can be considered as the continuation of the 2003 ruptured area, which probably left an unbroken patch. It is obvious that the recent event occurred within this asperity. Taking into account both events, the activated area, with a length of about 45 km in a SSW-NNE direction, covers the northern part of CLTFZ that is located west of Lefkas. This observation implies that the accumulated energy was released in two separate events instead of one, which would obviously have considerably larger magnitude. Such earthquake sequences, consisting of more than one event, have been reported since the historical times, as in the case of the earthquakes that occurred during 1948 [21].

The main characteristic of the sequence is that only a few aftershocks with M≥3.0 are located close to the mainshock's epicentre, suggesting that during the rupture process, no unbroken patches were left at the central part of the activated fault. The southern part of the activated fault, reaching the SW edge of Lefkas Island, is characterized by low seismicity. Concluding, the total length of the causative fault is of the order of 25 km, while the seismicity belonging to the southern and northernmost (1-3 and 7) clusters is probably not directly related to the CLTFZ. The length of the total activated area is about 60 km, much larger than the expected rupture length for a Mw=6.4 mainshock. This observation suggests that the clusters #1, #2, #3 and #7 have been triggered by stress-transfer.

The majority of the determined focal mechanisms are similar, related to dextral strike-slip faulting that was also revealed for the two earthquakes that occurred in Cephalonia during January – February 2014 [10]. The events located close to Lefkas Island are related to the main tectonic feature of the area, which is the Cephalonia-Lefkas Transform Fault Zone, along which other significant earthquakes occurred in the past, such as the 1983 Cephalonia earthquake. According to the results of the present study, the ruptured fault, with a length of approximately 25 km, is the prolongation of the 2003 Lefkas earthquake causative fault.

The occurrence of the 2015 Lefkas earthquake sequence provided the opportunity to obtain a more detailed deformation pattern, especially for the area between Lefkas and Cephalonia islands. For that purpose, two major scenarios are investigated. The first is a negative flower structure model prolonged towards the southern part of Lefkas. The other scenario includes the Cephalonia-Lefkas and the Ithaca-Lefkas major fault zones, converging in the area of Vassiliki bay, separated by smaller strike-slip faults in between, almost perpendicular to the CLTFZ. Considering the second scenario, both the WNW-ESE clustered seismicity, between the islands of Cephalonia and Lefkas, and the uplift region in the SW part of Lefkas Island, can be reasonably explained.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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